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Guide for Writing Technical Reports

For Final Year Projects and Postgraduate Studies in Engineering

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Sixth Edition

2024

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Abstract

This guide provides guidelines to engineering students for writing technical reports (for example on vacation work, experiments, design projects and final year projects), theses and dissertations. It provides a discussion of the contents of the various main elements of a technical report and gives the recommended format. Some of the important elements of a good microstructure and style, and practical guidelines for the compilation of a technical report, are also provided. The guide concludes with a checklist that can be used by students to eliminate general mistakes. The appendices provide more detailed guidelines for documenting experiments, designs, calculations, thesis proposals, the use of SI units and the use of the Harvard referencing method.

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The sixth edition include an appendix on the Harvard referencing style largely contributed by Erina (CS) Basson of the Language Centre at Stellenbosch University. The same edition also includes a significant revision of the appendix on thesis proposals. Gerhard Venter, Karel Kruger, Debby Blaine made substantial contributions to that revision.

Table of Contents

List of Figures

Page

List of Tables

Page

1 Introduction

The majority of engineering tasks include the writing of technical reports, even if the main objective is much more extensive. Since technical reports and papers are used to summarise information in a way that is easily accessible, they should be as concise, accurate and complete as possible, and be aimed at a specific group of readers.

The immediate objective of this guide is to help students following bachelor's, master's and doctoral programmes in engineering to approach report writing effectively during their studies and to present the reports in a professional format. A further objective is to prepare students for the writing of technical reports and papers in engineering practice. The format described in this guide is the prescribed format for student reports in the Department of Mechanical and Mechatronic Engineering at Stellenbosch University.

In this document, the term "reports" is considered to include theses and dissertations.

The emphasis in this guide falls on the prescribed format for a technical report, but a few hints on paragraph structure and writing method are also given. Although there are a number of standard formats, such as those of Beer and McMurrey (1997), Campbell and Ballou (1994) and Blicq (1987), only one format is described in this guide. Readers who would like to obtain more information on the writing of technical reports are referred to the books by Weisman (1974), Pakin (1982), Michaelson (1984), Pauley and Riordan (1985), Rathbone (1988) and Van Emden (1989). There is an excellent book on style written by Strunk and White (1979).

The format of this guide follows its own prescriptions as far as possible to serve as an example.

2 The Process for Compiling a Technical Report

As with any writing, one of the first questions that must be asked in the planning process is "Who is the target reader?" In engineering practice, the reader can be a client, a colleague, a manager or a junior. In academic writing, the target reader is usually the examiner. The examiner is normally independent and was not involved in the initiation or executing of the work being reported. The author must therefore ensure that sufficient background and detail is given to convince the examiner.

When academic writing is aimed at an examination process, the outcomes or assessment criteria must be thoroughly accounted for in the planning of the writing. It will be of great benefit to the author to study the relevant assessment criteria.

The process of writing a technical report begins with planning the work on which the report is based. Even at this early stage, the task can be broken down into elements which are likely to become the chapters or sections of the report. The final sequence of the chapters and sections will usually not correspond with the order in which the work was done, but will be determined by the desired structure of the report.

The general rule is to begin writing the sections of the report as soon as possible. The table of contents should be drafted very early in the process of writing the report since the table of contents provides a good overview of the entire document and, while the report is being written, provides an indication of which sections still need to be done.

Regardless of the order of the report, a chapter or an appendix (with tables and figures) should be written as soon as that part of the work has been completed, for example when some apparatus has been developed or set up, a section of theory has been derived, a computer program has been written, or a set of readings has been taken. It is also a good idea to give the written work to a fellow student or a supervisor as early as possible to criticize constructively. Some sections written as appendices in the early phases will remain appendices, while others will later be included in the main text and some will not be included in the final report.

It is important to keep in mind that report writing is an integral part of the thought process: it helps to define and order ideas and to derive well-considered conclusions so that further planning of the work can be undertaken.

3 External Structure

Professional technical reports are characterised by a scientific approach, typical external structure and formal style. This chapter discusses the recommended external structure and the way in which the scientific approach is reflected in this structure.

3.1 Sequence of Main Sections

The elements of a technical report, in their prescribed sequence, are:

Cover page
Title page

Abstract
Dedication
Acknowledgements
Table of contents
List of tables
List of figures
Nomenclature
Abbreviations
Introductory chapters(s)
Central chapters
Conclusions
References
Bibliography
Appendices

The "front matter" is the sections before the introduction section and the "back matter" is the sections after the conclusions section. The "body of the report" and the "body text" refer to the sections from the introduction section to the conclusions section.

The external structure does not only relate to the sequence of the elements, but also to the relationships between the elements and the importance and size of each. It is important that the emphasis be placed on the central chapters. A report is like a story: it must have a beginning, a middle and an end, but the middle is the actual story. The introduction must not be too long, and the central chapters must not be overpowered by the appendices. The conclusions should follow from the central chapters in a justifiable manner. In other words, the central chapters must present a systematic argument that leads to the conclusions.

The elements of a technical report are discussed separately below.

3.2 Cover Page

A cover page is only required for a printed document and not for electronic documents (for example in pdf format).

The purpose of the cover page is to protect and identify the report. It must contain the title, the initials and surnames of the authors, the date, the name of the department and university, and the emblem of the university.

The title of the report must be considered carefully. A good title is striking and clearly reflects the contents of the report. A few guidelines for the selection of titles are the following:

- Think about the reader’s first impression.

- Include important and distinguishing key words, for example the words that somebody will use in a literature search.
- Leave out any words that are not essential. Avoid meaningless expressions, such as “A Theoretical and Experimental Study of…”, or longwinded descriptions, such as “Concise Practical Guide for the Writing of Technical Reports and Papers”. Every word must count.

3.3 Title Page

The title page contains all the information given on the cover page, but, in the case of paper documents, the logo and footer are not repeated on the title page. For electronic documents (for example in pdf format), the logo and footer should be retained. Further, both paper and electronic formats, the status of the report (terms of reference) must be included, for example “Experimental Techniques Report: Project 1” or “Mechatronic Project 478 Final Report”. If an individual project is done under the guidance of a lecturer (for example a final year project or thesis), the supervisor must also be indicated, for example “Supervisor: Prof PJ Erens”.

3.4 Abstract

A short summary or abstract of 100 to 150 words must appear on the second page of the report. It must summarise the contents and most important findings so that the reader can decide whether he/she wants to read the rest of the report. A few guidelines for the abstract are given below:

- The abstract is not an introduction to the report. It often provides no background information.
- Every word is important. Limit the use of words that do not convey important information to a minimum, for example, do not say things such as “In this report, the failings of a compost turner are investigated”, but rather say “The failings of a compost turner are investigated”.
- Convey the key elements of the objective and context, and the most important methods, findings and recommendations.
- The abstract is usually the last part of the report to be written.
- Include in the abstract the keywords that someone may use to search for the report in a literature database.

In certain technical environments, an Executive Summary is given instead of an ordinary abstract. Executive summaries must be brief, but can be more than one page long, and provide sufficient quantitative information so that a manager can

identify the most important decisions arising from the report and grasp their extent and impact.

3.5 Dedication

This is a short sentence, in the middle of a separate page, in which the report is dedicated to a family member, friend or acquaintance. It may be left out and is seldom included in short technical reports. It is more suited to theses.

3.6 Acknowledgements

In this section, other people or organisations that were directly involved in the execution, presentation and financing of the project or report are acknowledged, such as technicians, typists and institutions that provided money or made facilities available.

3.7 Table of Contents

The table of contents must begin on a new page. The page is provided with a heading, such as “Contents” or “Table of Contents”, followed by a list of the three main levels of headings and their page numbers. Journal papers do not have a table of contents.

Regarding the front matter, two approaches are acceptable: In the first approach, all the headings of the front matter are included in the table of contents (for example Abstract, Dedication and Acknowledgement are included, with their page numbers). The Table of Contents heading will normally not be included in the table of contents itself. In the second approach, the first item in the table of contents is the first heading that appears after the table of contents, for example List of Figures. In the second approach, therefore, front matter that precede the table of contents are not listed, but front matter that follow after the table of contents are listed.

Appendices must be listed in the table of contents, each with their title and starting page.

3.8 List of Tables and List of Figures

These lists, arranged according to the table and figure number, each begin on a new page and indicate the relevant page number in the right-hand column. The titles of tables and figures must be descriptive enough so that a specific figure or table can be identified in the list and must correspond to the title used for the figure or table in the text.

3.9 Nomenclature

The list of the symbols that are used must begin on a new page. The list is arranged in the following sequence: All the ordinary symbols are listed first, followed by the superscripts and then the subscripts. Finally, the auxiliary symbols, for example overbar and underscore for vectors and averages or accent marks for time-dependent components, are listed. The following order must be used within each of these groups:

- Firstly all the Roman letters (in alphabetical order, with the capital letter of each symbol before the small letter, for example “A” followed by “a”, followed by “B”);
- Then all the Greek symbols (in the order of the Greek alphabet, capital letters before small letters);
- Finally, the symbols that begin with numbers, in numerical order.

Note: do not list units (like m, mm, kg) or standard mathematical notation (like e and π) in the nomenclature.

Units need not be given for nomenclature defined in this section, because the symbol represents a physical property that is independent of the system of units, while the units are related to a value attributed to the property. If units are given in the nomenclature to illuminate the symbols, a column heading must be provided to indicate that the units are "typical units".

A given report should use one of the following approaches consistently:

- All symbols are defined in the nomenclature list and also where the symbols are used first in the report; or
- All symbols are defined in the nomenclature list and never where the symbols are used first in the report; or
- All symbols are defined where the symbols are used first in the report and there is no nomenclature list in the front matter. This last approach is only appropriate in a short document that contains only a few equations and symbols, and the symbols are only used near where they are explained.

A consistent set of symbols should be used (for example do not use V, C and W for velocity, unless there is a consistent difference, such as V for relative flow velocity, C for absolute flow velocity and W for blade velocity). If equations are taken from sources that use other symbols, the symbols should be “translated” into the set that has been selected for the report.

3.10 Abbreviations

A list of abbreviations is only given if the body of the report uses many abbreviations that are not common technical knowledge or general knowledge. If the list is included:

- The list must begin on a new page.
- The list must be arranged alphabetically.
- All abbreviations defined in the text must be included (it is all or nothing).

