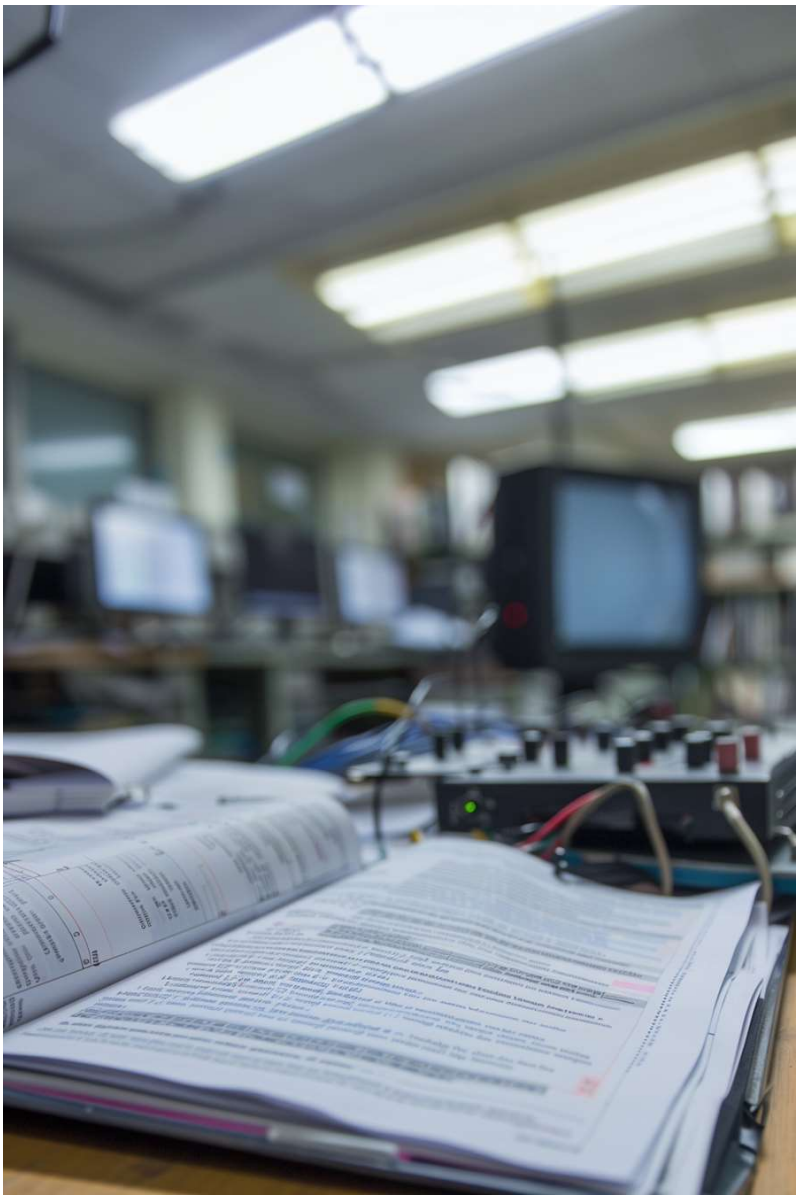

Report Writing

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Executive Summary

This document was written to provide advice on the writing of project reports for a typical university lecturer to mark. It consists of some general advice about writing styles, as well as advice about formatting, contents, and some examples of both good and poor practice.

A few tips about the use of both Microsoft Word and LaTeX are included. I have no preference about which one you choose, but I would urge you to learn about the powerful features of whichever word processor you decide to use.

The appendices contain three short example reports, one of which would be awarded a mark of around 80% (a distinction), one a mark of around 60% (an average mark) and one a mark of around 30% (a marginal fail), together with an explanation of the marking.

The Golden Rules

I have collected a few golden rules that underlie what I consider good practice in report writing:

- Be consistent in your formatting, and use of language. Even the smallest details of formatting should be consistent.
- Never try to surprise the reader. You are not writing a novel with plot twists and cliff-hangers.
- Good reports should be like fractals: no matter what scale you look at, the basic structure should be the same. For example, the whole report should have an introduction, body and conclusion, and there should be a logical flow through the sections. This should also be true for each section (with a logical flow through the sub-sections), and for each sub-section, and if possible, for each paragraph.
- Write clearly in plain English. You should aim to make your report easy to navigate and read. As well as being an act of kindness to your readers, this is an accessibility issue. You should not be trying to show how intelligent you are through your use of language; the content of the report should do that.
- Any report long enough to have an introduction section should also have a conclusions section.
- There should be nothing new in the conclusions, and nothing in the introduction which is not described in more detail in the main body of the report.[1]
- If you take any information from anywhere, then provide a reference to your source. Primary sources (datasheets, original research papers) are preferred over secondary sources (review articles, magazine articles), which are in turn preferred over tertiary sources (Wikipedia articles). If possible, reference a printed or archived document, not a webpage.
- All figures and tables should be referred to in the text, and all terms used in equations should be defined.

[1] There is famous quote describing the three parts of a sermon: “first you tell them what you’re going to tell them; then you tell them; then you tell them what you’ve told them”. Reports (and lectures) are similar; it helps the reader if you first prepare them for what they are about to read and summarise the most important points to emphasise them at the end.

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1 Introduction

Technical report writing is an important skill and will stand you in good stead in your future career. It is much more precise than many other forms of writing. A project report is not quite the same thing as a technical report[2], however it should show the same level of care and attention to detail.

This document was written to provide a few pointers about what I look for in a project report, and some tips for writing these documents using both Microsoft Word and LaTeX. It is written in the structure (but not the style) it recommends and contains examples of both good and bad practice. It assumes a reasonable familiarity with the use of word processors (although not at the level of an expert user), and a reasonable grasp of English grammar.

This introduction chapter describes the background and motivation that prompted its writing and outlines the structure of the rest of the document.

(You've now read the first couple of paragraphs of the introduction, and you should now have a good idea about what is in the rest of the document, whether you have the necessary background to be able to understand it and might find it useful, and what's in the rest of this introduction section. All reports should start like this.)

1.1 Background and History

I've been supervising undergraduate projects for over twenty years now, and I find myself constantly giving the same talk to different students. Not only is this getting a bit tedious for me, I find I often forget to mention something and a report then gets handed in at the end which is not as good as it could be. As a result, I decided to put down my thoughts (or at least those of them that I remember as I write this) and distribute this document. Other thoughts will no doubt occur to me later, and this document will be updated as I remember them.

Please note that there is no accepted standard for project reports. Different supervisors will have different opinions and preferences about style; in some cases, this document merely describes my preferences and opinions (I will try to make clear when this happens). Any final-year student reading this document is strongly

[2] At least I don't think it's quite the same thing. This is one of the points on which there is no agreement here: some people may tell you that a project report is a technical report. I'll write more about what I think the differences are later.

advised to discuss report writing with both of their supervisors and attempt to write a document to satisfy both.

1.2 Document Contents

The remainder of this document is arranged as follows: chapter two introduces the basic structure of a project report, and chapter three highlights important grammatical, layout and style issues when writing reports.

Chapter four discusses the important topic of academic misconduct: in the context of project reports this covers plagiarism and the acceptable and unacceptable uses of artificial intelligence (AI).

Chapter five gives advice for using both Microsoft Word and LaTeX for writing project reports, and chapter six describes some common mistakes to avoid. Chapter seven discusses proofreading and checking, and finally conclusions are given in chapter eight.

The appendix contains three examples of short project reports, one excellent (awarded 80%), one average (awarded 60%), and one a marginal fail (awarded 30%), together with a commentary about how they could be improved.

(A section like this, describing what is in the remaining sections of the report, should always be included in the introduction section of a report. It allows the reader to quickly determine whether the document contains the information they are looking for; it can be thought of as an extension of the table of contents, providing more detail about the contents than just the section titles. Conventionally it's the last thing in the introduction.)

2 Report Contents and Structure

There are likely to be detailed specifications in each module outlining what contents are expected in a report. Pay close attention to these, as the marking schemes will most likely be based on these specifications. In particular for group projects, make sure you know how much of the report should be about your own contributions and how much should be a description of the output from the whole team; in the past students have lost a significant number of marks by writing a good report with the wrong contents.

However, some modules may not fully specify the report structure expected; the details may be a list of the minimum contents required, rather than a proposed structure. This section describes a general report structure and some ideas about what to include.

I would recommend that before starting to write, you decide on the structure, and start a document with the appropriate headings. When making this report plan, pay particular attention to the word count. Due to marking deadlines and the increased number of students, the word count for many project reports can be restrictive. You will not be able to write about everything you have done, so you will have to be concise and selective. It's useful to be aware of this right from the start; it can save a lot of time spent editing and condensing content later.

2.1 Structure: What to Include

A typical final-year project report should include:

- a front page
- an executive summary or abstract (but not both)
- - optionally a preface
- an ethics statement
- - possibly a table of contents (not required for short reports)
- - optionally a glossary
- an introduction
- a literature survey or market survey
- some sections describing the work done
- a reflective management section
- a conclusions and further work section
- - possibly acknowledgements
- - possibly a bibliography
- a reference section

- - probably some appendices.

There's no need for version control or a revisions page: a project report will only ever have one published version (this is another difference between project reports and technical reports: technical reports can be updated and new versions released).

Reports written in the first or second year are shorter and may not have room for all of these sections.

A few more thoughts on each of these sections follow.

2.1.1 The Front Page

The front page may not be written as part of the same document, it does not have to be in the same format as the rest of the report. It could be prepared in a different file if necessary and combined with the rest of the document by merging the pdf versions of the front page and report[3]. You're often given specific instructions about the format and content of this page. If you are, stick closely to these instructions; if not then have a look at some other project reports and try and produce something with a clean, professional but eye-catching look.

2.1.2 Executive Summary or Abstract

One or other of these should follow (but not both). An executive summary is never any longer than one page, and often rather less. It is a summary of the report, including the key results. It is written for managers who only have time to read one page: bear this in mind when you are writing it. An abstract is a description of what is in the rest of the document, without necessarily containing any of the key results. It's about 100 words long, usually one paragraph, and acts as an advert for the rest of the report. After reading the abstract, a potential reader should know whether they want to read the rest of the document or not.

There should be nothing in the summary or abstract that is not also described (in more detail) in the main body of the report.

Both executive summaries and abstracts get separated from the main report, so they must be capable of standing alone. That means no references and no cross-references in either.

In most examples of an undergraduate or first-year postgraduate project report, I would suggest that an executive summary is more appropriate. Abstracts are more

[3] Several free “merge PDF” websites exist that can combine PDF files into one document.

appropriate for technical papers from where they are collected in abstracting journals and made searchable on the web; this isn't going to happen here.

2.1.3 Preface

Some reports (notably PhD, MPhil and MSc theses) have a preface at this point. The purpose of the preface is to place the report in context of the degree, and to allow a statement that all the work that has not been attributed to others is your own. This is a requirement for these documents. If the assessment criteria for your module do not specify that this section is required, it is safe to omit.

2.1.4 Ethics Statement

It is a requirement for most modules that the report contains a statement about ethics. If there are no instructions about where to put it, I would suggest just before the table of contents. That makes it easy to find, and it doesn't disturb the structure of the rest of the report.

For many projects there are very few ethical concerns to write about, but a statement saying something like "no ethical concerns have been identified relating the work described in this report" is required nonetheless. (If in doubt about what to write here, consult your module leader or project supervisor.)

2.1.5 Table of Contents

For reports that are more than a few pages long it is always a good idea to include a table of contents (Word and LaTeX can generate them automatically, provided you use the appropriate heading styles for your chapter and section headings), but make sure the table is not too long. For most project reports, more than two pages isn't sensible, it would take too long to find what the user wants to find. Not every sub-sub-sub-heading has to be here: use some discretion. Bear in mind that this is a table in name only: it doesn't need a caption or a number, and it shouldn't have a border.

Both Word and LaTeX can also automatically provide tables of figures and tables of tables as well (and tables of formulas, but that's going too far). You can include them if you like, but personally I don't find them particularly useful, and they increase the amount of scrolling required to get to the introduction.

Individual chapters can have mini-tables of contents themselves[4]; and this can be quite useful if the chapter has a lot of sub-sub-sub-headings that have not been

[4] This is another example of the fractal nature of reports: the same structure at a different scale.

included in the main table of contents. This is a bit awkward to do in Microsoft Word (although it's very easy in LaTeX), so if you're planning to do this, proceed with care.

2.1.6 Glossary

I like these, I find them very useful. Not just for the acronyms, but any terms that you are using to represent a particular technical concept (for example a “method” in OOP) can be included here.