3.11 Introduction

The introductory chapter or chapters should provide the reader with the following information:

- The context in which the report originated, including the work from which it originated, how it links to/differs from preceding or related work, the limitations that were placed on the work (as a result of external circumstances or through own choice), and so forth;
- The purpose of the report, such as the problem that was examined and the specific objectives of the work;
- The motivation for the work or report, that is, why the work was undertaken.

A good strategy to describe the background is to use the "funnel principle": start by describing the broad background ("big picture") and gradually move to the more specific context of the report. If it is relevant, the introduction will contain a general overview of previous work in the field and definitions of words or expressions that have a specific meaning in the document. An overview of the rest of the report is sometimes also provided.

In long reports, such as theses, the aforementioned content can be spread across more than one introductory chapter, but it should be kept in mind that the objectives of the work should be readily recognisable.

Particular care should be taken when formulating the objectives. The objectives should be stated in such a way that the Conclusions section can answer the following question "Has the objectives been reached?" The objectives should be distinct from the strategy to achieve the objectives, unless the evaluation of the success of a specific strategy is in itself an objective.

3.12 Central Chapters

The structure of the central chapters depends on the contents of the report. Typical contents of the central chapters for various cases (for example design reports and experimental reports) are given in the appendices.

The following are general guidelines for the central chapters:

- Every chapter should be focused on one topic. In other words, it should have a single, clear purpose. The title of the chapter normally reflects the purpose.
- The contents of the central chapters must remain strictly linked to the purpose of the report. Contents that are only of marginal importance should preferably be placed in the appendices.
- The following structure of chapters or within chapters can usually be followed and corresponds to a scientific approach:
  - Introduction: the purpose of the chapter, and how it links to the purpose of the report;
  - Underlying or simplified assumptions;
  - Analytical or numerical theory used, or the procedure for the investigation;
  - Measured results, results of the analysis or observations (verifiable results);
  - Processing of results: method and answers (objective);
  - Interpretation of results (subjective, but critical and well-motivated);
  - Conclusions: usefulness and importance of results; how the results contribute to achieving the purpose of the report.
- The central chapters do not usually follow the chronological sequence of the project.
- Each conclusion drawn in the conclusions must be corroborated in the central chapters.

3.13 Tables and Figures

This section focuses on the editorial and layout aspects of tables and figures, but starts with a few general guidelines for their use. More detailed guidance on the way to represent information in graphs is given in Appendix G.

Tables are used for quantitative comparisons, when the differences between lines on a graph will be too small, or when the relationship between the dependent and independent variables is not clear. Figures (drawings, sketches, graphs and photos) can usually be more easily interpreted by the reader than tables and are therefore preferable when the more qualitative nature suffices.

The following are general guidelines for both tables and figures:

- Each table and figure must have both a number and a caption. Figures are numbered as a single series and tables as another. The number of the chapter or paragraph can be used in the table or figure number (for example Table 2.1 or Table 3, and Figure 1.1 or Figure 2).
- Table captions are placed above the table and those for figures are placed below them.
- The text of the report must refer to each table and figure, but the text in the body of the report (the part from the introduction to the conclusions) should only in exceptional cases refer directly to figures or tables in the appendices.
- Tables and figures in the main text must be placed on the page where the first reference is made to it, or as soon as sensibly possible thereafter.
- If the layout of the table or figure is such that it needs to be rotated to fit on the page, the bottom of the table or figure must be placed on the right-hand side of the page.
- Tables and figures in the main text must be separated from the text by at least 2 open lines above and below the table or figure.
- A capital letter must always be used when a specific table or figure is being referred to, such as Table 2 and Figure 5. The abbreviation “Fig.” may be used in the caption of the figure.
- The text in the tables and the writing in the figures must not be smaller than 3 mm, and preferably similar to that of the report's text.
- It is a good idea to repeat the data used for all the graphs in the report, in tabular form in an appendix, for future use.

The following are general guidelines for the tables:

- Each column, and sometimes also every row, must have a title, with units if applicable.
- Tables in the main text usually do not have more than a few rows because they otherwise contain too much information and can impede the comfortable reading of the report. Larger tables should rather be included in appendices.

The following are general guidelines for graphs:

- The axes of a graph must be named in words, in conjunction with units.

3.14 Conclusions

The purpose of this section is to make it clear to what extent the purpose of the report was achieved and which findings were made. All statements in the Conclusions must be supported in the report.

The conclusion should:

- Outline how the document addressed the purpose of the document/project.
- Discuss to what extent the purpose was achieved. Summarise the most important findings or results.
- Discuss the implications of the findings, with emphasis on the most important findings. If the document is for a research project, this discussion should include how the document contributes to other related research. In engineering documents, this discussion normally includes the practical implications of the work presented.
- Outline the limitations of what was presented and suggestions further work to address those limitations, if appropriate.

3.15 List of References

The in-text references and list of reference are important elements in academic and engineering writing. The next two subsections consider two systems of references and their corresponding reference lists. Each system consists of two parts: the reference in the text, and the reference in the list of references. It is important to note that only references that were cited in the text may be included in the list of references, and vice versa.

The list of references is normally placed at the end of the main report, just before the appendices if there are appendices. In the past, the references section was sometimes placed after the appendices, at the end of the document, but that practice is now rare.

Unless other instructions have been given for the specific report, the alphabetical system is recommended.

3.15.1 The alphabetical system

Appendix F gives an excellent summary of the topic of references and examples of applying the alphabetical system.

An important advantage of the alphabetical system is that the references are completely independent of one another: any one can be taken out or added without influencing the others. This is particularly useful when new references come to light while a report is being compiled. Furthermore, readers who are familiar with the literature can often recognise the names of the authors in the text.

3.15.2 The numerical system

In this system, references in the text are indicated by numbers (in the order of their first appearance) in square brackets and in the list of references they are

arranged numerically. In other words, the first source referred to in the report, is [1] and the second is [2], without regard for the names of the authors or the date of publication. In the list of references, the references are listed in numerical order, but formulated similarly to the method used in the alphabetical system, except that each reference begins with its number and the year of publication is placed just before the page numbers.

3.16 Bibliography

In some schools of thought, a bibliography is a list of sources, usually books, that provide a broad background on the topic, but to which no specific reference is made. Only comprehensive technical reports and books have such bibliographies. It is rarely seen in engineering students' writing.

However, other schools of thought apply the term "Bibliography" to what is referred to above as the "References". However, large publishers of engineering literature like IEEE and Elsevier use the term "list of references".

3.17 Appendices

Details that disturb the flow of the main text, and particularly detail that does not form an integral part of the main text, must preferably be provided in the appendices. Examples of this are complicated technical derivations, detailed descriptions of apparatus, computer programs, lists of unprocessed data, sample calculations and concise commercial information (data sheets).

Just as in a chapter, every appendix must have a descriptive title.

The appendices are numbered “Appendix A”, “Appendix B”, etc. Examples of numbering are: page numbers “B1”, Table A1, Figure C2. In shorter reports, the page numbers of the appendices can follow on from those of the main report.

References in the appendices refer to the list of references of the report as a whole, unless the appendix has its own separate list of references.

4 Microstructure

The previous chapter discusses the macrostructure (the typical sequence of the main elements of a technical report), but the structure of a report goes much deeper. Every chapter, and even every paragraph, also has a structure. Just as the report must have an introduction, central chapters and a conclusion, each chapter must have an introductory section, a central section and a conclusion. Even a paragraph can have an introductory sentence, a central section and a concluding sentence, although the structure of paragraphs can be more varied. Furthermore,

just as the entire report has a central purpose or theme, a chapter and a paragraph should also have a specific purpose.

Paragraph structure is a specialised topic in its own right and cannot be completely dealt with in this report. A few guidelines for paragraphs and sentences are given here:

- A paragraph ideally should not be longer than 10 lines, because readers seldom read long paragraphs.
- It is usually a good idea to begin a paragraph with a theme sentence or to place the theme sentence prominently. The theme sentence states the purpose or theme of a paragraph.
- It is possible to distinguish between different types of paragraphs in terms of their purpose, for example the introductory paragraph, the explanatory paragraph, the linking paragraph and the concluding paragraph.
- The consecutive sentences of a paragraph, as well as the phrases in a sentence, must be linked to one another. A communal purpose or argument is a prerequisite for coherence. Markers (words that indicate the direction in which an argument is moving) play a very important role in this regard. Examples of markers are “except for”, “therefore” and “for example”.
- Place the main idea of a sentence in the main phrase.

A continuous theme in good report writing is to always approach the report from the point of view of the reader. The person who writes the report must therefore continuously ask how a reader will understand what he or she reads in the report. However, it is very difficult for writers with little experience to notice their own mistakes.

The consultation service offered by the Writing Laboratory of the University’s Language Centre is the ideal opportunity for students to learn how to write reports with a good microstructure early in their careers.

5 Style

A characteristic aspect of technical reports is formal and concise language use. As in the case of microstructure, style is a wide-ranging and complicated topic. Readers are encouraged to study sources such as that by Strunk and White (1979). Some of the important guidelines for style in technical reports are:

- Use only the third person. If unavoidable, the authors can be referred to as “the authors”, but this should only be done as a last resort.
- Each sentence must be a complete sentence: it must contain at least a subject and a verb, and often also an object.

- Do not link two sentences by means of a comma. Use commas sparingly.
- Active sentence construction is usually more striking that the passive construction.
- Use the present tense for something that is still valid, but the past tense for something that happened in the past or is no longer valid.
- Use the right word, not its second cousin (widely attributed to Mark Twain). This statement is of particular importance in relation to technical terminology. The reader's confidence in the technical ability of the author will be greatly impaired if the author does not use the correct terms.
- Sweeping statements must be avoided, since they indicate that the author is uncertain or not knowledgeable.
- Waffling, photographs of trivial details and irrelevant appendices are not at all permissible. The reader's time is precious and the thicker the report, the less positive his/her initial attitude will be to the report.
- It is important that the author keep the reader and his/her interests in mind. Remember, engineers are interested in results, not excuses: what was done, how was it done, and what does it mean? Nevertheless, it sometimes is necessary to briefly mention the problems that were experienced and the methods that did not work, but only if this will prevent the mistakes from being repeated. When in doubt, leave it out.
- The technical level of the language used must be adapted to the target reader. The target reader of undergraduate reports is a final year student in Mechanical or Mechatronic Engineering at another university.
- Avoid the extremes of banal expressions and pompousness.
- A writing style in which the author gives his/her reader instructions, for example "Add eq. (3) and (4)", should be avoided.
- If terms or names are abbreviated, the unabbreviated version must be given with the abbreviation where they are used for the first time in the body of the report, for example "Coherent Anti-Stokes Raman Spectroscopy (CARS)". This first use in the main body is required even if a list of abbreviations is provided in the front matter. After an abbreviation has been introduced in this way, only the abbreviation should be used in the remainder of the report. However, note the following exceptions:
  - Abbreviations should be avoided in headings.
  - Common language abbreviations, such as "e.g." and "etc." need not be defined at first use.
- Common abbreviations should preferably be written out ("for example" rather than "e.g.").

- Bulleted lists are used in technical reports only when all the items in a list are of equal importance and when the sequence is not important. Bulleted lists should be used sparingly.

6 Layout

6.1 Margins, Fonts, Page Numbering and Headings

Table 1 and Table 2 give the particulars of a widely accepted formatting scheme for technical reports. Draft reports may alternatively be printed at one-and-a-half spacing on A4 paper with margins of at least 25 mm.

The pages of the chapters and appendices must be numbered in the centre at the bottom using Arabic numerals (1, 2, …). The start of Chapter 1 (usually the Introduction) must be page 1. Pages before this are numbered in small Roman numerals (i, ii, iii, iv, ...), with the Abstract on page i.

The format for the headings of chapters, sections and subsections must be as in this report. Every attempt should be made to avoid requiring more than three levels of headings. Note that the main text of a report may not be in more than one type of font and the headings should all be in the same font, although the headings' font may be different from the text. Furthermore, it is very important that the layout throughout the report must consistently remain the same, for example with regard to the use of capital letters in the headings and spacing between paragraphs.

Table 1: Acceptable Page Layouts

Paper size	Margins	
	L/R [mm]	T/B [mm]
A4	35/35	26/44
A5	17/17	22/22

Table 2: Acceptable Letter Sizes and Line Spacing

Font	Paper size	Letter height* [pt]	Line spacing* [pt]
Times Roman	A4 A5	12 10	single or 14 single or 12
Arial	A4 A5	11 9	single or 14,4 single or 11,8
Computer modern	A4 A5	12 10	single or 14 single or 12
Charter	A4 A5	11 9	single or 13,6 single or 11,1
Calibri (Body), Cambria (Headings)	A4 A5	12 10	single or 14 single or 12

* Headings may be larger, but not smaller

6.2 Equations

Equations must be numbered sequentially, either 1, 2 …, or per chapter 1.1, 1.2 … and 2.1, 2.2 …. The second method makes it easier to write chapters independently of one another.

An equation must read like part of a sentence in the text. Two approaches to punctuation with equations can be used:

- According to the Chicago Manual of Style, if the equation is not in-line with the text, it must be followed by appropriate punctuation: for consecutive equations, all except the last one should be followed by a comma, while the last one is followed by a period if it is the end of the sentence. If one equation is split over multiple lines, there should be no punctuation added, except at the end of the equation.
- It is also acceptable to omit punctuation from the equations that are not in-line with the text, as seen in many text books.

One document should consistently use one of these punctuation styles.

The two acceptable formats for equations with a numerator and denominator are illustrated in the next two equations (note the vertical alignment of the punctuation after the superscript):

$$A/b = x^2/ (u + v)^{0,5}\,, \tag{1}$$

$$\frac{A}{b} = \frac{x^2}{(u+v)^{1/2}}\,. \tag{2}$$

Occasionally long equations are more easily dealt with by dividing them up, for example:

$$A = x^2\,, \tag{3}$$

$$b = (u + v)^{0,5}, \tag{4}$$

$$y = A/b\,,$$

where A is the area of the square object. (5)

Note that the letters representing variables or constants must be in italics (sometimes symbols representing matrices and vectors are not in italics, but bold), while functions (such as the trigonometric functions) and units must not be in italics, as in the following examples:

$$x = \cos\,\theta\,, \tag{6}$$

$$g = 9{,}81\ \mathrm{m/s^2}\,, \tag{7}$$

$$a_i = \omega^2\, R_i\,, \tag{8}$$

$$\alpha_1 = 20\ \mathrm{rad/s}\,. \tag{9}$$

In equation (8), the subscript *i* is also a variable and therefore is written in italics, while the subscript 1 in equation (9) is not a symbol, and is therefore not written in italics.

A space should be left between parameters that are multiplied (to create a space in Microsoft Equation Editor, hold "Ctrl" down when pressing the space bar), as shown in equation (10). An "x" should not be used for a normal multiplication, since it can be confused with a symbol or the cross-product operator.

$$Nu = C\, Re^n\, Pr^{1/3} \tag{10}$$

All equations must be indented by at least 10 mm. It is often neater when all the "=" signs on a page are placed below one another, although a large number of successive equations that each consist of more than one line look better if they begin the same distance from the left. A space must be left on either side of each "=".

7 A Checklist

A few questions to be answered while the report is being finalised, follows:

7.1 Contents Related

1. Does the introduction clearly and unambiguously state what the purpose of the report is?
2. Do the conclusions logically follow from the central chapters and expressly address to what extent the report has achieved the purpose given in the introduction?
3. Are the title of the report and headings of the chapters, sections, figures and tables self-explanatory and concise? The table of contents, the list of figures and the list of tables, should tell readers what content they can find where.
4. Does each chapter give sufficient emphasis to the important aspects? Have unimportant aspects been de-emphasised?
5. Does each chapter and section contain only information directly related to the chapter or section heading.
6. Is each chapter, section, paragraph, phrase and word necessary and directly focussed on the report's purpose? Remove or shorten wherever it can be done without detracting from the report's purpose.
7. Has duplication of information (also in figures and tables) been avoided?
8. Is the transition between chapters and sections logical and made apparent to the reader?
9. Are all axis titles of all the graphs technically precise, and their units given?
10. Are units given for all numerical data, for example in the column headings of the tables? Do the number of digits given reflect the accuracy and resolution of the data?
11. Does the abstract state how the report/project originated or why it was done, what the report's/project's objectives were, what was done to achieve the objectives and what was concluded at the end?

7.2 Layout and Formatting Related

1. Does the report contain all the prescribed elements and do they follow the prescribed sequence?
2. Is the use of capital letters in the heading titles and captions consistent?

3. Do the table of contents and lists of tables and figures correspond to the headings in the text and of the tables and figures? Word processors can be used to set these up automatically.
4. Are the in-text references and the list of references written according to the prescribed format? Are all in-text references included in the References section, and all references in the References section cited in the text?
5. Are all tables and figures referred to in the text?
6. Are all cross-references to section, figure, table or equation numbers correct? If a word processor's automatic cross-references tools are used, are all the cross-references active (no "broken" reference errors; best checked in a pdf version of the document)?

8 Conclusion

This guide discusses the format for a technical report that is prescribed by the Department of Mechanical and Mechatronic Engineering and provides helpful hints on the structure and compilation of a report. The external structure was discussed in detail and a few guidelines were provided for the microstructure, style and editing.

Students who follow the guidelines in this report will soon be able to compile professional technical reports.

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Appendix A Guidelines for the Documentation of Experiments

A.1 Principles

Reproducible experimental results are one of the foundations of a scientific approach. The point of departure for the documentation of experiments is, therefore, that all information required for precisely repeating the experiment must be provided. Such a large amount of detail is, however, typically only recorded in internal laboratory reports. Reduced information on the experiment itself will be included in most other reports.

In all cases, sufficient information must be provided to prove that the experimental results are credible. Typical considerations here include that potential sources of bias were considered and, where possible, removed. Also, to be duly considered are the selection of what was measured, the measurement accuracy and the repeatability of the measurements. Note that the measured and processed results must be clearly distinguished from interpretations and conclusions. The results are preferably objective and can be expected to be repeated by other researchers (except possibly in terms of accuracy), while the interpretations and conclusions are subjective.

When documenting experiments, particular attention should be paid to the tenses used. Past tense should be used for aspects that were done (for example how the experiment was conducted), but present tense should be used for aspects that are still "active" (for example the implications of the results will usually still apply).

The following sections provide a list of topics that should be considered for inclusion in a report on an experiment. The nature of the experiment and the purpose of the report will determine which are appropriate. The proposed sections are typical for a "standalone" report or appendix that documents an experiment, but can also be used as guide for a chapter in a larger document, such as a thesis.

A.2 Abstract

If the experiment is documented in a standalone report, an abstract would normally be provided. The abstract should concisely give the main aspects of:

- Why was the experiment done (a very brief background).
- What was the objective of the experiment.
- How was the experiment done (very briefly mention only aspects of the materials and methods that are particularly significant or unusual).
- What were the most significant results and implications.

A.3 Introduction and Preceding Chapters

Note that in documents such as theses, a literature review and the theoretical foundations of the experiments should also be discussed, but the following sections assume that those discussions precede the description of the experiment. If the document is a standalone report, the introduction should describe the background of the work, as for any technical report.

A clear and explicit statement of the purpose of the experiment must be given. The formulation of the purpose should allow a clear decision to be made about the success of the experiment in the conclusions section. If the experiment is a chapter in a larger report or document, the relationship between the experiment and the overall object or report must be described. In other words, the text should make it clear how the experiment contributes to the objectives of the project/thesis.

The actual context that is being simulated in the experiment, must be described. The description can vary in length from a paragraph or two as part of the background description, up to a subsection on its own. In cases where theoretical aspects will be evaluated in the experiment, the theory should be explained, either as part of the experiment's documentation in detail in the next section, or in a prior chapter in the report. If relevant, other known solutions of similar cases, albeit analytical or experimental, should be described.

The motivation for and/or importance of the experiment must be given. This can be given as part of the context description, although the context is usually objective, while the motivation is subjective.

A.4 Literature Study and Theoretical Background

If literature is available that describe similar or closely related experimental work, that should be described here. Similar previous experiments can serve to confirm the validity or limitations of the experimental procedures used here and/or to validate the experimental results.

The theoretical background for the experiment, including the equations used, should be discussed.

A.5 Materials or Experimental Setup

Note that the Materials and Methods sections may be combined into one section titled "Materials and Methods".

The overall objectives of this section are:

- The selection of the experimental setup must be justified by explaining why it is suitable to achieve the experiment's objectives.

- The experimental setup should be sufficiently described that another researcher can repeat the experiment.

An experiment is intended to represent an actual situation, but it is only an approximation. The selection of the experimental setup, with the inherent simplifications and approximations therefore must be described and motivated.