Note that the previous paragraph has a mistake in it. OOP is an acronym, and as such, it should be defined the first time it is used. Having a glossary at the beginning does not eliminate this requirement. So, it should have read "(for example, a “method” in object-oriented programming (OOP))".

2.1.7 Introduction

The introduction has two functions: to introduce the project (why you're doing it, what part of your degree it takes (if you haven’t already said that in the preface) and what the aims were), and to introduce the report (what is coming in the following sections). After reading this, the readers should know what the project is about, why you are doing it, whether they have the necessary background to understand the rest of the report, and know how to find whatever they want in the rest of the report.

Probably the most common fault with introductions is that they go into too much detail, too fast, assume knowledge that the reader doesn’t have, and don’t put the report in context. A useful visual image is that of a cone: the first paragraph of the introduction should be very broad and understandable to “the man in the street” so that everyone can understand how the subject of the report relates to something they are already familiar with. Then the following paragraphs should narrow the focus, explaining what part of the previous paragraph the report is concerned with, and why it is an interesting part of the wider problem. The last paragraph can then introduce the specific subject that the rest of the report will consider.

(Take a look at any article in a broadsheet newspaper to get the idea: the first sentence gives the basic facts of the story at a level that can be understood by everyone, further down the story will come details and language that only specialists in the area might understand. This way the paper can satisfy all their readers with the same article.)

The second most common fault with introductions is when they don’t introduce the document, only the project. They should do both.

2.1.8 Literature Survey or Market Survey

This should be the next section: a literature survey for theoretical projects or a market survey for projects that ask you to build something for production. It's evidence that you have looked at what others have done in the field. As the saying goes "a couple of weeks in the lab can save almost an hour in the library"[5]. If you haven't looked up what others have done before, you are almost certainly not working efficiently.

There are two things to bear in mind while writing a literature survey: firstly, don't just give a list of sources and describe their contents. You will get more credit for comparing and contrasting different source than just for describing them as this requires a higher level of engagement. Secondly, use good, reliable reference sources, avoiding personal blog posts that just give one author's unedited opinion in particular.

2.1.9 Sections Describing the Work

I'll try in this section to give some advice about how to describe work done; this is often one of the hardest sections of the report to structure in an easily readable way. I'll point out the purpose of each paragraph in square brackets at the end. [Hypothesis/Purpose]

For a project report, I've found these are best written chronologically, telling the story of how you got to wherever you did and what steps (and blind alleys) you went along to get there; this is the easiest way to impose a structure on the document. Of critical importance are the reasons why you made any decisions (if you don't write these in the report, you are sure to be asked about them in any potential viva). [Previous experience]

If the project has different strands (e.g. if software and hardware were developed essentially independently), then these can be separated in different sections; otherwise I'd suggest writing them in terms of the phases of the project: planning, implementing and testing, perhaps; or whatever else seems appropriate. Each section, and each subsection of a report can be divided along similar lines; this section of this report included. Of course, not all of the sections mentioned here will be relevant to every part of your report, but you might like to think about them, or use them as a structure. When reporting on an actual experiment, I would expect to see all of them. [Experiment design]

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[5] Although that saying is a bit out-of-date. Perhaps it should now be "a couple of days in the library can save almost five minutes with Elicit".

For each section, it is often useful to consider exactly what you are trying to say. A lot of the time you can use the structure:

1. Hypothesis/Purpose. First, state what you are trying to do or trying to find out, as clearly as possible.

2. Previous experience. Describe relevant information from the literature review, advice gained, and any other relevant facts.

3. Experiment design. State how you designed the experiment and any simulations, including what results would be considered to confirm the hypothesis, and what results would be expected to reject it (with supporting maths if appropriate).

4. Experiment execution. What happened when you tried to run the experiment, what went wrong, what unexpected things happened (if any).

5. Experiment results. Was the hypothesis confirmed or rejected?

6. Conclusions. Including what you would have done better.

[Experiment execution]

I've tried to divide this section of this report along the lines it describes. It's not a perfect fit, since I am not describing an experiment here and I have no results to discuss. Nonetheless, I hope you can see how this section is structured. It's useful to consider the structure of every document, and every section of a document, along these lines. It really does help the reader if there is a logical flow of ideas, rather than a whole series of facts and observations in no particular order (or at least not in an order that is clearly stated at the beginning).

Of course, there are also parallels between the hypothesis/purpose to an experiment and the introduction to the whole report; and between the previous experience described in this subsection and the report's literature review. This is an example of the golden rule that good reports are like fractals: no matter on what scale look you should be able to find the same structure. [Conclusions]

2.1.10 Management

Unlike projects in industry, academics don't really 'manage' your projects; we don't have time. We just supervise them. You will have to manage yourself, in the sense of setting milestones, budgets and monitoring progress. In your report, you will almost certainly be asked to include a management section including a breakdown of what you spent most of your time doing, how you planned your time, whether

your original time-plan was followed, and if not, why not. If you are not explicitly asked for this section, it is usually a good idea to add it anyway.

This is where any project planning documentation (e.g. Gantt chart) is included. There is a common problem with Gantt charts in reports: they are often shrunk so much to fit onto the page that they become illegible. You won't get much credit for an illegible chart, so try and create hierarchical charts, or split up the chart into multiple charts each covering a short period of the whole report.

2.1.11 Reflection

This is a comparatively recent addition to the requirements of a project report. You are asked to reflect on your experiences of doing the project. In this section you should try and answer the questions:

- What would I do differently if I were to do the project again?
- Why did I not do these things the first time?

There are several tools you can use to inform your discussions. One is the Belbin Team Roles framework, another is your own employability goals. The module assessment specification may specifically require you to consider these frameworks in your writing; if they do, make sure you do include them, as there will be marks assigned to this task.

The key thing in writing a good reflection section is to always ask yourself "why" and don't be afraid to propose theories even if you only have your own personal feelings to support them. "I didn't contribute much to the meetings because I am a quiet person and get overwhelmed easily" is fine, and exactly the sort of thing we are looking for here. It would be even better to continue and consider whether this is a theme in your professional life, and what strategies you might use to improve your performance in future.

This is the one section in the report which must always be written in the first-person singular, active voice. It's all about the thoughts that are going on inside your head.

2.1.12 Conclusions and Further Work

This is always one of the most interesting chapters to read (anyone short of time will tend to read the introduction and this chapter first). A couple of rules about conclusions: they should always follow logically from the rest of the work, and they must never reference any material not already included elsewhere. There should be no new information contained in this chapter; it is just a summary of what has been stated before, and what can be logically deduced from it.

The only exception to this is in the "ideas for further work" section. This is the only content in this section that can be new to the reader. (If there are a lot of ideas for further work, this could be separate chapter, coming just before the conclusions.)

2.1.13 Acknowledgements

It's always nice to thank people that have helped you. (This section can also be placed right at the start of the report.)

2.1.14 Bibliography / Further Reading

Technically, a bibliography is a list of all of the sources that you've found useful for background information whether you have cited them or not. References are only those sources which you have cited in your text.

There is a requirement in every project report for a reference list (which lists only those sources you have cited in the text), but providing a more extensive list of documents is not required. Should you wish to draw the reader's attention to any sources of information which you have not directly quoted, or taken any specific piece of information from, then one way is to have a separate "further reading" section just before the references. There should be no citations in the text pointing to a particular document in this list.

Conventionally, further reading sections (and references sections) don't have chapter numbers.

2.1.15 References

A reference is a source from which you have taken a specific piece of information that you have used in your work. Unless your work is completely original (highly unlikely), you should have some references. The golden rule about references is that they should contain enough information for the reader to easily find the original sources without using a search engine. For a technical paper this means name of author(s), title of paper, journal or magazine title, date of publication, volume number and page references; for a book this means name of author(s), title of book, edition, date of publication and publisher. For a web-site, just the URL and the date you accessed it might be all you have, although most web-pages have titles, and if you know the name of the author then include that as well.

All academic publishers have their own set of (very strict) guidelines about the format of references. Unfortunately, they do not agree: the IEEE style is not the same as the IET style, and the Kluwer style differs again. The important thing is to be consistent. For electronics reports you could do worse than adopt the IEEE style [1], and if your assessment specification does not specify the use of a different style,

this is the one that I would recommend you adopt. In this style, details as the titles of books of papers, conference proceedings or journals are placed in italics, and the authors' initials and surname precede the title. Book titles are followed by the edition number, publishers and publication year; journal titles by the volume, page numbers and date.

You can ask ChatGPT to format references in the style of your choice. It's quite good at it, but do check the output carefully.

Some examples of references in an acceptable and consistent style follow:

[1] M. Shell (2015, Aug. 19), *LaTeX class file for IEEE publications*, ctan.org [Online]. Available: http://www.ctan.org/tex-archive/macros/latex/contrib/IEEEtran/IEEEtran.cls [Accessed: 17th September 2017].

[2] B. Crow, I. Widjaja, J. Kim, P. Sakai, "IEEE 802.11 Wireless Local Area Networks", *IEEE Communications Magazine*, Vol. 35, no. 9, September 1997.

[3] European Telecommunications Standards Institute, "Digital Video Broadcasting (DVB): Implementation guidelines for DVB terrestrial services; transmission aspects," European Telecommunications Standards Institute, ETSI TR-101-190, 1997. [Online]. Available: http://www.etsi.org. [Accessed: Aug. 17, 1998].

[4] J.G. Proakis, *Digital Communications*, 4th edition, McGraw-Hill, September 2004, pp. 123-125

Web-pages are usually not good references for two reasons: firstly, many web-pages are not peer-reviewed and have not been edited for accuracy so the information is not reliable; and secondly web-pages can change at any time, and anyone looking at your reference might not see the same thing that you saw. At the very least, the reference should have information about when you viewed the page.

Wikipedia is (sometimes) an exception: some articles are read (and corrected) by a large number of knowledgeable people, and this results in some information about technical subjects being quite good (although there are some exceptions). There are two golden rules for using Wikipedia as a reference source: always read the "talk" pages so you are aware of any controversy and can check whether anyone else has reviewed the article; and reference the actual version of the web-page you are reading (Wikipedia helpfully keeps a historical record of all previous versions of articles). This is easy to do: in the "Tools" list on the left-margin menu, select the "Cite this page" menu item, then choose whichever version fits into the referencing style you have chosen (Chicago is a good one to start with for engineering articles,

although you will need to modify the formatting slightly to use the IEEE style). You should end up with something like this:

[5] Wikipedia contributors (2024, Jul. 21). *Reference*. Wikipedia, The Free Encyclopaedia [Online]. Available: https://en.wikipedia.org/w/index.php?title=Reference&oldid=1235800587 [Accessed: July 25, 2024].

At this point, I should add that most academics don't encourage people to use Wikipedia (or any other encyclopaedia) as a reference source, since it is not the original source of any information: anything in Wikipedia has been taken from other publications available elsewhere, and there may have been an error in the process.

It's much better to go to the original sources of the information (the 'primary sources') and read and reference them. However, Wikipedia is often a good place to start, and there are often a good set of references at the end of the articles that are worth looking up and reading.

2.1.16 Appendices

Appendices should contain anything that isn't essential for reading the report, but the reader might find useful. I can think of a few possibilities for suitable contents in project reports:

- software code listings
- introductions to subjects that some readers will need, but others won't (for example OOP)
- a set of circuit diagrams (preferably drawn in a suitable computer-aided design (CAD) package
- raw test-result in list or graphical form which are analysed and discussed in the main body of the report.

Again, the rule is that they should not be essential content: the reader should be able to read and understand the entire document without having to look at the appendices.

(It is very frustrating, when reading a document, to have to continually flip over to the appendices and back when reading the text. It's even more annoying if you are reading such a document electronically, and have to keep scrolling back and forth.)

Appendices do not share the same numbering scheme as chapters. If there is only one appendix it can just be called "Appendix", otherwise the first appendix is usually "Appendix A", the second "Appendix B", etc; whereas chapters are more conventionally numbered.

Appendices can cite references, but these references should be included in the main references section (so uniquely, the references in this case come before the citations).

3 Grammar, Formats and Writing Styles

While the requirements on issues such as formality and objectivity vary between the different types of document you will be asked to write, all of your writing should pay close attention to the rules of grammar.

Good grammar is important: it shows that you care about your outputs, and that lends a professionalism and credibility to your work. On the other hand, if your writing is chaotic or error-ridden, then people will instantly draw conclusions about the quality of your engineering, and a careless engineer isn't much use to anyone: just overlooking a single detail in a new design can mean the whole product is useless, or at worst dangerous.

This section discusses some of the most common grammatical and formatting issues I have found through reading hundreds of reports: spelling, basic grammar, sentence and paragraph construction, tenses, acronyms, use of the first person and passive voice, font selection, etc.