An important part of the setup is the selection of the **parameters**, which must be defended, including the following considerations:

- What questions need to be answered to fulfil the experiment's purpose, and what parameters can be measured to answer those questions? How do the set parameters relate to the physical properties that are being investigated (a dimensional analysis and/or an order of magnitude analysis may be offered to support the selection of parameters).
- The parameters should be classified according to:
  - Dependent parameters: the values of these parameters are dependent on the other parameters. The values of some of these parameters are required to answer the above questions.
  - Controlled independent parameters: these parameters can be intentionally varied or maintained at preferred values, independently from other parameters; their values affect the values of measured parameters.
  - Extraneous independent parameters: these parameters are or cannot be controlled, but their values affect the values of measured parameters (for example environmental conditions).
- How can each parameter be measured? The accuracy (how close is the measured value to the actual value), repeatability (if the same actual value is measure repeatedly, how much does the measured result vary), resolution (how many significant digits can be given for the measurement) and signal-to-noise ratio of each parameter measurement must be evaluated. The same parameter can be measured in more than one way to improve the overall accuracy. Parameters measured as controls or comparators (for example measuring overall mass flow or support load) can also be considered.

If the experiment involves many parameters, it may be appropriate to use the statistical technique of "Design for Experiments" to decide which combinations of parameter settings to test, to thereby reduce the number of experiments to what is affordable.

When describing the setup, including the following should be considered, where relevant:

- Drawings of purpose-built apparatus, including:
  - Detailed dimensions.
  - Schematic layout drawings.
  - Positions of measuring points.

  - The parts of the environment that could have an influence on the results.
- Figures of a physical setup and schematic diagrams of information, material and/or energy flows can be useful. The figures usually should be annotated to indicate all elements that the text refers to.
- A small number of carefully selected photographs of the set-up (do not waste the reader's time with photographs of trivial details).
- Complete specifications for the equipment used, including:
  - Manufacturer, model no., series no.
  - Settings for the equipment used.
  - Calibration certificates with dates and the person or organisation that carried out the calibration.
- Documentation of calibrations.

The above focusses primarily on quantitative engineering parameters. However, if the experiment involves human subjects and if qualitative methods are used, such as surveys and focus groups, the choice of parameters and measurement methods must be in agreement with the selected methodology, as described in the next section. For qualitative research, the materials and methods discussions are often integrated into one section.

A.6 Methods or Experimental Procedure

Note that, as mentioned above, the Materials and Methods sections may be combined into one section titled "Materials and Methods".

Similar to the Materials or Experimental Setup section, the overall objectives of the Methods section are:

- The selection of the experimental procedure must be justified by explaining why it is suitable to achieve the experiment's objectives.
- The experimental procedure should be sufficiently described that another researcher can repeat the experiment.

The Methods section normally contains a chronological description of how the experiment was (or will be) done and how all of the data in the Results section were (or will be) obtained, including aspects such as:

- Preparations before commencing the collection of data, for example
  - Settings on the equipment used.
  - Calibrations.
  - Zero measurements before runs.
- The sequence in which independent variables were adjusted.
- The time allowed for stabilisation after changing independent variables.
- The sequence and frequency of measurements.
- The provision for determining repeatability and accuracy, for example zero measurements after runs.

The description should not be in an instructive style, but in a descriptive/informative style. Note that the processing of the measured data is usually discussed in the Processed Results section and not in the Methods section.

If experimental methods from a published study are used, they should include a citation and a summary of the procedure in the text.

Figures (including schematic diagrams and/or photographs) of the experimental setup should be used where sensible. If the text refers to an aspect in a figure, that aspects must be clearly identifiable. Annotations should be added to the figure if the aspect is not self-apparent.

When formulating the experimental procedure, sources of measurement error (for example signal noise, aliasing and bias) should be considered and countered, for example by randomisation, replication and repetition. It is advisable to consult a good textbook in this regard, for example Figliola and Beasly (2006).

In engineering work, safety considerations are often integral to the experimental procedure and safety-related parts of the experimental procedure should therefore be explicitly described. A risk analysis that supports the selected safety procedures can be included as an appendix.

For qualitative studies, an established qualitative research method that is well grounded in literature (for example appreciative enquiry, survey or case study) must be used and motivated as appropriate for the study question.

If ethical clearance was required and obtained for the research, the aspects relevant to the ethical considerations must be discussed.

A.7 Measured Results

All the raw (measured) data should be kept as record. If the amount of data allows, the raw data can be included in an appendix. Alternatively, it can be documented in a separate laboratory report or recorded in an online data repository that is used in the particular discipline. If the complete set of measured data is not included in the experiment report, it is customary to give a selection of typical data, giving preference to data that supports main or unexpected results.

When creating the record of the data, it is important to include sufficient "metadata" so that the record will be understandable even without the report in the experiment. This includes documenting the independent (controlled and extraneous) and dependent parameter values, with a description of each parameter (including whether it was an independent or dependent parameter) and the units used for the values.

Please note the advice regarding figures and tables given in the next section.

A.8 Processed Results

This is one of the most important sections in a report of an experiment because readers will usually first look at the experiment's objectives and its results, before deciding whether they are interested in reading the rest. Therefore, it is important that the main or most significant results are easy to identify, with figures and/or tables that are close to self-explanatory and that accurately convey the results.

The section must describe and defend the processing applied to the measured results to obtain the processed results. Note that this section should present objective observations of the measured results and should be repeatable by other persons. Interpretations of the meaning or implications of the results must not be introduced into this section.

This section should also give the basis for claims in the later section about the validity and accuracy of the experimental results. Validation can include comparisons with theoretical or previously published experimental results, repeatability achieved in the measured results and cross-validation between independently measured parameters. The accuracy (or error ranges) and resolution of the measured data should be reported.

Complete sample calculations should be provided, usually in an appendix (SMathStudio is a convenient tool for such sample calculations). Refer to the appendix titled "Guidelines for the Documentation of Derivations and Calculations" when documenting sample calculations. In experimental work, it is particularly important to ensure that the number of significant digits given in the calculated results correspond to the accuracy of the measurements.

Any statistical processing of measured data must be described in full, for example how averages were calculated, how outliers were treated and how error or confidence ranges were determined. The methods used to analyse the data must be statistically sound and appropriate sources must be cited for any statistical methods beyond the generally known ones.

When documenting the results in figures and tables, keep the following in mind:

- Ensure that the parameters that are plotted or tabulated are clearly defined, with units, ideally in the table or figure itself. Table headings and figure legends should be detailed enough that readers can understand the data without reading the main text because readers will often refer to a table or figure before reading the text.
- The number of digits for numbers in tables should reflect the accuracy of the data (for example do not give lengths to micron precision if the measurement accuracy was ±0,5 mm).
- Figures should, ideally, include measures of uncertainty, such as standard deviation or confidence intervals. Box-and-whisker plots are useful when the

independent parameter has discrete values. Error bars can be used on graphs with continuous independent variables.

- When the reader is expected to compare results, show those results in the same figure or in the same table. However, aim to avoid repeating results. If a figure is included in the main text, a table giving the same results (albeit more precisely) should be placed in an appendix.
- Avoid placing figures and tables that give trivial or peripheral results in the main text. A short textual summary of those results in the main text, possibly with quantitative results in an appendix, will normally be preferred.
- Avoid using tables with much data in the main text. Such tables should rather be placed in an appendix and, if necessary, a smaller table with an extract of the data can be given in the main text to support the discussion in the text.

A.9 Interpretations and Conclusions

This section gives a discussion of the implications of the results (the "so what"). It should emphasise the most important results and point out unexpected results. The discussion should critically evaluate the credibility of the results, typically with reference to the validation results presented in the Processed Results section. If the experiment is part of a larger project, the implications of the experiment's results for the larger project must be explained.

Note that the discussion in this section is usually subjective. It presents the opinion of the authors.

Appendix B Guidelines for the Documentation of Designs

B.1 Purpose and Principles

Professional accountability plays an important role in the compilation of design reports. The document must indicate that the engineer carried out the design with the appropriate care and judgement. The information in the report must therefore be such that a third party can review and evaluate the design.

Furthermore, the main purpose of a design must be reflected in the report, viz. that the needs of the clients were interpreted correctly and that the chosen design meets the needs.

Another purpose of a design report is that it can serve as the basis for later changes or improvements to the product. The report should enable the engineers who undertake any further development to avoid repetition of the design work previously done.

The following sections provide guidelines for the contents of design reports. All the aspects will be present in most design reports, although the level of detail will be determined by the circumstances.

B.2 Assignment and Background

- The designer’s assignment. All the relevant clients must be identified.
- The scope/boundaries/extent of the project. Interfaces with other projects. The system context (the surrounding systems or environment that interact with the product).
- Time framework.
- Design team.

B.3 Requirements

- The requirements (engineering requirements or design specifications) that the product had to satisfy. This can be stated in terms of functional requirements (what the product must do to fulfil the client's needs), non-functional requirements (such as reliability and maintainability) constraints (parameters that affect the design, but are beyond the influence of the design team) and performance metrics with target values (that conveys "how well" the product must perform the functional requirements).
- A derivation of the design requirements from the needs of the client (for example by QFD), particularly if there are multiple clients with conflicting requirements.
- Comparison with competing products.

B.4 Concept Development

- Describe the concept generation approach which must ensure that all reasonable concepts were considered.
- Evaluate the concepts using only the design requirements identified above.
- Provide a well-motivated elimination and selection of concepts. Discuss the most important selection factors and, if relevant, why other “obvious” concepts were not selected.
- Describe the selected concept in terms of function and layout.

B.5 Analysis and/or Testing of Performance

- Prove, to the extent possible, that **all** the engineering requirements were met.
- For each aspect:
  - Explain the aspect that is to be considered, for example a physical description of a part and the failure modes that will be analysed;
  - Explain all assumptions, simplifications and approaches;
  - Use explanatory sketches (indicate the notations on these);
  - Provide the analysis or describe the test, as well as the results.
- State conclusions explicitly, in other words, does the analysis or test indicate that the requirement was met
- Also follow the guidelines for the documentation of calculations, which are given in another appendix.

B.6 Technical Definition of Product

- Provide a complete description, for example set of assembly and detail drawings with bills of materials.
- Provide a precise description or specification of bought out components or subsystems, including the supplier, catalogue number and main dimensions or main performance parameters (for example 3 kW induction motor).
- Provide instructions for the entire life cycle of the product, for example assembly, maintenance and disassembly.