3.1 Spelling and Grammar

Many people have problems with producing correct spelling and grammar. Although we can make allowances for specific requirements (e.g. work with a yellow sticker will not have marks removed for spelling and grammar errors providing that it is readable) it is still important to acknowledge that a professional end product needs to be well written, well-formatted, and have good grammar and spelling. If this is a problem for you, do whatever you can to produce that professional-looking product (e.g. taking extra time to proofread your work; making extensive use of spelling and grammar checkers; seeking help from the University Writing and Language Skills Centre etc.).

Automatic grammar and spelling checkers have been getting much better over the last few years, so there is now no excuse for confusing "it's" and "its", or "who's" and "whose". (Although you shouldn't be using contractions such as "it's" or "who's" in a formal report anyway – see later in this section.)

Microsoft Word does a reasonable job, but there are many other sources of advice for spelling and grammar, including tools such as Grammarly (https://www.grammarly.com/). Grammarly is available as a plug-in to Microsoft Word and Chrome and can offer advice as you write. I would recommend that you at least try this (or a similar system): the basic system is free, and getting quick feedback and suggestions on improving your grammar can help improve your style.

You can also use AI systems such as ChatGPT to offer suggestions on your writing (see section 4.2 for more details about the acceptable uses of AI).

Run these checks frequently, especially when you start writing, and you may find it trains you to be a better writer, which saves time in the long run.

While there is no requirement to act on all of the suggestions given, it is important to be aware of the issues so that you can be consistent. (For example, Grammarly usually recommends the Oxford comma[6] which is optional in many cases).

(If you do use a tool such as Word's spellchecker or Grammarly, make sure you set the language to "British English", otherwise you may be penalised for spelling words such as "colour", "signalling", "analyse" and "practise" incorrectly.)

3.1.1 Some Frequent Mistakes

Even the best grammar and spelling checker can miss some problems, and of course writing is much faster if you don't make the mistakes in the first place. A list of some of the most common problems I come across follows; please make sure you are aware of these issues.

- "it's" (with an apostrophe) is short for "it is" or "it has". "its" (without an apostrophe) means "pertaining to it". It's important to get this right, otherwise a document loses its credibility.
- "dependent" is an adjective, it means something that relies on something else; "dependant" is a noun, referring to your children or aged relatives.
- Hyphens separate parts of compound words (e.g. brick-red), and there is no space between the words and the hyphen. If you put space around a hyphen (e.g. brick - red), it becomes a dash. Dashes have a similar use to colons: they separate related phrases in the same sentence. Do not confuse the two.
- "effect" and "affect". Both can be nouns and adjectives (so even grammar checkers have trouble with these words), but unless you're a political journalist you are unlikely to use effect as a verb; and unless you're a

[6] An Oxford comma is a comma after the penultimate item in a list before the final 'and'. For example, in the sentence "here are some photographs of my parents, Taylor Swift, and the Pope" the comma after "Swift" is an Oxford comma. The use of this comma is optional in many cases, but as always it is important to be consistent. In general, I would recommend its use, since it can prevent ambiguity. (If it were not present in the previous example, the reader could be left thinking that the photographs in question showed only two people, and that the author had very unusual parentage.)

psychologist, you're unlikely to use affect as a noun. I'm hoping to affect your report writing skills and have an effect on your final mark.

- "principal" is usually an adjective (although can also be a noun, especially in the US) referring to something highest in rank or importance; "principle" is a noun referring to a law. "The principle of superposition was demonstrated by the principal engineer."
- "Discrete" means composed of individual separate parts (a discrete waveform); "discreet" means modest, or unobtrusive. A "discreet waveform" is one that doesn't draw attention to itself: a rather charming, if useless, concept.
- "Compliment" means something nice someone said about you. "Complement" means something that makes something complete. I gave a compliment to the complement of students on my course.
- Every sentence must have a verb in it.
- In formal documents, try to avoid starting sentences with "so", "and", "but", "therefore", "moreover" or "however". These words are used to link two concepts or ideas; putting both concepts in the same sentence (perhaps with a semi-colon) helps establish this link.
- (If an entire sentence is enclosed within brackets, the full stop comes within the brackets.) Otherwise, if a sentence starts before the open bracket, the full stop comes after the closing bracket (like this).
- Semi-colons. There are many times when they are useful: separating items in lists; separating items in a sentence that have their own internal commas; joining two complete sentences with very closely related contents.
- Colons mean "OK reader, here it comes", and must follow what, up to the colon, has been a complete sentence. You need many things to write a successful project report: a good writing style; a good report structure; and something interesting to say.
- It's acceptable to occasionally split an infinitive[7] when the alternative would be cumbersome.

[7] A split infinitive occurs when an adverb is placed between the "to" and the base form of the verb in an infinitive. For example, "to occasionally split" is a split infinitive, as is perhaps the most famous split infinitive "to boldly go". Some strict grammarians forbid the use of split infinitives.

- kHz, please, not KHz or khz ; similarly for MHz. It's always entertaining to read about processors running at 20 mHz[8], but it doesn't get many marks. You might have to convince Word not to automatically 'correct' these for you; this can be done in the Tools/Auto-correct window.
- I prefer the convention that there is a space between the number and the units "3.4 kHz", not "3.4kHz", but this is a matter of taste. The important thing is to be consistent. The problem with this comes when you get to the end of a line end up with the 3 on one line and the kHz on the next. This looks inelegant. There's an easy way round this if using Word: don't use a normal space between the 3 and the kHz, use a Ctrl-Shift-Space. Word won't break a line on a Ctrl-Shift-Space. (The same is true for Ctrl-Shift-hyphens, Word won't split a line on those, even though they otherwise look exactly like a normal hyphen.)
- Fewer people, less noise. If you can count them, use "fewer". If you can't, use "less". Whoever wrote the notice "eight items or less" sometimes found at supermarket checkouts is clearly illiterate.
- License is a verb, licence is a noun. The magistrate granted a licence, licensing the licensee.

3.1.2 Numbers

There is a rule of thumb that says "spell out the number in letters (e.g. "three" not "3") if you can do so without using a hyphen, otherwise use digits (e.g. "27" not "twenty-seven"). It's just a guideline, but it does seem to make sentences flow more easily.

But again, the most important thing is to be consistent. Whatever you do, don't write something like "there are three resistors and 4 capacitors in the circuit".

3.1.3 Tenses

When writing a project report, you should stick to the simple past tense when describing what you did, and the present tense when describing your output, or simple facts (for example information taken from datasheets). The future tense should only ever be used in the "Future Work" section (if there is one).

For example, a sentence such as "this report will describe the construction of the widget" in an introduction is not correct. The report in question will not, at some

[8] In other words, one cycle every fifty seconds.

future time, suddenly start describing the construction; it does that right now. So, use the present tense: "this report describes the construction of the widget".

Another example: "the resistor chosen had a value of 10k". This is mostly likely the incorrect tense as well, as the resistor will probably still have a value of 10k, it's not something it only had in the past. However, the present tense: "the resistor chosen has a value of 10k" is awkward, as the two tenses of "chosen" and "has" collide. The problem can be avoided by rephrasing ("a 10k resistor was chosen") or by use of the active voice ("I chose a 10k resistor").

3.1.4 Contractions, Colloquialisms, Abbreviations and Acronyms

A contraction is when two words are combined into one, with an apostrophe indicating any missing letters. For example: "isn't" (rather than "is not") and "couldn't" (rather than "could not"). If you are writing in any sort of formal style (e.g. a project report) then they are best avoided.

(Please note that "its" means "belonging or pertaining to it" and does not have an apostrophe. "It's" is a contraction of "it is" or "it has". Getting this wrong is a very common error.)

A related issue is the use of colloquialisms. Colloquialism is the use of informal language that you might use when speaking, but not when your writing is intended to be read in a formal context. For example, instead of "amazingly, it worked" try "against expectations, the circuit operated as intended", and avoid adjectives with no well-defined objective meaning such as "tiny" or "huge".

(You may have noticed that I use these subjective adjectives quite often in this document. I just did it again with "quite often" in the previous sentence. This is because this is not a project report: it's a document providing advice, and it's written in a lighter, more colloquial style to make it easier to read.)

Commonly used abbreviations (such as "i.e." for "id est", "Fig." for "Figure") are fine to use, provided you use them consistently.

The golden rule with acronyms is that they should always be defined when you first use them in the text. Collecting them together into a glossary at the start of the report does not remove this requirement. Another common issue when using acronyms is the appearance of the grocer's apostrophe[9] in the plural. The plural of "LED" is "LEDs" not "LED's".

[9] A grocer's apostrophe is an apostrophe that incorrectly appears in plurals, e.g. "Carrot's £1"). In the extreme form it can imply words that do not exist, for example "potatoe's".

I have given up trying to convince people that LED is not an acronym[10].

3.1.5 Use of the First and Second Person

There are occasions (e.g. a datasheet or a formal technical report) in which the use of the first person is never appropriate. These are documents in which the reader is not interested in who did what or on any opinions, thoughts or ideas, just in the objective, verifiable facts. It doesn't matter who the author is, the content would not change. When writing these documents, you should never find yourself asking "should I be using the first person", since your thoughts, opinions or actions are not relevant.

This is also true for individual sentences and paragraphs in other styles of writing. Always consider what your reader is likely to be most interested in, and try and make that the subject of the sentence. In most cases, this will not be you.

For example, consider the following paragraph:

"I decided to use iOS for my app because I have an iPhone. So, I looked into the compilers available and I found that the most common was Xcode so I chose that for the development of my synthesiser code."

This is poor style, since the first person is being overused (this is a common problem in many project reports) and the phrase structure is repetitive.

To improve this: in the first sentence the reader is more interested in what you have chosen, rather than the fact that it was you who chose it (which is usually obvious from context). In this case, the passive voice can be helpful so that the most important thing in the sentence comes at the start. However, the reason that iOS was chosen is because of something particular about you, so the first person is appropriate here. The result is:

"iOS was chosen for the app because I have an iPhone."

Never start a sentence in any type of formal writing with "So…" (it is too colloquial). Also, the first part of the second sentence is redundant, since if you have found something out about compilers, then you must have looked into them. The fact that Xcode is the most common compiler is an objective fact (which should be

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[10] It isn't an acronym; it's an initialism. An acronym is pronounced as if it was a word, not as a series of initials. So, ASCII and NASA are acronyms, but CIA and FBI are not. If LED was pronounced the same as the metal lead, then it would be an acronym. But it isn't; it's pronounced "el-ee-dee".

referenced), and if the object of the phrase is to state this objective fact, then you are not relevant in the phrase. So, the second sentence could become:

“Xcode is the most common compiler [12], so I chose that for the development of my synthesiser code."

You could improve this still further by noting that this sentence now contains two active clauses with different subjects. This requires the use of the word “that” to refer back to Xcode. This is inelegant, and a possible source of confusion, as the reader has to pause to work out what “that” refers to. This problem could be solved by writing the second clause using the passive voice which would avoid the need for the extra pronoun. This results in:

“iOS was chosen for the app, since I have an iPhone. Xcode is the most common compiler [12] and was therefore chosen for the development of my synthesiser code.”

Never use the “royal we” (in other words, don’t refer to yourself in the plural). This is sometimes done in single-author journal articles, where the implication is that the author has been working as part of a team, but it is not good style.

The only occasions in which the use of the second person (“you”) is appropriate in technical writing is if someone is being quoted, or you are trying to give advice (which is rare in an assessment). Otherwise, the reader should never be addressed as “you”.

(You may note that I use “you” frequently in this document. This is because the primary function of this document is to give advice. You will likewise often find the second person used in application notes, which have the same function.)

3.1.6 The Passive Voice

Sentences can be written in either the active voice (where the subject of the verb comes before the verb, e.g. “the cat sat on the mat”) or the passive voice (where the subject of the verb comes after the verb, e.g. “the mat was sat on by the cat”). In most cases, the active voice is preferred, as it is more direct and easier to read.

However, there are four cases where the passive voice can be helpful. The first case is when the object of the verb in the sentence is closer to the current focus of the reader’s attention. (We have just seen one example of this in the sentence about the Xcode compiler above.)

Another example: after discussing an experiment, it would be better to write “the results are shown in Figure 3” (passive) rather than “Figure 3 shows the results”

(active) because at this point the reader will be expecting to hear about the results, not have their attention diverted to a figure they haven't come across yet.

On the other hand, "Figure 2 shows the experimental set-up; Figure 3 shows the results" would be fine, since this is sentence about the figures, and the reader will be expecting to hear about Figure 3 after reading about Figure 2. (This is another application of the rule "don't surprise the reader".)