Appendix C Guidelines for the Documentation of Derivations and Calculations

C.1 Introduction

Only a few broad guidelines are provided here. There are a number of books on the subject, for example Gillman, L "Writing Mathematics Well, A Manual for Authors", The Mathematical Association of America, 1987.

C.2 Nomenclature

- List all symbols and their specific meaning. If necessary, refer to a figure that illustrates the symbol.
- Be consistent when using symbols: use the same symbol everywhere for the same variable, even if it comes from different sources.
- Use symbols that are commonly used.
- Eliminate unnecessary symbols. Nomenclature must make it easier for the reader!

C.3 Sample Calculations

- Repetitive instances: Show one calculation in its entirety, and only the input values and answers for the rest.
- If own computer programs or spreadsheet calculations were used, provide all equations and a sample calculation. If iterated, only show the final iteration.
- If software applications (such as FEM or CFD) were used, provide the complete input values and options that were used. Provide sample calculations of a simple, relevant case, as well as a comparison with analytical results, to demonstrate that the software was used correctly.
- Explain how the results were interpreted.

C.4 Paragraphing

- Keep the reader informed about what the calculation or derivation is aiming at and what route is being followed: before the calculation begins, explain what is being aimed at and fill in words between the equations that describe the route and why it is being followed (for example "To eliminate β, substitute (2.3) into (2.5)"). Provide direction-indicating words, for example "If" or "then the dynamic pressure can be expressed as follows:".
- State the conclusion explicitly after the calculation, for example "The calculated safety factor is lower than the selected limit".

- Equations must form part of the sentence. Symbols represent a word or a phrase and must fit into the flow of the sentence, for example “=” represents “is equal to”, or “which is equal to”.
- Use normal punctuation if the equation forms part of the sentence. If the placing of a full stop after an equation becomes confusing, change the structure of the sentence.
- Do not begin a sentence with a symbol.
- Put spaces before and after “=”, as well as between letters that represent different parameters. Do not use a full stop (“.”) or an “x” to indicate multiplication, unless it refers to a dot product or cross product in vector algebra.

C.5 Layout of Equations and Numerical Values

- Every equation can be numbered or, alternatively, only the last one in a derivation.
- Use a consistent numbering style, for example 1, 2, 3, … (one series throughout the entire report or appendix) or 1.1, 3.1., 3.2, …
- The number of the equation must be placed on the right-hand margin (use a right tab).
- Start 10-15 mm from the left margin.
- Place all “=” signs underneath one another if the equations are short enough.
- Calculations: First give the equation in symbols, then with the values substituted, and then the answer (WITH THE UNITS). Leave out the other intermediate steps.
- Derivations: State the assumptions expressly, say when previous equations are substituted and only show the most important intermediate steps.
- The number of digits must ALWAYS be in proportion to the accuracy. The number 2,13242 implies a precision of 0,001%!
- Provide a unit for each number, except inside equations.
- Use the technically correct and generally used forms of units, for example mm AND NOT cm, and stress in MPa or 10^6 Pa.
- Use SI wherever possible (see other appendix for guidelines).

C.6 Traceability

- Provide the sources of each equation, unless it is general knowledge. If conservation laws are used, only provide their name, for example “Energy conservation gives the following:”.
- Provide the sources of all material properties.

Appendix D Guidelines for Thesis Proposals

The particular content of a thesis proposal depends to a large extent on the thesis topic. The styles of thesis research proposals also can vary significantly. There are, however, general principles that all research proposals should satisfy, and these principles are outlined in this appendix.

The main focus here is on master's theses, but this appendix is also largely applicable to PhD dissertations. PhD students should note that the Engineering Faculty has particular requirements for PhD research proposals.

D.1 Purpose

A thesis proposal should always clarify what the research objectives and scope are, and clarify how the research will go about achieving those objectives.

A thesis proposal can also fulfil the following roles:

- It formulates a time frame required for achieving the objectives.
- It may form part of an agreement between the student, the supervisor(s) and the host department about what is expected from the student.
- It may be used as an agreement between a funder of the research and the student/supervisor(s)/host department.
- It may be used by a host department to ensure that the department can provide the context (facilities, budget, expertise, ...) required for the student's research.
- If an ethics clearance application will be submitted, the proposal normally has to accompany that application.

An indirect benefit to a student writing the proposal is that most of the proposal (typically sections D.1 to D.7) will be included in the thesis and, therefore, writing the proposal is the first step towards the major undertaking of writing the thesis.

D.2 Overall Structure

The cover page typically should follow the general guidelines given in this guide. The title page should give the thesis title, that the document is a thesis research proposal (as the terms of reference), the degree it is aimed at and the name(s) of the student and supervisor(s).

A thesis research proposal should contain a plagiarism declaration, an abstract and a table of contents, but other sections found in the front matter of longer reports or theses, are normally omitted.

The chapter-division (choice of headings and subheadings) is a matter of style and students should ask their supervisors' advice and recommendation in this regard. The discussions below can be used as guideline for chapter or subsection headings, but the focus here is primarily on the content, rather than on the structure.

D.3 Abstract

Primary function: *provide a concise summary of the proposal so that reader can determine the relevance of the proposal to their interests.*

The abstract should briefly describe each of the following (optionally, headings using the italics text can be placed in the abstract to create a "structured abstract"):

- *Research and application context*: other relevant research; the needs or gaps in the application context.
- *Purpose of the research*: the main/overall aims and objectives; significant limitations on the scope of the research, if any; the motivation can be implied by the aims and objectives or briefly summarised.
- *Method*: the research methodology or methods that will be employed.
- *Expected results*: the type of results that are expected; the practical and/or research value that the results are expected to have.

It may also be useful to add keywords to the end of the abstract:

- *Keywords*: three or four keywords; if these keywords are used in Google Scholar or Scopus, the results should give research that is closely related to that proposed here.

D.4 Background

Primary function: *explain the technical context of the research, including which technical fields the research relates to and how it relates to those fields.*

The background should enable the reader to understand where the research objectives fit into the broader technical field. The technical terms used in the objectives can therefore be used as indicators of what to discuss in the background.

An additional perspective on the function of the section is that it is *problem focussed* – as such, the section:

- Describes the broad problem: the origin/cause of the problem and how it has manifested in a given context.

- Describes why the problem is worth solving (in general) or, in other words, what the benefits or possibilities are that would be realised if the described problem is solved. If a motivation section is included later, avoid giving explicit motivations for the thesis' specific objectives here.

Follow the funnel approach: the discussion should start wide (or broad or general) and progressively narrow the focus to the specific research of the thesis. When considering how broad to start, assume that the target reader is an academic staff member in the host department or a peer. By the end of the background, the focus should be on the narrow context within which the project/research will be conducted. Figures can be used to aid the understanding of the reader.

The most significant literature relevant to the background, and closely related studies by the author's immediate predecessors in the research group, should be mentioned briefly. Please note:

- References should be given to background literature.
- Important, but complex, concepts can be introduced briefly in the background to the level necessary to understand the objectives. Forward references may be given to the literature review where a more complete discussion of the concepts is given.

D.5 Problem Statement, Aims, Objectives and/or Hypothesis

Primary function: *list and clearly define the thesis' problem statement, aims, objectives and/or hypothesis (here collectively referred to as "objectives"), in such a way that at the end of the research study, the thesis conclusion can scientifically assess to what extent the "evidence" presented in the thesis shows that the objectives have been met. In other words, the objectives must be clear, actionable and measurable.*

Secondary function: *define the scope the study, and also what will be excluded or what restrictions or prescriptions apply to the research.*

Additional function for PhD research: *describe the anticipated original contribution to a field of engineering science.*

The format of this material varies considerably between contexts. At least one of problem statement, aims, objectives or hypothesis should be included, but some contexts require a combination of these. Students should consult their supervisors about what is expected in their context.

As with any project, it is important to clearly identify the bounds or scope of the research. The limitations to the investigation imposed by time, financial and other constraints, and in terms of discipline and application areas, must be described.

The objectives of a research project can often be stated in one or more of the following formats:

- Define the objective in terms of something that must be developed to meet an identified need. The "something" can be, for example, a system, device, process or software application.
- Define the objective in terms of a hypothesis that is to be tested. The methodology and/or workplan parts of the proposal should then outline how the research will test the hypothesis by trying to prove and disprove it (both are required to test a hypothesis).
- The objectives can be formulated as one or more research questions to be answered.

Common errors in this section are that strategies to achieve the objectives or motivations for the objectives are mixed with a description of the objectives themselves. Unless an assessment of a specific strategy to achieve an objective is an objective in its own right, strategies should be addressed in the Workplan section.

D.6 Motivation

Primary function: *convince the reader that the thesis objectives are worth pursuing, highlighting the importance or value of the proposed contribution.*

This section should focus on the research objectives and not motivate what was stated in the background. The background is assumed as a given. The focus here should be on how achieving the study's objectives will contribute to addressing the overall problems/challenges described in the background.

A reverse funnel approach may be used, by starting with the immediate value of the intended research results and gradually expanding the discussion to the broader context.

D.7 Methodology

Primary function: *describe the strategy and tactics chosen to reach the proposed objectives, test the hypothesis (prove and disprove) or answer the research questions. Explain the approach, highlight important decisions, compare this approach to that used by other studies (how are they similar or different, and what are the implications).*

The format of this material varies between contexts and students should consult their supervisors in this regard. If such a distinct section is not explicitly included, the information should be integrated into the workplan. Also, in some cases, it would be more appropriate for the methodology to follow the literature review.

Note that this section is concerned with the research process (research design) and is not a workplan written in terms of tasks/activities. The methodology should give the reasoning that resulted in the workplan.

There are various established research methodologies that can be used to guide a student in formulating this section. Care must be taken to use appropriate words related to methodologies and technology readiness levels, such as "case study" and "prototype". The methodology presented in this section should reflect the correct meaning of such terms.

The methodology may include designs, experimental investigations, numerical simulations and/or analysis from first principles. Invariably, the results obtained from these approaches will have to be interpreted. The section should identify what research "tools" will be applied to achieve the objectives, and motivate why their use is appropriate. Remember that the research must enable firm conclusions to be drawn at the end of the thesis research. A critical evaluation of the capabilities, as well as limitations, of each part of the methodology will demonstrate a maturity of judgement.

During the formulation of the methodology, careful consideration should be given to ethics clearance and students should consult their supervisors in this regard. If the research will require obtaining ethics clearance, the methodology and workplan must take that into account, in particular the information that will be required in the ethics clearance applications.