The second case is where you want to focus the reader's attention on the object of the verb rather than on the subject. For example, "the circuit was damaged by an electromagnetic pulse" (passive). If the report is about the development of the circuit, then it's the circuit that is the most important thing here, rather than the electromagnetic pulse that caused the damage.

The third case is when you lack information about the subject. In this case the passive voice allows you to avoid having a subject in the sentence. For example, if you don't know who cut a wire, you could write "the wire was cut" rather than "someone cut the wire" which sounds weak and uncertain.

The fourth case is to provide variety in your writing where the subjects of a series of consecutive sentences are the same. It's tedious for the reader to read something like "I looked on-line for a suitable component, and I found the Acme widget. I ordered one, and when it arrived, I fitted it to the circuit. I switched it on, and it exploded." It's repetitive, and monotonous. Putting some of these phrases into the passive voice when the focus of the reader's attention is on the widget would add variety and interest to your writing.

The passive voice should not be used solely to avoid the use of a first-person subject. "I selected a 10k resistor" is better than "a 10k resistor was selected", since it is easier to read and contains more useful information: it tells the reader who performed the action.

3.2 Headings, Fonts and Layouts

To produce a professional-looking report, you should pay particular attention to the format and consistency of headings, the choice of fonts, and the layout of the paragraphs and pages. This section highlights the key points to consider.

3.2.1 Headings

Use hierarchical headings in which the font, font size and style clearly differentiate between different heading levels.

Never have one heading immediately following another heading. This is a sign of a missing introduction to the section. (This introduction should inform the reader what the section is about, so they can decide whether to read it or skip over it. Sections and subsections should have introductions in much the same way that the entire document should have an introduction. This is an example of the rule that reports should be structured like fractals.)

A numbered section should never contain only a bulleted list, or only a figure, or only a table. There should be at least one sentence introducing the content in the section.

Multi-level lists (with automatically numbered sections) are a very good way to keep your writing organised and allow a table of contents to be produced automatically. (If you don't know how to produce a table of contents automatically using your chosen word processor, look it up. It saves a lot of time, especially when you want to change the structure.)

It is rare for more than four levels of headings to be appropriate. More levels than this should be used sparingly.

3.2.2 Fonts

There is a lot of research and controversy about the optimum choice of fonts for report writing. In general, the consensus seems to be in favour of serif[11] fonts for printed text, but sans-serif fonts for reading on screens. Given that project reports can be either, this presents the author with a problem. There is also some evidence that dyslexic readers prefer sans-serif fonts while non-dyslexic readers prefer serif fonts for printed documents, making font choice an accessibility issue.

At present there is no clear policy on fonts in the department, so you are free to select a font scheme. This document is written in Cambria, with headings in Calibri; both are good modern fonts. Please avoid unusual or quirky fonts, and do not use Comic Sans under any circumstances.

Without doubt, the most common problem I find with font selection when reading project reports is consistency. If you are not consistent with your font choice, then

[11] A serif is a small line attached to the end of larger stroke in a letter. This can create the sense of a line along the bottom of a line of text, which some people claim makes it easier for the eye to quickly scan along a line. The text in this document is written in Cambria, which has serifs. The section headings are in Calibri, which is a sans-serif font (in other words it does not have serifs).

your document will stand out as being unprofessional. Pick a font (or two, one for text and one for headings) and stick to them.

The instructions for the report you are writing may specify the font size to be used, but if not, use a minimum font size of 11 pt in all writing in the main document (footnotes can be 10 pt).

3.2.3 Layouts

Some golden rules about layouts:

- Be consistent with spaces between items.
- Try not to have large white space at the bottom of a page (except at the end of a section). If you have to move where some figures and tables appear in the text to remove these spaces, then do so.
- Either put some space between paragraphs (it doesn't have to be a complete line) or indent the first line in every paragraph. Don't do both and be consistent throughout your document. (Failing to do either makes it difficult to know when a new paragraph starts.)
- In any form of writing intended for reading from a printed copy, add page numbers in a footer at the bottom of the page. The header at the top of the page should contain information that helps the reader know what document they are reading; you can also include the title of the current section (although that takes a little more time to set up).

3.3 Paragraph and Sentence Construction

The usual rule of thumb is "one idea per sentence, three to five linked sentences on a single theme per paragraph". The first sentence in a paragraph should introduce the theme of the paragraph, the next sentences should develop it, and where possible the last sentence should provide a hint about the theme of the next paragraph (another case of the "don't surprise the reader" rule).

Another rule of thumb: if you cannot easily read a sentence out loud without taking a breath in the middle, then the sentence is too long. You risk your readers forgetting how the sentence started before they get to the end.

As with all rules of thumb these are just guidelines; but if you find yourself consistently breaking the guideline in a formal report then there's likely to be something amiss.

4 Plagiarism and the Use of AI

This could well be the most important section in this document. Academic misconduct carries strict penalties: get something wrong just once, and you could lose 10% of the project mark instantly for cheating. Get something wrong a second time, and the result could be a mark of zero, or even result in failing your degree.

The two forms of academic misconduct it is essential to avoid are plagiarism and unacceptable use of artificial intelligence (AI) and in particular large language models such as ChatGPT. (AI systems can be incredibly useful, so it is vital to know what you are, and are not, allowed to do.)

In both cases the underlying principle is that it is fine to use tools to help your work, but you should never take credit for work that you have not done, whether it has actually been done by another human being or an AI system.

4.1 Plagiarism

Plagiarism is becoming an increasingly important subject as more and more cases of people copying sections from books, notes and webpages into their reports are discovered.

The rules are simple. You can include any material you like from anywhere (up to the maximum amount permitted by copyright law – usually about a page) provided it is correctly attributed and referenced. If you didn't write a sentence, then it should be enclosed in quotes, and referenced. If you didn't derive an equation yourself, it should be referenced to the place you took it from. If you didn't draw a diagram, then it should be referenced (usually at the end of the caption). See the examples below. Do this for every figure and every quotation that you take from the web.

Failure to do this will result in heavy penalties, and could, in theory, result in you being thrown out of the University for cheating.

The most common thing students get wrong is in the attribution of figures. If you did not draw a figure yourself, then it needs to be obvious where it came from. Just adding a citation to the source document is not enough. For example, consider the following figure:

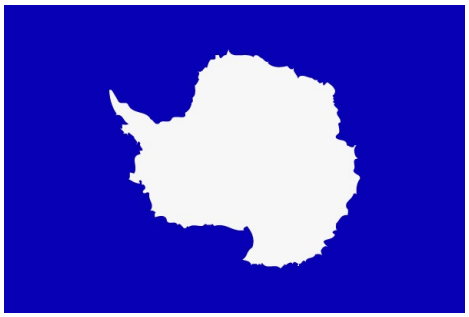

Figure 4-1 – The proposed flag of Antarctica (taken from http://sunsite.tus.ac.jp/multimedia/pics/flags/antartica.gif)

is fine. Alternatively, so you could use:

Figure 4-2 – The flag of Antarctica (taken from [2])

but this is not acceptable:

Figure 4-3 – The flag of Antarctica [2]

since this would mean that you had drawn the figure yourself from the information contained in the cited reference.

4.1.1 Plagiarism in Indiana

I found a useful example from America, which I've taken from the web-pages of the University of Indiana, and reproduce here in its entirety [3].

"Here's the ORIGINAL text, from page 1 of *Lizzie Borden: A Case Book of Family and Crime in the 1890s* by Joyce Williams et al.:

The rise of industry, the growth of cities, and the expansion of the population were the three great developments of late nineteenth century American history. As new, larger, steam-powered factories became a feature of the American landscape in the East, they transformed farm hands into industrial laborers, and provided jobs for a rising tide of immigrants. With industry came urbanization the growth of large cities (like Fall River, Massachusetts, where the Bordens lived) which became the centers of production as well as of commerce and trade.

Here's an UNACCEPTABLE paraphrase that is **plagiarism:**

```
The increase of industry, the growth of cities, and the explosion of the
population were three large factors of nineteenth century America.  As
steam-driven companies became more visible in the eastern part of the
country, they changed farm hands into factory workers and provided jobs
```

for the large wave of immigrants. With industry came the growth of large cities like Fall River where the Bordens lived which turned into centers of commerce and trade as well as production.

What makes this passage plagiarism? The preceding passage is considered plagiarism for two reasons:

- the writer has only changed around a few words and phrases, or changed the order of the original's sentences.
- the writer has failed to cite a source for any of the ideas or facts.

If you do either or both of these things, you are plagiarizing.

NOTE: This paragraph is also problematic because it changes the sense of several sentences (for example, "steam-driven companies" in sentence two misses the original's emphasis on factories).

Here's an ACCEPTABLE paraphrase:

Fall River, where the Borden family lived, was typical of northeastern industrial cities of the nineteenth century. Steam-powered production had shifted labor from agriculture to manufacturing, and as immigrants arrived in the US, they found work in these new factories. As a result, populations grew, and large urban areas arose. Fall River was one of these manufacturing and commercial centers (Williams 1).

Why is this passage acceptable?

This is acceptable paraphrasing because the writer:

- accurately relays the information in the original uses her own words.
- lets her reader know the source of her information.

Here's an example of quotation and paraphrase used together, which is also ACCEPTABLE:

Fall River, where the Borden family lived, was typical of northeastern industrial cities of the nineteenth century. As steam-powered production shifted labor from agriculture to manufacturing, the demand for workers "transformed farm hands into industrial laborers," and created jobs for immigrants. In turn, growing populations increased the size of urban areas. Fall River was one of these hubs "which became the centers of production as well as of commerce and trade" (Williams 1).

Why is this passage acceptable?

This is acceptable paraphrasing because the writer:

- records the information in the original passage accurately.
- gives credit for the ideas in this passage.
- indicated which part is taken directly from her source by putting the passage in quotation marks and citing the page number.

Note that if the writer had used these phrases or sentences in her own paper without putting quotation marks around them, she would be PLAGIARIZING. Using another person's phrases or sentences without putting quotation marks around them is considered plagiarism EVEN IF THE WRITER CITES IN HER OWN TEXT THE SOURCE OF THE PHRASES OR SENTENCES SHE HAS QUOTED."

Not only is that an excellent description of plagiarism with some very useful examples, but it's fine to include here, because I've said, right at the start, that I've taken the whole thing from the web, I've put the whole thing in quotation marks so the reader knows exactly where the quote ends and my own words start again, and I've referenced it. If I had failed to do any of these things, I could be heavily penalised.

Note that as it is such a long quote, I have also added horizontal lines to make it absolutely clear where the quote starts and stops. You will rarely need to do this, as you would be well advised to maximise how much of your report you personally write. You will not gain many marks by just cutting-and-pasting other people's words.

4.2 Acceptable and Unacceptable use of AI

This is a rapidly developing subject at present. Universities have still to find the optimum balance between the advantages or using these tools, and the problems they cause. At time of writing, most university's policies are based on the concept of "false authorship". "False authorship" refers to the idea that the AI system, rather than you, is in some sense the author of the work that you submit.

In summary, the current regulations suggest that you can use AI for:

- Making suggestions for content you can include in your report
- Providing explanations of concepts that you are having difficulty in understanding

- Suggesting how to rephrase portions of text that you have already written to improve the grammar and legibility

But, you cannot use AI for:

- Writing sections of your report from scratch
- Rewriting sections of your report which you then simply cut-and-paste into your final report
- Translating your report from a different language into English

Note that the dividing line between acceptable and unacceptable can be somewhat hazy. The advice is therefore not to take any risks and be cautious in the use of AI.

Remember all AI systems can make mistakes; they are trained on vast amounts of information, but cannot critically think about what they produce. They therefore tend to repeat commonly-held misconceptions and widespread factual inaccuracies. It is your responsibility as the author to ensure that everything you write is correct. So, you do need to check everything they come up with.

4.3 Elicit

By far the best-known AI system for writing and editing is ChatGPT, but there is another system that it is very useful to know about: Elicit (https://elicit.com/). Elicit searches the published academic literature, finds relevant papers and summarises their content; this is exactly what is required for completing a literature review at the start of a project report. You just give it a research question, and it produces a short literature review.

This is very helpful in two respects: it identifies some useful sources and references for your work, and it gives an example of what a literature review should look like. What you can't use it for is producing text that you directly use in your report (that would be "false authorship").

With any review produced by Elicit, it's always recommended to read the actual papers that Elicit identifies as relevant. For each one, ask yourself "if I had come across this paper, would I include it in my report?" and if the answer is no, then you should not use it. If there is a viva or interview (which may occur in cases where academic misconduct is suspected) you may be asked to describe the contents of any paper that you have referenced in your literature review and explain why you have included it. Inability to do this could be interpreted as evidence of "false authorship".

5 Report Formatting

Most students write their project reports in either Microsoft Word or LaTeX. Both word processors have their advantages and disadvantages. This section contains a brief overview of the differences between these very different systems and some advice for preparing reports in whichever system you choose.

There are two big advantages of using Microsoft Word: it is very easy to configure the appearance of the documents with menus to access the options, and it is a "what you see is what you get" (WYSIWYG) system, so you can see the results of any changes you make instantly.

Preparing a LaTeX document is more like writing a program. You have to know the language and the commands for any text formatting, equations or figures that you want to use. Once you have completed the "program", it is then compiled into a professionally-formatted document. It is a much steeper learning curve, but there are fewer bugs.

5.1 Working in Microsoft Word

Most people will be familiar with Microsoft Word already, so I won't spend much time writing about the basic operation of the program. What I will discuss is those things that, in my experience, a lot of people get wrong (or simply don't know how to use): numbering sections, adding captions and equations, referencing, and headers and footers.

5.1.1 Section Numbering

Any technical or project report should have its sections and subsections numbered. This makes it easy to refer to a particular point in a document (e.g. "as discussed in section 5.1.1…") and easy for the reader to find what they are looking for. In Word this is done using an appropriate style file using a "Multilevel List". This can be selected from the "Paragraph" section of the "Home" menu tab (see Figure 5-1).

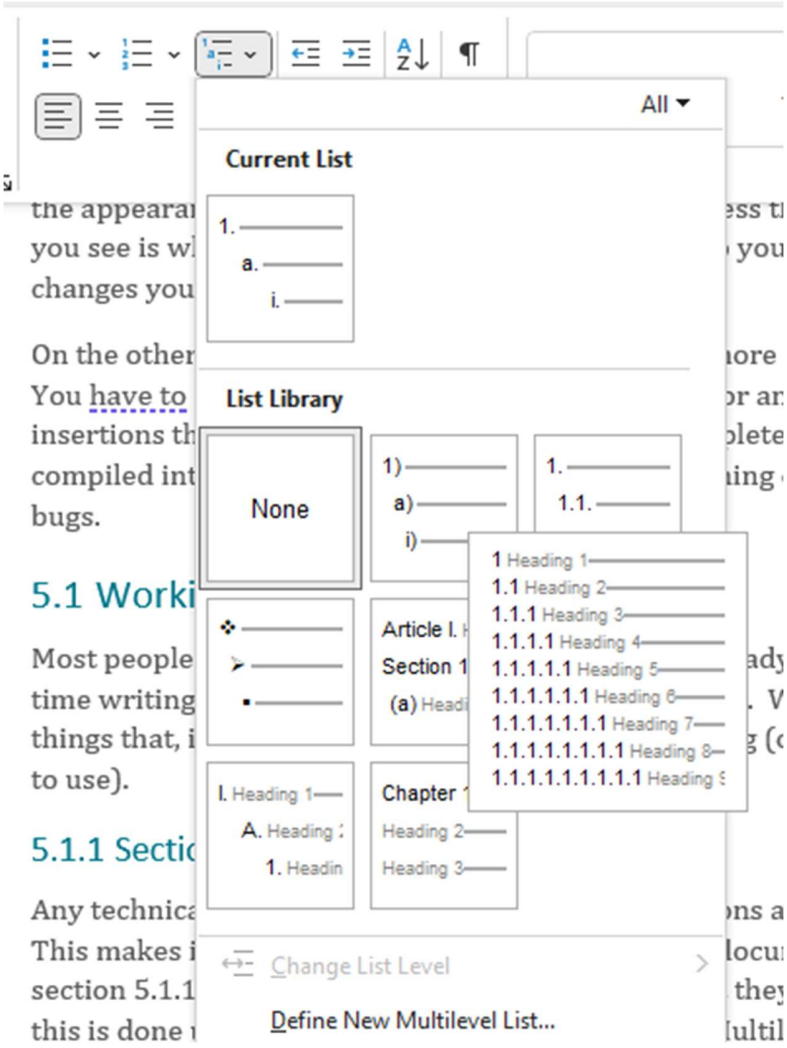

Figure 5-1 Selecting a multilevel list in Word

With an appropriate multilevel list format (the highlighted one is a good choice), all you should need to do is choose the format you want for your headings. This is done using the Styles gallery. Just right-click on the style in the gallery and select "Modify…" (see Figure 5-2), then change the font, size, colour, spacings and indentations to whatever you like. All the content in your document defined to be of that style should then change to reflect the new style format.

Another approach is to find a document that has a format you like, make a copy of it, then use the styles in that document. (Word has a large number of sample styles built in, but unfortunately none of them is particularly suitable for a project report.)

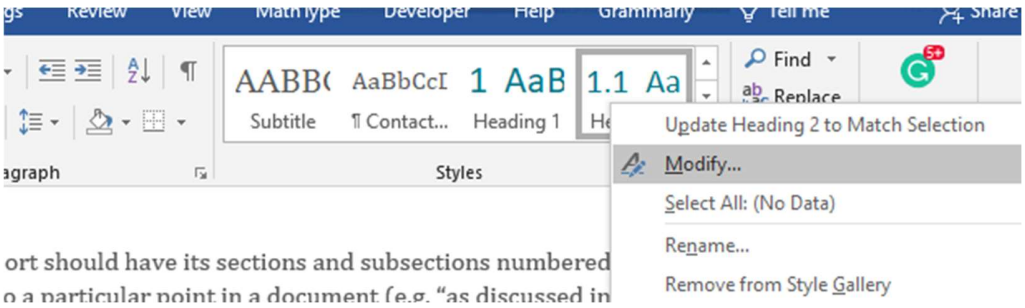

Figure 5-2 Preparing to modify a style

5.1.2 Figures and Tables in Word

Adding figures in Word is best done using "Paste Special… / Picture (Enhanced Metafile)". Just using the default paste command can result in pictures that appear behind or in-front of other text and which can move around by themselves. Always centre-justify figures, images and captions: the fastest way to do this is to select the figure and use "Ctrl-E".

Tables are added using the "Table" commands in the "Insert" menu tab.

5.1.2.1 Figure and Table Captions

These are very simple to add in Word, and they are recommended for all reports: all images, figure and tables should be captioned (with the possible exception of the picture on the front cover).

Captions in Word are added using the "Insert Caption" menu item in the "Captions" section of the "References" tab of the menu bar. Just select what you want to add a caption to, and click on "Insert Caption". With luck, Word will identify whether you want to add a figure or table caption, but if it gets this wrong, it is easy to adjust in the pop-up window. You add your caption text into this pop-up window.

Also in this pop-up window is the "Numbering…" button. This controls the number given to the figure. Click on this, and ensure that the "Include chapter number" checkbox is checked.

If you want to reference a figure in the text (note the golden rule: "all figures and tables should be referred to in the text), press the "Cross-reference" button, select the type of item that you want to cross-reference (most likely this will be "Heading", "Figure" or "Table"), and then change the "Insert reference to:" field from the default to "Heading number" or "Only label and number", then press "Insert".

(For some bizarre reason, the default type of cross-reference is to "Entire Caption" which produces cross-references like this: "Figure 5-2 Preparing to modify a style".

This is not a good style of cross-referencing, and is rather a waste of words when you are writing with a limited word count.)

One tip: to automatically update all of the section numbers, caption numbers and cross-reference numbers in a Word document the fastest way is to select the whole document (using 'Ctrl-A') and then press 'F9'.

5.1.3 Equations in Word

If you need to write a lot of equations in Word, then there are three choices: use the built-in equation editor (in the "Insert" menu tab); use a plug-in (MathType); or format them in a different application and paste them in as images.

MathType is a very good and powerful tool, capable of not only producing professional-looking equations, but also taking care of equation numbering and cross-referencing. It has an intuitive menu structure and a vast array of possible formatting options; it's also easily configurable with your own short-cuts. This is the software I use for all my documents.

Unfortunately, it's not free, and the new pricing plans are outside the budget of most casual users. Your university may have the software installed on student campus machines, but if you do a lot of your writing on your own laptop, you might prefer to use something else.

The Microsoft equation used to be a cut-down version of MathType, however a few years ago Microsoft dropped the MathType software in favour of their own equation editor, which is not as good. It's fine for producing one-line equations, and can manage, without too much difficulty, things like this:

$$I = \frac{1}{8}\int_0^{2\pi} x \sin\left(\frac{x}{2}\right) dx$$
$$= \frac{\pi}{2} \qquad (5.1)$$

but it's a bit awkward to use when it comes to aligning multiple-line equations, and trying to number equations is a manual process. A few tips if you decide to use this tool:

- Make sure that all of your lines are in Display format (right-click on the small arrow to the right of the equation box and select "Change to Display" if necessary, see Figure 5-3).

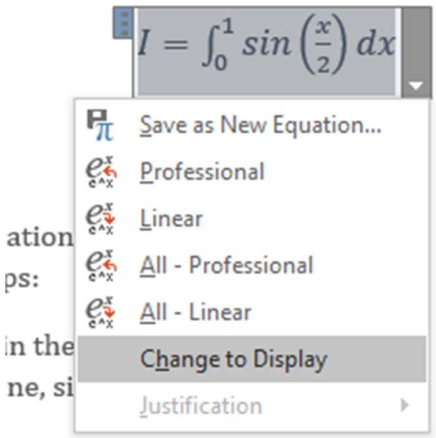

Figure 5-3 Setting equations to Display mode

- To align equations, you will need all of the equation lines to be in the same paragraph. To ensure this, use Shift-Enter at the end of every line, except the last line. (Shift-Enter generates a new line without starting a new paragraph.) Then on each line, right click on the equals sign, and select "Align at this Character" from the menu that appears.
- By default, the equation lines are usually placed too close together, so select the lines, and set "Line Spacing" to something like 1.5 lines (see Figure 5-4).

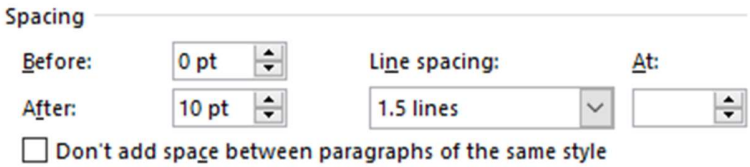

Figure 5-4 Setting the line spacing for equations

- You may notice that in the example above only the last line of the equation has an equation number. There's a quick way to do this in Word: while editing your equation, add the characters #(X.Y) at the end, and then press "Return". This will generate a right-justified equation number. (You will have to number the equations yourself though, I don't know of an automatic way to generate equation numbers.)

If you want to generate equations that have right-justified equation numbers on every line, and a wider range of symbols and formats, then you might be better off not using Word's equation editor.

There is a good reason why anyone wanting to produce a document with a lot of mathematical derivations (and who cannot afford MathType) often ends up writing

in LaTeX. If your report has a lot of mathematics, my advice would be to seriously consider LaTeX even if you have not used it before.

If you do decide to use Word, then another alternative to Word's equation editor is to use something like Mathcha (https://www.mathcha.io) and export the equations as images, although this does require learning to use another software application.

5.1.4 Headers and Footers

Headers and footers are a simple way to give your document a professional look. The golden rule here is to keep things clean and simple. You may note that this document has a simple header with just the title of the document and the section name, and a simple page number at the bottom. That's fine.

5.1.4.1 Chapter Names in Headers

It's not obvious how to get the chapter name into the header. If you want to do this, then the technique is:

- Place the cursor where you want the chapter name to appear.
- Go to the "Insert" tab on the menu bar, and in the "Text" group select "Field…" from the "Quick Parts" dropdown menu.
- In the Field dialogue box choose "StyleRef" as the Field name, then "Heading 1" as the Style name (note this will only work if you have used "Heading 1" as the style for all of your chapter headings.
- Make sure that "Preserve formatting during updates" is checked, and press "OK".

5.1.4.2 Page Numbers in Footers

You may notice this document has footers with page numbers starting at the introduction chapter, and has lower-case Roman numerals for the pages before this, except the title page which does not have a page number. This is standard practice for reports, but it's not obvious how to do this in Microsoft Word. It's done with section breaks.

There are four sections in this document: the title page, the preliminary pages before the introduction, the main body of the document and the appendices. Word allows you to set up headers and footer differently for each section.

Section breaks can be added through the Layout/Breaks menu. In this document I've opted for the "Next Page" option. One point to note: by default Word tends to set the flag "Link to Previous" on the headers and footers in any new section. I find it best to turn this flag off, so I can set the headers and footer in every section

independently. (You find this flag in the "Design" menu tab that appears when you start editing a header or footer.)

Once you have headers and footers set up, you can add page numbers in a variety of styles using the "Page Number" item in the "Design" menu bar.