D.8 Literature Survey

Primary function: *give a review of the work that others have done in the field relevant to the thesis objectives. In the proposal, a preliminary review is given, focussing on the literature directly relevant to the information given elsewhere in the proposal (as allowed by the available time; the review is expanded in the thesis).*

This section should show the supervisors (and, eventually, the examiners) that a student can

- identify the literature topics relevant to the thesis objectives, and
- effectively integrate and present information, from several sources, on each selected topic – identifying similarities and differences in the reviewed literature.

Note: This section should not include the student's own research or opinions, but rather objectively reflect the work done by others on the topic. It is usually recommended to add a section at the end of the chapter wherein the student discusses the presented review and places the student's intended work within this context. In other words, the last section should indicate what gaps in the literature

the proposed research will be aimed at or what prior research will be repeated for confirmation. If conflicting information was given by different sources, this discussion should indicate how the contradiction will be handled or resolved in the thesis research, for example by presenting arguments as to why the one point of view is selected above the other or by including a further investigation of the issue into the thesis research.

D.9 Workplan

Primary function: *identify the main activities of the proposed thesis research, demonstrate each activity's alignment with the methodology (unless obvious), and provide the basis for the resource requirements, schedule and risk assessment. The workplan must be specific to the objectives and generic statements must be avoided.*

For each activity, the proposal should describe what it will entail, how it will contribute to achieving the research objectives (how it relates to the methodology) and what will be the output or deliverable of the activity.

The workplan must be coordinated with other sections in the proposal, for example the activities must logically follow from the methodology and the time schedule (for example a Gantt chart) presented later in the proposal must have precisely the same activities. The activities should be subdivided or described in sufficient detail so that the time and resources required for the activity can be deduced.

D.10 Resource Requirements

Primary function*: identify the resources (including operating and capital costs, facilities and equipment) that will be required to complete the research, so that stakeholders (for example the supervisors and the host department) can determine whether sufficient resources are available.*

If appropriate (students should consult their supervisors), this section can consider the requirements for each activity identified in the workplan or, alternatively, consider the research study as a whole.

D.11 Project Schedule

Primary function*: determine how much time may be spent on each activity to achieve the thesis objectives within the deadline agreed with the supervisors. If the study requires access to resources shared with others, the schedule will also indicate when these resources will be required.*

A Gantt chart is commonly used to convey the schedule. The activities identified in the workplan should be used verbatim in the Gantt chart.

Ample provision must be made in the planning for the formal “writing up” of the thesis and for supervisors to review drafts of the thesis. A guideline for the time required is two hours per page for writing up after the work being documented, has been completed. Students should ask their supervisors for estimates of the time required for reviewing drafts.

D.12 Risk Assessment

Primary function*: identify all the risks that may prevent the successful completion of the research and describe how these risks are mitigated.*

Focus on substantial, non-obvious risks, for example:

- The workplan makes certain assumptions that entail risk, for example that ethics clearance will be obtained by a certain date. The mitigation could be to ensure enough time is included for revision of the ethics clearance proposal in case it is refused in the first attempt.
- The availability of facilities or funding critical to the research is uncertain. The mitigation could include measures to ensure availability or gaining access to alternative facilities or funding.
- The research relies on expertise other than that provided by the student or supervisors. The mitigation could include measures to ensure availability of an expert or gaining access to alternative experts.
- The execution of the research could cause significant safety hazards. The mitigation could include ensuring that all relevant statutes and regulations are abided by and/or providing additional time the schedule to accommodate/minimise hazardous contexts.

D.13 Conclusion

The proposal should conclude with a clear statement of the main contributions that the thesis can be expected to make to the body of scientific knowledge: What will someone who has read and understood the thesis be able to do with the knowledge and insights? At this stage the contributions will still be vague, but they should refer back to the objectives and research questions.

The proposal's conclusion should also give a sense of the student's confidence that the proposal will enable achieving the research objectives, and motivate that confidence.

Appendix E Guidelines for the Use of SI Units

E.1 Introduction

South Africa changed to the use of SI units in the 1960s. This system is generally used in Europe and increasingly in North America. The following references are valuable:

- The International System of Units, 7th ed, 1988.
- SABS M33a, The International Metric System.
- Els, DNJ, 2003, Guide for the Use for the International System of Units, Dept of Mechanical Engineering, Stellenbosch University.

A few guidelines for the elimination of common mistakes are given in this appendix.

E.2 Writing Style

- SI units are written in normal letters (not *italics*).
- Abbreviations: lower case letters, unless derived from a proper name. No full stop after the abbreviation, unless at the end of a sentence.
- Written in full: lower case letters, unless the first word in a sentence.
- No plurals.
- Combination of abbreviations:
  - N m or N·m (space or half-high dot)
  - m/s or $m \cdot s^{-1}$
  - $m \cdot kg/(s^3 \cdot A)$ or $m \cdot kg \cdot s^{-3} \cdot A^{-1}$
- Prefixes: become part of the symbol (MJ kg^{-1}) and are never used on their own (correct: $10^6/m^3$; incorrect: M/m^3).
- Leave a space between the number and the unit, for example 3,4 km and not 3,4km. The space should be a "hard" space, that is a space that is not stretched by line justification. In MS Word, a hard space is entered by typing Ctrl-Shift-Spacebar.

E.3 Basic Units, Prefixes and Derived Units

- The SI has 6 basic units: metre, kilogram, second, ampere, degrees kelvin and candela.
- The following are the preferential prefixes in SABS M33a: tera (T), giga (G), mega (m), kilo (k), milli (m), micro (μ), nano (n), pico (p), femto (f) and atto (a)
- Derived units that are permitted by SI:

plane angle	radian	rad
solid angle	steradian	sr
frequency	hertz	Hz
force	newton	N
stress, pressure	pascal	Pa
energy, work	joule	J
power	watt	W
electrical charge or flux	coulomb	C
magnetic flux	weber	Wb
electrical potential	volt	V
electrical resistance	ohm	Ω
inductance	henry	H
capacitance	farad	F
conductance	siemens	S
magnetic induction	tesla	T
luminous flux	lumen	lm
illumination	lux	lx

- Non-SI units that are accepted for use together with SI units:

minute	min	60 s
hour	h	
day	d	
degree	°	(π/180) rad
minute	'	(1/60)°
second	"	(1/3600)°
litre	L	10^{-3} m^3
metric ton	t	1000 kg

TAKE NOTE: the abbreviation for litre used now is a capital L, and no longer the cursive lower case letter.

E.4 Decimal Point or Comma?

SABS M33a prescribes that the decimal comma must be used, and a small space between thousands, for example 123 456,23. However, in many international journals, the use of a decimal point is prescribed. Both formats are therefore acceptable in engineering reports. However, consistency is always required, that is, within a given report, either the decimal point or the decimal comma must be used consistently.

Appendix F Referencing and Plagiarism

The various referencing systems in common use all consist of two parts: the reference in the text, and the reference in the list of references. This appendix first gives general guidelines and then gives examples for the Harvard referencing system (alphabetical system) applied to various cases typically found in technical writing.

For a more complete list of different types of sources, see the Referencing Guide on the Stellenbosch University Library website:
https://libguides.sun.ac.za/c.php?g=743000

F.1 General Guidelines

F.1.1 When should a Reference be Given?

The scientific approach requires that every piece of information (for example statement, definition, equation, figure, data or other intellectual property) in the report must satisfy one of the following:

- The information is obviously true or is general knowledge (for example, commonly included in junior undergraduate text books such as Newton's laws, the laws of thermodynamics or the Bernoulli flow equation). Such information are usually not cited.
- The information is proven or motivated to be true in the report itself. No citation needs to be given but if others have published similar information, it may be appropriate to cite that.
- One or more other sources of the information have reported the information. In these cases, references to the sources (wherever possible, the original source) should be cited.
- The report must make it clear that the information is conjecture (for example using phrases like "it is assumed that" or "it may be that").

In engineering and scientific writing, acknowledging sources is encouraged. The references point to sources where readers may obtain further information, and give credibility to the work presented when recent and authoritative sources are cited.

In the academic and research environment in particular, but also in general, it is very important to avoid plagiarism and self-plagiarism.

- Plagiarism is the use of the ideas or material of others without acknowledgement, thereby implying that it is the ideas of the author(s) of the report. Referencing is the accepted way of avoiding plagiarism. In other words,

referencing is used to give credit to the sources used when writing the report. Note that:

- Even if another's text is paraphrased or translated, it would be plagiarism if the source is not acknowledged.
- Using information or text generated by applications or websites for paraphrasing and content generation also constitutes plagiarism unless the source is acknowledged. In many academic contexts, the use of such tools would be unacceptable even if the source is acknowledged.
- If a source is quoted verbatim, the quote should be indicated expressly, for example by including the quote in quotation marks or by placing the quote in its own paragraph and using italics text.

- Self-plagiarism is the re-use of one's own previously evaluated or published material without acknowledgement or indication thereof.

F.1.2 What is a Good Source to Cite?

When considering whether a source is acceptable, the CRAAP test (Blakeslee 2004) is useful. CRAAP is an acronym for Currency, Relevance, Authority, Accuracy, and Purpose:

- Currency: is the information the most recent available and has it not been revised or updated?
- Relevance: is the information and, more importantly, the original intended audience relevant to the use of the information in the current report?
- Authority: can the author, publisher or sponsor be trusted?
- Accuracy: does evidence support the correctness of the information?
- Purpose: was the original purpose for publishing the information, acceptable (purpose can be, for example, informing, selling, entertaining, research or even self-gain)?

Note that the term "accuracy" as used in the CRAAP test, is different from the normal engineering use.

F.1.3 Placement of In-text References

The placement of in-text references is significant and the following options can be considered:

- The authors' surnames can be included as part of the sentence, followed by the date in brackets, for example: "Figliola and Beasly (2006) give a useful discussion of dependent and independent variables". Note that "and" is used between names when the names form part of the sentence, even if "&" is used in the reference list. Note, further, that many automatic referencing tools (such

as Mendeley) cannot create this format of reference and the automatically generated reference would have to be edited.

- The in-text reference can be given immediately after the relevant concept is mentioned, for example "The experimental procedure should include strategies to counter noise on the measured signals (Figliola & Beasly 2006), because such noise can have a significant impact on the accuracy achieved".
- The in-text reference can be given after the last period of a paragraph if the whole paragraph is attributed to the source and no other sources are cited in the paragraph, for example:

  > The experimental procedure should take into account whether a measured parameter is an independent of a dependent variable. Also, the procedure should include strategies to counter noise on the measured signal.(Figliola & Beasly 2006).