Warning: be very careful if you are trying to use something like "Page X of Y" in your footer, as this can cause problems: the default number of pages that Word calculates includes all the pages in the document, and if you have some pages at the start which are not numbered in sequence (as this document has) you tend to end up with the last page being something like "Page 46 of 51" which is just confusing, as the reader thinks there are some pages missing. If you want to do this, you have to first add the "Page X of Y" from the Design menu, then right-click on the number of pages (the 'Y'), select "Edit Field" and replace "NumPages" with "SectionPages". That works as long as all of the pages you want to count are in the same section. Otherwise, just leave this until the very end of the editing process, and add the total number of pages into the footer as simple text.

5.1.5 References in Word

Word has a built-in reference formatter which is quite simple to use. You can find it in the "Citations & Bibliography" section on the "References" menu (see Figure 5-5).

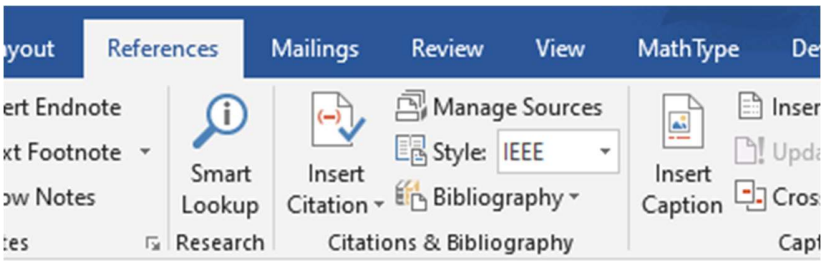

Figure 5-5 The citations and bibliography menu in Word

Set the style to "IEEE" (unless your module leader has told you otherwise). Then to insert a new reference, place your cursor where you want the citation to appear, then click on "Insert Citation" and either select a reference source you have already defined, or choose "Add New Source…".

If you add a new source, you will be asked to choose what type of source it is, and then prompted for all the information that the selected style requires. For example, referencing this report would look like this:

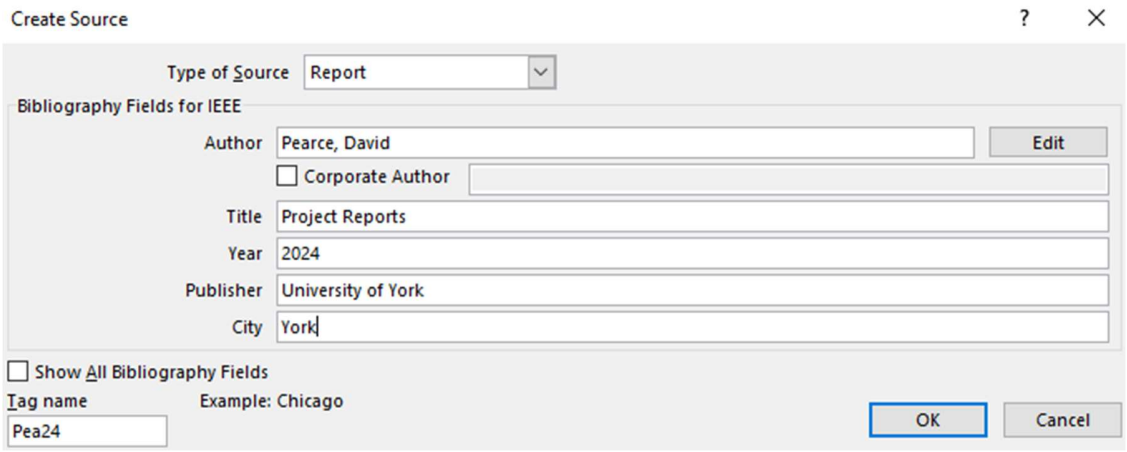

Figure 5-6 Creating a new source in Word's reference list

After the conclusions section, add the references section (which Word calls a "bibliography") by using the "Bibliography" command on the menu. Note that if you do this using the built-in style, the references section will probably given a chapter number (at least it will if you are using the recommended Multilevel List style to automatically number headings). If you would prefer not to give your references section a chapter number, then you can just backspace over this number in the heading to delete it.

One issue to be aware of with references in Word is that if you delete a citation, the reference does not automatically get removed from the references section the next time you update the references table. To remove the reference from the references section, select the "Manage Sources" menu item (see Figure 5-5) and delete any unused references from the "Current List" on the right-hand side of the Source Manager window.

5.2 Working in LaTeX

If you are new to LaTeX there are a few things to know:

- It's pronounced "lah-tech" or "lay-tech", not "lay-teks". (The last character isn't a capital 'X', it's an upper-case Greek chi.)
- You don't work on formatting a WYSIWYG (what you see is what you get) document as you do in a more conventional word processor such as Word. In LaTeX you prepare a source file which is then compiled into a document. (It's a bit like writing software, except that the output is not an executable program, it's a document.)

- It can be difficult to modify templates to produce what you want, so most people just use a pre-existing template. This tends to make all LaTeX documents look the same (but it's a perfectly acceptable look).
- The most convenient way to use LaTeX is a webapp called "Overleaf" (https://www.overleaf.com/project).

LaTeX is not as easy to use as Word, as there are no helpful menus with intuitive names and icons that easily allow you to change the formatting or appearance of your text and instantly see the results; instead, there are a lot of cryptic commands and codewords that need to be included in the source file. But LaTeX does have one advantage over Word: fewer bugs and unexpected behaviours. In general, the commands do what they claim to do.

One "feature" of LaTeX source files that can trip people up: comments start with percentage signs. So, if you write, for example:

```
After 100 trials, 98% of the kittens recovered, but two
kittens died.
```

what would be produced in your document would be: "After 100 trials, 98 kittens died." If you want a percentage sign, then you have to use '`\%`' rather than just '`%`'.

5.2.1 Overleaf

Overleaf is a webapp that integrates a text file editor with a LaTeX compiler (see Figure 5-7). You edit the source "code" on the left-hand side, then press the "Recompile" button, which produces a document on the right-hand side of the screen that can be downloaded as a pdf.

(Since it is a webapp, Overleaf stores your work on its cloud. If you trust it that's fine, but I would recommend downloading and backing up your work regularly just in case.)

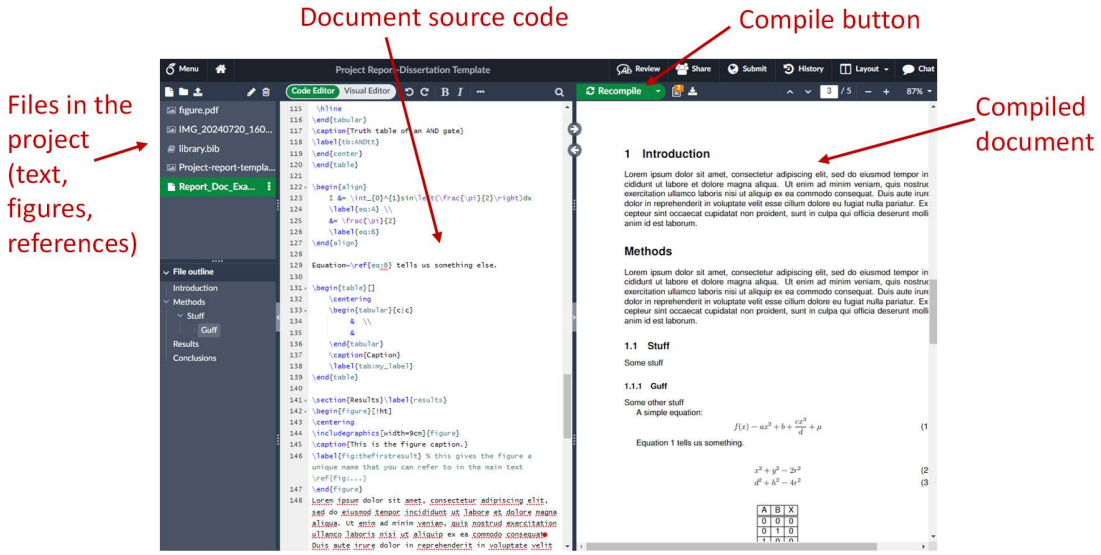

Figure 5-7 The Overleaf webapp

Your university may provide premium-level access to Overleaf, but to use this you will have to sign into Overleaf using your university user id and password using the SSO (single-sign on) system (see Figure 5-8). This button should automatically appear provided you are logged into Google with your student ID in the browser.

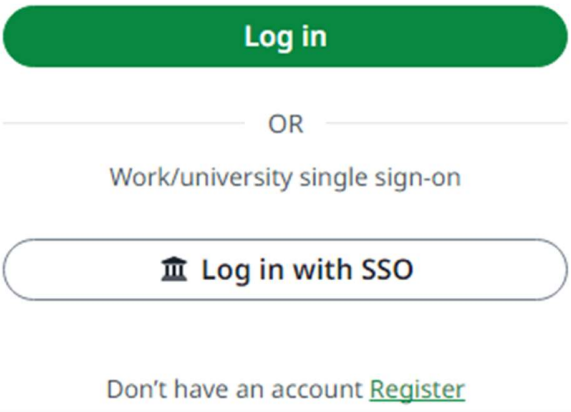

Figure 5-8 A University Single Sign-On Button at Overleaf

Overleaf has an excellent help section: https://www.overleaf.com/learn. I would recommend anyone new to LaTeX to take a look through these webpages.

If you start a new project in Overleaf (they are called "projects" not "documents"), you will be given the choice of using an existing template. There are hundreds to choose from. Universities often provide a set of recommended templates including one for project reports, and this can be found under the "Institution Templates"

menu when setting up a new project. (Note that to see this menu item you will have to be logged in to Overleaf using your university account.)

5.2.2 Section Numbering

Any technical or project report should have its sections and subsections numbered. This makes it easy to refer to a particular point in a document. LaTeX makes it very easy to number sections, subsection and subsubsections: it does it automatically. (If you don't want it number sections, then just add an asterisk after the section specifier. For example, to get an unnumbered ethics statement, use:

```
\section*{EthicsStatement}
```

rather than

```
\section{EthicsStatement}
```

This works for figures and tables if you don't want to give them a number as well.)

You can add subsection headings with `\subsection{Subsection Title}` and third-level headings with `\subsubsection{Sub-subsection Title}`. It is much more difficult to add a fourth layer of the hierarchy. So, my advice would be to avoid using that many layers of hierarchy in a LaTeX document: start a new chapter if required, or consider bullet point lists. It should be relatively rare to require a fourth level of the hierarchy in a project report.

To add cross-references to sections (or figures or tables) in LaTeX you have to add a label to the item, separate from the number, like this:

```
\section{Introduction}\label{IntroSection}
```

You then cross-reference to that label. It is up to you to ensure that the cross-references are unique in your document (although the compiler will warn you if you use one twice).

5.2.3 Figures and Tables in LaTeX

Adding figures in LaTeX is a little more complicated than in Word. You have to upload your image into Overleaf, then insert it into your document where you want it to go, using the commands:

```
\begin{figure}[!ht]
\centering
\includegraphics[width=9cm]{Name of the image file}
\caption{This is the figure caption}
```

```
\label{fig:athing}  % Unique name for cross-referencing
\end{figure}
```

Tables are added using the "\begin{tabular}" command. Just as with figures, there is no simple "drag and drop" method to produce tables, you have to first decide what your table is going to look like (number of rows, number of columns, column widths, lines, etc.), and then write the relevant code to produce that table. The help in Overleaf gives a good introduction to the commands required, but they can get quite lengthy. For example, to produce the truth table of an AND gate (see Figure 5-9):

A	B	X
0	0	0
0	1	0
1	0	0
1	1	1

Table 1: Truth table of an AND gate

Figure 5-9 Image of a LaTeX table

the following commands are required:

```
\begin{table}[!h]
\begin{center}
\begin{tabular}{|c | c | c |}
 \hline
 A & B & X \\
 \hline\hline
 0 & 0 & 0 \\
 \hline
 0 & 1 & 0 \\
 \hline
 1 & 0 & 0 \\
 \hline
 1 & 1 & 1 \\
 \hline
\end{tabular}
\caption{Truth table of an AND gate}
\label{tb:ANDtt}
\end{center}
\end{table}
```

Note that there is no requirement to tell LaTeX to give figures and tables a number. This is all done for you by the graphics package that should be included in your source file (using the line

```
\usepackage{graphicx}
```

in the preamble to your document).