F.1.4 Formatting

The Harvard referencing system allows some variations, for example, in punctuation, in indicating the access date for electronic documents, in giving the URL for an internet site, in indicating page numbers and using "and" or "&" between authors' names. The golden rule for every report is that these stylistic aspects be consistent throughout the report. However, some environments do prescribe these details too and then these prescriptions should be adhered to.

F.1.5 List of References

In all referencing systems, every source used is cited in two parts: in the list of references and in the text. Specific examples of references as formatted in the Harvard system are given in the subsections below, but the general rule is that the list of references should give enough detail about every source used so that a reader can find the specific source.

All the authors of a particular source are given in the reference list. Sources by the same author(s) in the same year are distinguished by adding a, b, c, . . . after the year (2019a, 2019b, 2019c, . . .). In the Harvard referencing system, the list of references is sorted alphabetically according to the authors' surnames. If two sources have the same author(s), they are sorted by the year of publication.

Electronic sources can be identified by either the URL or the DOI (the Digital Object Identifier). The DOI is an assigned number that helps link content to its location on the Internet. The DOI is the preferred identification of a source and should always be given if available. Note that there is no full stop and no access date after the DOI in the reference list.

Do not cite an institutional repository's URL for a journal – cite the original publication.

When citing a PDF, avoid linking directly to the PDF. Instead, link to the page that hosts the PDF.

Latin abbreviations can be used for missing information:

- s.a. (*sine anno*: without year)
- s.l. (*sine loco*: without place)
- s.n. (*sine nomine*: without publisher's name; do not use s.n. if the author's name is unknown)

The above abbreviations should be formatted consistently with other Latin abbreviations, such as "etc." and "i.e.", in the report.

F.1.6 Unknown Authors or Authors that are not Natural Persons

Avoid using “Anonymous (Anon)” as author wherever possible. Rather cite the corporative author, if available, or use the title as “author” in the reference list.

A corporative author (the name of the company or organisation) is usually given when there is no individually named author. When alphabetising names of organisations omit articles (a, an, the) at the beginning.

Where an organization has an accepted acronym, the acronym can be used with the full name in brackets in the reference list. In the in-text reference, only the acronym can be given, for example, UNCTAD (United Nations Conference on Trade and Development).

F.1.7 In-Text References

The in-text references in the Harvard referencing system usually cite the author or authors (surname only) and the date of publication, as follows:

- For a single author: (Smith 2021)
- For two authors: (Smith & Williams 2021)
- For three or more authors – all the authors are given in the reference list and in the first in-text reference to the source; after that use “et al” in the in-text citation: Smith, Williams and Booth 2021 (first citation); Smith et al 2021 (further citations); if periods are used in abbreviations elsewhere in the report, then "et al." should be used. Italics should be used for "et al" only if all other abbreviations from other languages are written in this way (such as "etc." and "e.g.").

Page numbers may be added to in-text references for specific content (for example paraphrases, summaries, direct quotations, and figures and tables) taken from a larger source (for example a book) when it may be difficult for a reader to find the parts that are cited, for example "(Smith 2021:209)".

F.1.8 Secondary References

In some situations a source that is accessible (the secondary source) cites another source (the primary source) which is not accessible to the author of the report. In these cases, the report should cite in the text the authors of the secondary source, as well as the primary source's authors. A page number may be added to the citation of the secondary source, as for other in-text references. In the reference list, only the secondary source is included.

An example in the text is:

> For turbulent computations, the turbulence model of Baldwin and Lomax (1978, cited by Gordon & Smith 2003: 156) is employed.

The corresponding example in the reference list is:

> Gordon, R.E. & Smith, N.R. 2003. Computation of three-dimensional nonlinear panel flutter. *Journal of Aerospace Engineering* 22.1:155-166.

F.2 Books

Examples of typical items in the references lists are given below. Note that the name of the book is given prominence by writing it in italics.

F.2.1 Printed Book

> Callister, WD & Rethwisch, D. 2011. *Material Science and Engineering* 8th ed. Hoboken, NJ: Wiley.

F.2.2 Chapter in a Printed Book

> Holloway, L. 2010. Fiber Composites. In: Domone, P & Illistin, J. (eds) *Construction Materials. Their Nature and Behaviour* 4th ed. London and New York: Spon Press. 317-364.

F.2.3 Electronic Book (E-book)

If it is certain that an E-book has a printed equivalent or if it can be obtained from a publisher, it may be referenced in the same way as a print book. Otherwise, when referencing an E-book, it is necessary to include the details of where the book was found (online, library data base or E-book collection).

- Online in an e-book collection:

  > Bond, AR. 2015. Mechanics. *The Science of Machinery* [Online] Salt Lake City: Project Gutenberg. Available: https://gutenberg.org/ebooks/49445 [11 November 2022].

- Online in a library database (URL):

  > Monti, A & Benigni, A. 2022. *Modeling and Simulation of Complex Power Systems*. [Online]. Stellenbosch University Database – IET Digital Library.

Available: https://digital-library-theiet-org.ez.sun.ac.za/content/books/po/pbpo118e [11 November 2022].

- Online in a library database (DOI):

  Monti, A & Benigni, A. 2022. *Modeling and Simulation of Complex Power Systems*. [Online]. Stellenbosch University Database – IET Digital Library. DOI 10.1049/pbpo118e

- Referenced as a print book

  Monti, A & Benigni, A. 2022. *Modeling and Simulation of Complex Power Systems*. London, United Kingdom: The Institution of Engineering and Technology.

F.3 Conference Papers

Examples of typical items in the references lists are given below. Note that the name of the proceedings is given prominence by writing it in italics, but not the title of the paper.

F.3.1 Published in Conference Proceedings

Masendeke, DM & Basson, AH. 2016. Communication in a LabVIEW Based Holonic Controller. *Proceedings of the International Conference on Competitive Manufacturing*, 27-29 January 2016. Stellenbosch, South Africa. ISBN No: 978-0-7972-1602-0.

F.3.2 Unpublished Conference Paper

Ferguson, D. 2019. Who chooses who belongs: tactics and strategies in engineering classrooms. Unpublished paper presented at the Scholarship of Teaching and Learning Conference, Stellenbosch University, Stellenbosch, 26-28 October.

F.4 Journal Papers (Periodicals)

Journals, and in particular international research journals, are normally considered to be excellent sources to cite. However, be wary of "predatory journals" that superficially appear sound, but have inadequate review processes. Various resources to identify predatory journals are available on the web.

Typical entries in the list of references are given below. As for conference papers, the name of the journal is given prominence by writing it in italics, but not the title of the paper. The volume number, and issue number if available, should be given, followed by the page numbers. The examples show one format, but formats such as "Vol 42, No 6, pp725-743" are also commonly used. One consistent format must be used throughout a report.

If the paper has been pre-released online before it appears in a printed volume, then the volume, issue and page numbers are omitted if not available, and the paper number is added.

F.4.1 Printed Journal Articles

Bosdogianni, A & Olivari, D. 2007. Wind- and rain-induced oscillations of cables of stayed bridges. *Journal of Wind Engineering and Industrial Aerodynamics* 64: 171–185.

F.4.2 Articles in Online Journals

Note: Use the DOI whenever it is available. Online journal articles available in web page form only usually do not have page numbers.

Lindgren L-E, Edberg J, Åkerström JP & Zhang Z. 2019. Modelling of thermal stresses in low alloy steels, *Journal of Thermal Stresses*, 42:6, 725-743. DOI:10.1080/01495739.2019.1587329

Lindgren L-E, Edberg J, Åkerström JP & Zhang Z. 2019. Modelling of thermal stresses in low alloy steels, *Journal of Thermal Stresses*, 42:6, 725-743, [Online] Available: https://www.tandfonline.com /doi/full/10.1080/01495739.2019.1587329?src= [21 November 2022].

F.4.3 Online Pre-release Journal Articles with Paper Number

Human, C, Basson, AH & Kruger, K. 2023. A Design Framework for a System of Digital Twins and Services, *Computers in Industry*, 144, 103796. DOI:10.1016/j.compind.2022.103796

F.5 Theses, Dissertations, Final Year Project Reports

Dissertations and theses follow the same conventions as for the references for books, with the exception that the title of the dissertation or thesis, if unpublished, is not typed in italics. The university is given as the publisher.

F.5.1 Published

A dissertation or thesis is considered published when it is publicly available from a database such as ProQuest Dissertations and Theses Global or PDQT Open, an institutional repository (for example SUNScholar), or an archive. If the database assigns publication numbers to dissertations and theses, the publication number must be included in parentheses after the title of the dissertation or thesis without italics, for example:

Adam, J. 2017**.** *Development of a supplier segmentation method for increased resilience and robustness: A study using agent-based modelling and simulation.* Published doctoral dissertation. University of Kentucky. DOI: 10.13023/ETD.2017.416

F.5.2 Unpublished

An example of an unpublished report in the reference list is:

> Conradie, JP. 2005. Control of Thermal Deformation in Punch and Die Platens. Unpublished Mechatronic Report 478. Stellenbosch: Stellenbosch University.

F.6 Lecture Notes

Lecture notes are usually not good sources because it is difficult to access them other than enrolling for the course. Also, they have an unpredictable and typically short lifetime. However, if necessary or if the preceding caveats do not apply, lecture notes can be included in the references list as follows:

> Livermore, C. 2006. *Lecture 17: Stress Transformation*, lecture notes. 2.001 Mechanics and Materials 1, Massachusetts Institute of Technology, delivered 21 May 2006.

F.7 Data Sets or Data Files

For online data sets, include the accessed date and the URL.

> Statistics South Africa. 2022. *Manufacturing: Production and Sales: September 2022*. Statistical release P3041.2. [Online]. Available: https://www.statssa.gov.za/?page_id=1854&PPN=P3041.2 &CH=73155 [21 November 2022].

F.8 Figures and Tables

All figures and tables (or the data from figures or tables) from another source must be accompanied by a citation in the usual in-text format, normally at the end of the figure or table caption. If the original figure or table was altered in any way, that must be indicated by adding “adapted from" before the in-text reference, for example "(adapted from Ferguson, 2019)". A page number may be added as for other in-text references. References to figures and tables should be listed in the reference list.