5.2.4 Equations in LaTeX

Writing equations in LaTeX is completely different than writing them in Word: you have to write a series of coded commands that the compiler then translates into your equation. This is fine if you have time to learn all the commands, but it is harder to get started than with Word's WYSIWYG equation editor. For example, to produce the integral equation shown in above (in section 5.1.3), you would have to write:

```
\begin{align}
  I &= \frac{1}{8}\int_{0}^{2\pi}xsin\left(\frac{\pi}{2}\right)dx
  \label{eq:A} \\
  &= \frac{\pi}{2}
  \label{eq:B}
\end{align}
```

and although this would have the advantage of producing a different right-justified equation number on every line, the format is far from obvious. There is a lot of good documentation available, but the learning curve is steep.

(In brief: the '`&`' here indicates where the alignment of the lines should occur, the '`_`' indicates a subscript, the '`^`' a superscript, '`\left(`' produces an open bracket that expands to whatever size is required, '`\frac{num}{dem}`' produces a fraction. '`\label{eq:A}`' adds a label which can be used to cross-reference the equation from the text, and the '`\\`' indicates the end of one line.)

One point to note here: check your university LaTeX project template to see if it uses the mathptms package: there is a line at the start of the document

```
usepackage{mathptmx} % Times Roman Font
```

which will include the commands to format maths equations into your project using this package. This is not the most common equation formatter in LaTeX, and it now appears to be obsolete. The online help in Overleaf will assume you are using the amsmath package. So, you will probably want to replace the line above with:

```
usepackage{amsmath}
```

otherwise you may find a lot of the suggestions you find online and in the Overleaf help pages don't work.

5.2.5 BibTeX

BibTeX is the referencing system for LaTeX. Using BibTeX you create a list of references in a defined style, and then let LaTeX sort out the citation numbers in the correct order and the correct formatting of the reference section at the end of the document.

If you start a project with most university templates, a BibTeX source file (called "library.bib") is generated in the project workspace. This is the file where you add the details of all the references you want to use. By default, it looks like this (see Figure 5-10):

```
@article{WFBrownPR1963,
  title = {Thermal Fluctuations of a Single-Domain Particle},
  author = {Brown, William Fuller},
  journal = {Phys. Rev.},
  volume = {130},
  issue = {5},
  pages = {1677--1686},
  numpages = {0},
  year = {1963},
  month = {Jun},
  publisher = {American Physical Society},
  doi = {10.1103/PhysRev.130.1677},
  url = {https://link.aps.org/doi/10.1103/PhysRev.130.1677}
}

```

Figure 5-10 Initial BibTeX file for a sample university project template

All you have to do is add further articles, websites, books, etc. in the correct format. If you plan to use LaTeX, it is well worth learning how to do this. There is a good introduction to the topic at https://www.bibtex.com/g/bibtex-format/.

There are currently 14 different types of sources; the example above is of type "article" which is suitable for a magazine or journal article. After the '{' on the first line is the "citekey": this is what you will use in the report text itself (using an instruction like \cite{WFBrownPR1963} where you want the citation to appear).

This is then followed by a number of fields of the form:

```
parameter = {value of parameter}
```

separated by commas, before the closing '}'. You will probably have to do most of this formatting yourself.

There are several websites that offer a free "generate BibTeX" service and these can save some time, but I have found their output often requires a significant amount of editing. Another option is to use ChatGPT: just give it all the details of your source and ask it to produce a BibTeX style reference. This can save a lot of time, but be sure to check the output.

(Elicit can output the references it finds in BibTeX format, but unfortunately at time of writing this requires quite an expensive subscription.)

Having completed your library.bib file with all your references, you just need to add:

```
\bibliographystyle{IEEEtran}
\bibliography{library}
```

into your document where you want the references section to appear, and BibTeX will do the rest. (Note that this is not the default style in the most project report templates: to use IEEE format references you will need to edit the referencing style as shown above.)

5.3 Non-ASCII Characters in Word and AutoHotKey

If you are working on a Windows PC in Word, then it's worth knowing about the AutoHotKey utility. This is a very powerful tool for defining (or re-defining) the functions of the keys on the keyboard. It intercepts keystrokes, and converts them to something else.

I use AutoHotKey when writing to make it easy to access Greek letters, and some other symbols I use frequently (such as the degree symbol °, the infinity symbol ∞, the plus or minus symbol ± and so on). This is much easier and quicker than using Word's Insert->Symbol feature.

You will need to install AutoHotKey (sadly this is not provided on University computers, so you will only be able to use this if you have your own Windows PC), then run a script. The relevant parts of a script I often use is shown below. Note comments are anything that appears after a semicolon on a line, and "SendText" is a function that puts the parameter passed to the function in the keyboard buffer as if it has just been typed (so for example, I can add the Ω symbol by typing "Alt Gr" and "O" at the same time, or a Δ by pressing "Alt Gr", "Shift" and "D").

```
#Requires AutoHotkey v2.0
#Warn  ; Enable warnings to assist with detecting common errors.
```

```
; This script allow typing some common non-ascii characters.
; Mostly this is done by adding scripts to the AltGr (alternate
; graphics) key, which is <^>! in AutoHotkey.
; Note ">^" means the right-hand control key. ("<^" is the left
; control key; "^" is either control key. "!" is normal alt, and
; "+" the shift key.)
; This is the AutoHotKey version 2 version of this script.

; AltGr key symbols:
<^>!a::SendText("α")  ; Greek alpha
<^>!b::SendText("β")  ; Greek beta
<^>!d::SendText("δ")  ; Greek delta
<^>!+d::SendText("Δ") ; Greek capital delta
<^>!e::SendText("ε")  ; Greek epsilon
<^>!f::SendText("φ")  ; Greek phi
<^>!g::SendText("γ")  ; Greek gamma
<^>!i::SendText("∞")  ; Infinity
<^>!o::SendText("Ω")  ; Greek capital omega
<^>!p::SendText("π")  ; Greek pi
<^>!r::SendText("ρ")  ; Greek rho
<^>!q::SendText("θ")  ; Greek theta
<^>!s::SendText("σ")  ; Greek sigma
<^>!t::SendText("τ")  ; Greek tau
<^>!u::SendText("μ")  ; Greek micro
<^>!w::SendText("ω")  ; Greek omega
<^>!+::SendText("±")  ; Plus or minus
<^>!=::SendText("≈")  ; Approximately equal
<^>!<::SendText("≤")  ; Less than or equal to
<^>!>::SendText("≥")  ; Greater than or equal to

; Other alt symbols:
!e::SendText("é")   ; e with acute
!r::SendText("√")   ; Square-root
```

5.3.1 Non-ASCII Characters in LaTeX

If you are using LaTeX then the recommended way to insert these characters is to use the LaTeX escape codes, for example μ produces a μ and π produces π.

The '$' delimiter is used for inline equations inside paragraphs, so what this is really doing is writing a one-character equation. This has the side-effect that the characters are in italics by default, as they are treated as equation variables, but this is not usually a problem. (If you did want a non-italic π there is no simple way to get one. This is a good example of LaTeX doing what it does very well but not being very easy to persuade to do anything different.)

6 Common Mistakes

Despite my best attempts, I find the same mistakes being made every year. I've gathered up the most common ones here. You could perhaps use it as a checklist. Please make sure that you haven't made any of these mistakes before submitting your report.

- Not using Heading Styles for the chapter and section headings

It makes life a lot easier, really it does. Suddenly your document has a set of consistent styles: all headings are the same size, in the same font, and the table of contents can be created automatically. It also makes your document more accessible, as most screenreaders expect these styles to be used.

- Not using Multilevel lists to do automatic numbering of chapters

It's a little harder to find these in Word 2007 than it was in Word 2000. (In Word 2007 select "Multilevel List" from the Paragraph pane in the Home window, and choose a suitable style from the library. I'd recommend the one that starts "1 Heading 1".)

(Or, just take the Word version of this document and delete all the text. Then start writing again using the styles in the document. They have outline numbering built-in.)

If you don't do this, you'll have a terrible time trying to generate the table of contents. If you do, you can generate a great-looking table of contents in a few seconds.

- Not using Microsoft Word's 'Insert Caption' feature to title figures

Again, people seem to use Word as a typewriter. It really would be worth learning more about what Word can do before starting to write your report. Use the automatic "Insert Caption" feature, and all figures are automatically numbered (and re-numbered when you add or delete a figure).

- Not referencing figures in the text

I often come across figures just floating around, with nothing in the text referring to them at all. It's usually obvious what they are, but this is another 'Golden Rule': all figures must be referred to in the text.

- Inconsistent styles of heading

Most often a problem with overseas students who are not used to the difference between 'lower case' 'UPPER CASE', 'Title Case' and 'Sentence case'. All chapter

and section headings should be in title case, figure and table captions can be in title case or sentence case provided the document is consistent.

- Putting citations after the full stop

For example, adding a citation like this. [3]

Why do so many people do this? Where does it come from? You can't have copied the idea from anywhere, no-one publishes papers or books like this. If a citation applies to something in a sentence, the citation must be in the same sentence. And that means before the full stop, like this [3].

- Putting something in a section that comes as a surprise

All sections (and subsections, and sub-subsections) should have short introductions telling the reading what is coming up in the rest of the section.

- Putting two section headings together with no text in-between

See above – if there are two headings with no text in-between then the introduction to the second section is missing.

- Not putting in enough references

This is a very frequent problem. I read things like "research has shown that a = 2.7 is a good value to use". What research? Where did this come from?

Or perhaps I might read "MIMO systems can help improve capacity". How do you know? Where I can go and read more about how? No-one is born knowing this.

This is another of the 'Golden Rules': if you take any information from anywhere, then always provide a reference to the source of that information.

- Not starting new chapters on new pages

It's easy to do in Word. Just use a "Ctrl-Enter" to add a page-break. It makes the report look more professional.

- Not defining all the quantities in an equation

This happens a lot. I often read things like "the capacity of the link is then given by:

$$C = W \log_2\left(\det\left(\mathrm{I} - \frac{\lambda}{\sigma^2}\mathrm{H}\right)\right) \tag{1.1}$$

where H is the channel matrix."

Fine, but what is W? What is λ? What is σ? If you write an equation, you should clearly state what all the terms in the equation represent.

- Writing something in the report you don't understand

I can see how tempting this might be to do. If you just can't get your head around a derivation or a proof, you just copy it from a textbook into your report. However, this is very dangerous. We may ask you about it in a viva, and if you can't explain something in your report, it really doesn't look good. It's much better just to quote the result and add a reference to where the derivation comes from. Writing anything is a claim that you understand it (unless you put it in quotes, so it's obviously not your own words).

7 Preparing for Submission

Try to get as much feedback about your writing as you can. Ask your supervisor(s) what their policy is about this. For example, for first-year supervisees and final-year project students I am happy to read draft copies of a report before submission. However, I am not happy to read slightly different versions of the same chapter over and over again, and I won't have time to read anything if I am presented with a large document only a few days before the deadline. (For second-year project students I am afraid I cannot offer a review service because there are too many of you, but I am happy to look over and offer some comments if shown some example writing in the lab sessions. You are encouraged to consult your project team mentor to ask their help in reviewing reports.)

I have come up with a few rules for how this can best work for both student and reviewer:

1) Run all chapters through a spelling and grammar checker before you send them for review, and take note of the advice provided. I use Grammarly, which in its simplest form is a free plug-in available for Word, and can provide some useful advice and catch many basic errors.

This is particularly important if English is not your first language. If the grammar and spelling are so poor that the reviewer has difficulty in understanding what you are trying to say, then be prepared to have the document returned. There are a lot of on-line grammar tutorials on the Internet, which you may benefit from, and other help is available in most universities. Ask your supervisor for advice if you need more help here.

2) Don't wait until you have a complete draft of your report before asking someone to review it. It's easier to find the time to review individual chapters one at a time, so please submit these as soon as they are complete (or as soon as you want some comments on them). This minimises the amount of reading the reviewers have to do just before the submission deadlines, and I hope will encourage you to write as you go along (which always a good idea).

3) If you are sending your reviewer a chapter for the second time, then please make it clear where the changes have been made, so they don't have to read through everything again. (Try turning on 'Track Changes' in Word, or do a comparison of the current version with the last version you sent for review, then mark the new sections, perhaps using colour.)

8 Conclusions and Further Work

This report has tried to highlight good (and bad) practice in writing technical reports in a format suitable for an undergraduate student. Both Microsoft Word and LaTeX word processors are described.

References

[1] I. Publications, “IEEE Reference Guide,” 2023. [Online]. Available: https://journals.ieeeauthorcenter.ieee.org/wp-content/uploads/sites/7/IEEE_Reference_Guide.pdf. [Accessed 21 July 2024].

[2] G. Bartram, “Proposed Flag of Antarctica (Graham Bartram),” 12 June 2024. [Online]. Available: https://en.wikipedia.org/wiki/Flag_of_Antarctica. [Accessed 21 July 2024].

[3] I. U. Writing Tutorial Services, “Plagiarism,” 22 March 2003. [Online]. Available: http://www.indiana.edu/~wts/wts/plagiarism/plagiarized. [Accessed 18 May 2003].

Appendix – Samples of Project Reports

This appendix contains three examples of project reports, together with the mark they would typically be awarded, and comments on how the authors could have improved their marks.

In all cases, the students were asked to write a short lab report about an experiment to determine if the period of a pendulum is a function of the amplitude of the oscillation. A lab script was provided that asked them to measure the period of the pendulum as accurately as possible for both small and large amplitude oscillations, and make conclusions from their results. They were told that their report should be between 400 and 600 words long.

Report A is an excellent report, awarded a mark of 80%

Report B is an average report, awarded a mark of 60%

Report C is a marginal fail report, awarded a mark of 30%

Report #1

1 Introduction

This report describes an experiment to determine if the often-quoted formula for the period of a pendulum:

$$T = 2\pi\sqrt{\frac{l}{g}}$$

still applies if the amplitude of the pendulum varies. The report first describes the experimental setup and the results obtained, then the analysis of the result. Finally, conclusions and suggestions for further work are given.

2 Experimental Setup and Results

The experiment was performed using a 500g mass on the end of a non-elastic string. The mass was created using the TeQuipment lab racks and masses [1], and the distance from the axle of the pendulum to the centre of mass of the weight was 82.5 ± 0.2 cm.

First, we set the pendulum swinging in a plane freely with an amplitude of 20 degrees. We then used an online stopwatch to determine the time for 50 oscillations. This resulted in a measurement of 91.55 ± 0.25 seconds. During this time the amplitude of the oscillation decreased from 20 degrees to 15 degrees due to air resistance.

Following this measurement, the pendulum was set swinging again with an amplitude of 5 degrees, and the time for another 50 oscillations was determined, this time giving a total time of 91.15 ± 0.25 seconds.

The confidence limits were established by repeatedly attempting to measure the time required for one period: measurements were always within 0.2 seconds of the average; a confidence limit of 0.25 seconds was therefore used to provide some margin.

3 Results and Analysis

The confidence limits for the mean period of the large amplitude pendulum were determined by dividing the maximum and minimum times by the number of oscillations. This gave the results shown in the following table:

	Minimum period	Maximum period
Large amplitude	1.826	1.836
Small amplitude	1.818	1.828

There is an overlap between the confidence limits in both cases, therefore there is no evidence of a dependency of the period on the amplitude of the swing. However, the overlap is very small, so a further experiment was performed with 100 oscillations to produce more accurate results. This results in a measurement of 183.2 seconds for 100 periods with a large amplitude, and 182.4 seconds for 100 periods with a small amplitude. This gives results shown in the following table:

	Minimum period	Maximum period
Large amplitude	1.829	1.834
Small amplitude	1.822	1.827

With this more accurate measurement there is no overlap between the confidence limits in both cases, and therefore it can be concluded that the period of a pendulum is not independent of the amplitude of the swing.

4 Reflection

The experimental set up followed the description in the lab book without problems, and was completed within the set time. The only problem I experienced was with the pendulum initially rotating as well as swinging, but this issue did not last. I am happy with the results, as they confirm the theory found online [2].

I performed this experiment as part of a pair, however my partner did nothing except watch me build the apparatus and perform the experiments, and write down the results. I asked whether they wanted to also time the period of the pendulum, but they said they thought I could do it better. I don't agree; I think that having two independent measurements would give more confidence in the results, but my attempts to explain this did not work. I don't know why my partner was so reluctant to help.

5 Conclusions and Further Work

The experiment has established that the period of a pendulum is not independent of the amplitude of the swing. Further work could attempt to validate the formula found online for the period of a large-amplitude pendulum [2]:

$$T = 2\pi\sqrt{\frac{l}{g}}\left(1+\frac{1}{16}\theta^2+\frac{11}{3072}\theta^4+\ldots\right)$$

References

[1] TecQuipment, “Work Panel”, https://www.tecquipment.com/engineering-science/work-panel (accessed Jul 14, 2024)

[2] Hyperphysics, “Large Amplitude Pendulum”, http://hyperphysics.phy-astr.gsu.edu/hbase/pendl.html (accessed Jul 15, 2024)

Report #1 Mark awarded: 80%

What is good:

- Use of confidence limits and the analysis is correct, and the conclusion follows logically from the results.
- There is enough information for someone else to repeat the experiment.
- Going back to take more measurements when the first experiment was inconclusive shows excellent dedication and real understanding of the method.
- The reflection section is good, as it highlights an issue with the pair.
- The structure and grammar of the report are excellent.
- The references are correctly formatted in a consistent style.
- Suggesting appropriate further work to extend the lab is good practice, and finding, quoting and referencing the more accurate formula for the period in terms of the amplitude is very good.

What is wrong:

- The first formula quoted is not referenced. It is not obvious, so it needs to be referenced to a reliable source.
- Nothing in the introduction prepares the reader for the reflection section, so this comes as a surprise.
- The tables do not give the units of time.
- TecQuipment is misspelt in the text.

What could be improved:

- The equation could be numbered (to make it more readable in the text).
- A diagram or photograph of the test setup would add valuable information without requiring many more words.
- No mention is made of the assumption that the weight of the string is being neglected, or of how the distance from the axis to the centre of mass was determined.
- It would be better to reference a book or published article rather than a transient webpage.
- The tables could be given captions and numbers, e.g. “Table 1: Results for 50 periods”.
- There could be a discussion of how accurate the online stopwatch is likely to be.
- There could have been a deeper reflection on the issue of the non-participation of the lab partner: was the problem reported to a

demonstrator? has the lab partner been similarly useless in other labs? Can you suggest any reasons why your partner is not doing anything? If they think you are more capable, what could you do to get them more involved?

Report #2

1 Introduction

This experiment aims to determine if the formula for the period of a pendulum is always correct, no matter what the amplitude of the swinging is.

$$T = 2\pi\sqrt{\frac{l}{g}}$$

We did this by measuring the period for large and small amplitude oscillations to see if the result is the same as the formula predicts it should be.

2 Experimental Method

We put a mass of 500g on one end of a long string and suspended the other end from a fixed point. We then set the pendulum going with an amplitude of about 20 degrees. We found a stopwatch online [1] and used this to measure the time for 50 oscillations, starting and stopping the stopwatch with a mouse click as the pendulum passed its midpoint.

After we'd taken this measurement, we set the pendulum going again with a much smaller amplitude, and this time the time for 50 oscillations was again measured using the same stopwatch.

We estimate that this result is accurate to at worst +/- 250 ms because we don't need to consider human reaction time; we can see when the pendulum is about to reach the centre of its swing, and all measurements were started and stopped at that point. We think we can do that with an accuracy of 250 ms at worst.

After the end of the experiment we stopped the pendulum and let it hang there.

3 Results and Analysis

The results we got are shown in the following table:

	Time for 50 oscillations
Large amplitude	91.55 +/- 0.25 s
Small amplitude	91.15 +/- 0.25 s

Table 1 - Experimental Results

These confidence limits overlap, as it is possible that both measurements are actually 91.35 s. Therefore, there is no evidence that the period of the pendulum depends on the amplitude. So, there is no evidence that the formula is incorrect.

4 Reflection

We followed the instructions in the lab book and did not have many problems. The only thing that did start to go wrong was that the pendulum started spinning when we first put the weight on it, but we just waited for the spinning to stop before starting the measurements.

In total the experiment took about an hour, including building the equipment.

We were supposed to do this experiment as a pair, but my lab partner did nothing to help, they just watched. All the equipment, readings and analysis are my own work. I found this frustrating. At the start of term my partner did try to help, but recently they have just been watching what I do. I think it is a bit unfair that I have to do all the work.

5 Conclusions and Further Work

The experiment has been inconclusive. The average period for large swings was slightly greater than that for small swings, but the difference was not significant. So, we cannot conclude that the formula is incorrect.

Further work measuring the period more accurately might change this conclusion.

References

[1] Google stopwatch, https://www.google.com/search?q=stopwatch (accessed Jul 14, 2024)

Report #2 Mark awarded: 60%

What is good:

- Use of confidence limits and the analysis is correct, and the conclusion follows logically from the results.
- The instructions were clearly followed, and the experimental method is correct.
- The reflection section is good, as it highlights an issue with the pair, although there is very little detail given. (Why do you think this is happening? Has the problem reported to a demonstrator?)
- The structure of the report is fine.
- The references are correctly formatted in a consistent style.
- The table has a caption and a table number.
- Suggesting appropriate further work to extend the lab is good (although no details are given about how this could be done).

What is wrong:

- The first formula quoted is not referenced. It is not obvious, so it needs to be referenced to a reliable source.
- The introduction section does not introduce the rest of the report, only the experiment itself.
- There is not enough information for someone else to repeat this experiment: the length of the pendulum is not specified; it is not specified whether the pendulum is moving in a plane or with a circular or elliptical motion; there is no indication of what the "much smaller amplitude" was.
- Some irrelevant content: it doesn't matter what happened after the experiment finished.

What could be improved:

- The equation could be numbered (to make it more readable in the text).
- No mention of how the amplitude changes through the measurement; this sort of observation is always good to include.
- The grammar is awkward, there are some colloquialisms and sentences do not flow well.
- A diagram or photograph of the test setup would add valuable information without requiring many more words.
- No mention is made of the assumption that the weight of the string is being neglected, or of how the distance from the axis to the centre of mass was determined.

- There is no discussion of how a more accurate measurement could be made.
- The confidence limits are not well justified.
- It would have looked better to use “±” rather than “+/-“ in the text.

Report #3

This experiment determines if the formula for period of a pendulum is independent of amplitude of the swing. We did this by measuring the period for large and small amplitudes of swingings to see if the period changed.

We put a mass on one end of a long string, and attached the other end to the rack just like it said in the lab script. We set the pendulum going with a big amplitude of the swinging. We measured the period of the oscillations by using the Google stopwatch which starts and stops when you click the mouse.

We found a stopwatch online [1] and used this to measure the time for 50 oscillations, starting and stopping the stopwatch with a mouse click. We did this twice, once for big swingings and once for really small swingings. We got 91.5 seconds for the big swingings and 91.1 seconds for the small swingings for all the fifty oscillations we measured.

Difference is 0.4 seconds, and we make timings with the stopwatch more accurately than this, so we think this difference is not due to our timing errors. Therefore, the periods are different in the two cases, and therefore the period does depend on the amplitude of the swings, and therefore the formula must be wrong. Or at least it must be wrong for big swingings of the pendulum.

We were supposed to do this experiment as a pair, but my lab partner did nothing to help. Sometimes they don't even turn up. When they do, they just sit there and watch, or wander off and drink a coffee. I have to do everything, so this is all my work. It is unfair that I have to do all the work, and they can just write things down and get the same mark.

References

[1] https://www.google.com/search?q=stopwatch

Report #3 Mark awarded: 30%

What is good:

- There is awareness of the importance of knowing the accuracy of measurements.
- The conclusion does follow logically from the assumptions and measurements.
- The instructions in the lab script were clearly followed, and the experimental method is correct.
- The basic structure of the report is fine: introduction paragraph, details of work, a conclusion and a reflection section; everything required is there.

What is wrong:

- The grammar and spelling are poor ("swingings" is not a word; some articles are missing).
- The formula referred to is not quoted. This is frustrating for the reader.
- There are no section headings, this makes it harder for the reader to find something in the document, and harder for the marker to mark (there are often marks specifically for the introduction, and not having a clear introduction makes the marking harder; this is never a good idea).
- The introduction paragraph does not introduce the rest of the report.
- There is not enough information for someone else to repeat this experiment: the length of the pendulum is not specified; it is not specified whether the pendulum is moving in a plane or with a circular or elliptical motion; there is no indication of how large the amplitude of oscillations was in either case.
- The confidence limits are not stated (all the reader can deduce is that they are less than ±200 ms).
- The references are not correctly formatted in a recognised style.
- Inconsistency in formatting: "50" then "fifty".
- The reflection is just a complaint: why is your partner behaving like this? What has been tried to try and improve their engagement?
- The word count is below the minimum specified.

What could be improved:

- The equation could be numbered (to make it more readable in the text).
- No mention of how the amplitude changes through the measurement; this sort of observation is always good to include.
- Sentence construction is awkward, there are colloquialisms and sentences do not flow well.

- A diagram or photograph of the test setup would add valuable information without requiring many more words.
- No mention is made of the assumption that the weight of the string is being neglected, or of how the distance from the axis to the centre of mass was determined.
- There is no discussion of how a more accurate measurement could be made.
- The confidence limits are not well justified.