Example in the text:

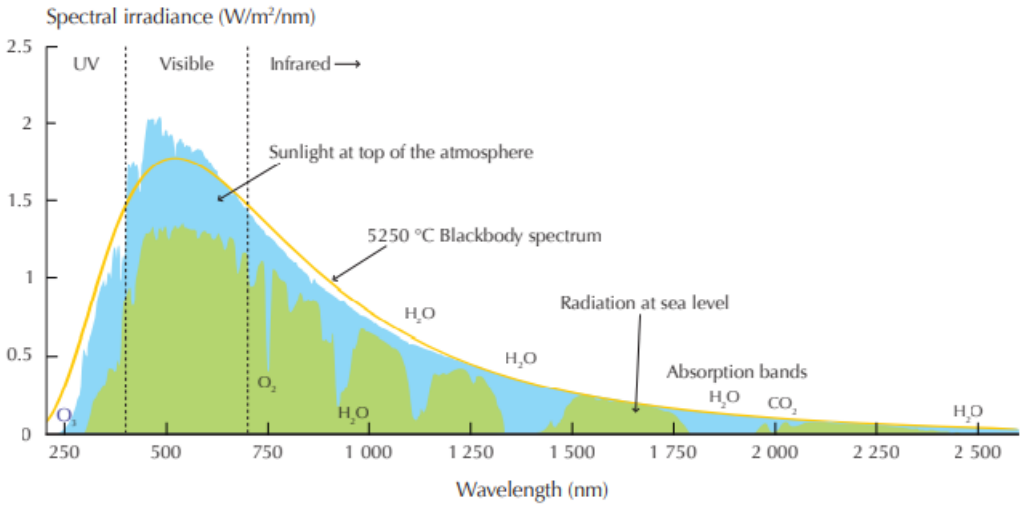

Figure F.1: Spectrum of Solar Radiation at the Top of the Atmosphere and at Sea Level (IEA 2011: 37)

Corresponding entry in the references list:

> IEA (International Energy Agency). 2011. *Solar Energy Perspectives*. [Online]. Available: https://www.iea.org/reports/solar-energy-perspectives [21 November 2022].

F.9 Global Organisation Publications

Examples of typical items in the references lists are given below. Note that the name of major documents (like reports) is given prominence by writing it in italics, but not the title of shorter documents like position papers.

Acronyms for organisation names should only be given if the acronyms are formally or widely used.

F.9.1 White Papers

> World Economic Forum. 2021. A Framework for the Safe and Efficient Global Movement of Batteries [White Paper]. January 2021. [Online]. Available: https://www.weforum.org/whitepapers/a- framework-for-the-safe-and-efficient-global-movement-of-batteries [21 November 2022].

F.9.2 Reports

> World Economic Forum. 2021. *Using technology to improve a billion livelihoods*. [Online]. Available: https://weforum.org/reports/using-technology-to-improve-a-billion-livelihoods [21 November 2022].
>
> UNCTAD (United Nations Conference on Trade and Development). 2021. *Technology and Innovation Report 2021*. [Online]. Available:

https://unctad.org/page/technology-and-innovation-report-2021 [21 November 2022].

F.10 Government Publications

Government publications include items such as government gazettes, acts and regulations. The authors are often government departments. Citing the relevant section of the act or paper in the text is appropriate when referring to particular content in these publications. Government documents are freely available online through a particular government's portal and, therefore, the relevant URL and the date of access information must be included as per usual website reference.

F.10.1 White/Green Papers

Republic of South Africa. 2020. White Paper on Fire Services. [Online]. Available: https://www.gov/za/documents/white-paper-fire-service-25-sep-2020-0000 [21 November 2022].

F.10.2 Legislation (Acts and Regulations)

- Statutes

Republic of South Africa. 1993. *Occupational Health and Safety Act 85 of 1993.* Pretoria: Government Printers.

Republic of South Africa. 1993. *Occupational Health and Safety Act 85 of 1993.* [Online]. Available: https://jutastat-juta-co-za.z.sun.ac.za/nxt/gateway.dll?f=templates&fn=default.htm&vid=Publish:10.1048/enu [21 November 2022].

- Regulations (published in the Government Gazette)

Republic of South Africa. 2009. *Occupational Health and Safety Act 85 of 1993: Lift, Escalator and Passenger Conveyor Regulations*. Government Gazette no. 33561, 17 September 2010. Available: https://www.gov.za/documents/occupational-health-and-safety-act-regulations-lift-escalator-and- passenger-conveyor-0 [22 November 2022].

The corresponding in-text reference could be:

According to section 3(1) of the Lift, Escalator and Passenger Conveyor Regulations (Republic of South Africa 2009), no person shall install or permit the installation of a new or used lift, escalator or passenger conveyor unless …

F.10.3 Reports

Department Forestry, Fisheries and the Environment, Republic of South Africa. 2018. *State of the Forests Report 2018*. [Online]. Available: https://www.gov.za/documents/state-of-the-forests-report-2018-5-aug-2022-0000 [21 November 2022].

F.11 Standards

Standards can be cited as follows in the references list (note that the standard number must be given after the title):

> SANS (South African National Standards). 2022. *Electric flexible cables with solid extruded dielectric insulation.* SANS 1574-5. Edition 1.2. Pretoria: SABS Standards Division.

The in-text reference may include the standard number, for example:

> The cabling in the system must comply with SANS 1574-5 (2022) or an equivalent international standard.

F.12 Patents

Governments issue numbered patents to give entities the sole right to produce, use or sell inventions. In the references list, the patent number must be given after the title, for example:

> Finatzer, KHN. 2012. *Conveyor Belt Patent*. (Patent: WO2012159130A2). [Online]. Available: https://patents.google.com/patent/WO2012159130A2/en. [22 November 2022].

F.13 Websites

If unavoidable, websites may be cited as sources. Because links to websites have an unpredictable and typically short lifetime, the organisation responsible for the information should be indicated, wherever possible. The date at the end of the citation is the most recent date on which the author of the report accessed the information at that website.

Typical entries in the references list are:

> FESTO. 2022. *Digital engineering tools*. [Online]. Available: https://www.festo.com/za /en/e/ products/digital-engineering-tools-id_650881/ [17 November 2022].
>
> Cranmer, Z & Schell, K. 2022. Investing in Wind and Renewable Energy for Climate Goals. [Online]. Available: https://doi.org/10.1287/orms.2022.05.10 [24 November 2022].

F.14 Multimedia

Sources such as YouTube should be used as a last resort because the quality of the information is not tested by the publisher. Ted Talks have somewhat more credibility. Examples of such items in the reference list are:

> Keplinger, C. 2019. *The artificial muscles that will power the robots of the future*. [Online]. Available:

https://www.ted.com/talks/christopher_keplinger_the_artificial_muscles_that_will_power_the_robots_of_the_future [21 November 2022].

Ansys Incorporated. 2019. *Noise, Vibration and Harshness Analysis*. [Video file]. Available: http://www.youtube.com/watch?v=FIJ3thJ319Y [22 November 2022].

F.15 Newspaper or Magazine Articles

The popular press can be cited, if the quality of the information is appropriate for the report. An example of such an item in the reference list is:

Campbell, R. 2022. First ever flight of a military aircraft using only sustainable fuel successfully conducted in UK. *Creamer Media's Engineering News*. [Electronic]. 21 November. Available: https://www.engineeringnews.co.za/article/first-ever-flight-of-a-military-aircraft-using-only-sustainable-fuel-successfully-conducted-in-UK-2022-11-21 [21 November 2022].

F.16 Personal Communication

Personal communication may include materials such as emails from unarchived sources, private memos or unrecorded interviews or conversations. Because the data of these sources cannot be recovered or is not publicly available, it is acceptable to cite these types of sources only in-text, with details in running text or in parentheses. Information can be given in the text to assess the quality of the information source, for example by giving the credentials of the persons who provided the information.

The required information is the person's name, position and affiliation, and the date/s of the contact. Also, the format the personal communication should be indicated, such as [Personal interview] [Telephonic conversation] [Email conversation] [Forum message]. An example in-text reference is:

During the interview conducted on 6 June 2018, Prof John Simmons (Department of Mechanical Engineering, Southfield University) stated that . . .

However, if required by the type of document created or the institutional rules, an entry can be included in the references list, for example:

Simmons, J. 2018. Professor in Mechanics, Southfield University. Personal interview. 6 June 2018.

F.17 Software

Software can be cited as follows in the references list:

MATLAB version 9.7 R2019b, 2019, computer software, The Mathworks Inc. Natick, Massachusetts.

F.18 Manuals and Data Sheets

Technical manuals, data sheets and specifications are increasingly only published online. Examples of such items in the references list are:

> Dell Technologies. 2022. *Latitude 3480 Owner's Manual*. [Online]. Available: https://www.dell.com/ support/manuals/en-za/latitude-14-3480-laptop/ [17 November 2022].
>
> Priority Wire and Cable. 2021. *Aluminium Conductor Steel Reinforced*. [online]. Available: https://www.prioritywire.com/specs/ACSR.pdf. [9 November 2022].

Appendix G Guidelines for Graphs

Graphs are commonly used in technical reports to show trends and relationships. They can convey a wealth of information in a compact and easily understandable format. However, as with all parts of a technical document, care must be taken when using graphs to convey information as precisely as possible. It is therefore very important to take some fundamental aspects of graphs into account. This appendix gives guidelines for the correct use of graphs. It should be noted that the default settings in some commonly used software (like Excel) are usually incorrect for scientific graphs.

"Fundamentals of Data Visualization" by CO Wilke is a recommended text in this area. The book is published by O'Reilly, but the author has made a version of the book available on his website.

In this appendix, for brevity, y is used to refer to the property represented by the vertical axis, and x for the horizontal axis.

One of the most important aspects of graphs is whether the data should be displayed using markers, lines and/or other symbols. Sections G.1 to G.3 give guidelines for determining whether a representation is appropriate for the type of data displayed. The last section gives guidelines for other aspects of graphs.

G.1 Markers and Bar Charts

Discrete markers, such as dots and crosses, are used to show discrete data points, for example data measured or observed at discrete intervals. An example is shown in Figure G.1. Where-ever appropriate, error bars should be shown with markers (see section G.3) to show the accuracy or uncertainty of the data.

A linear or logarithmic x-axis should only be used if the x-property is continuous, such as mass and speed, even if the data was only sampled at discrete values. Bar graphs are only appropriate when the horizontal axis represents discrete values or non-numerical properties. Figure G.2 gives an example.

G.2 Lines and Curves

Straight lines or curves should be used to show continuous relationships.

Lines should rarely be used to join measured data points, since the measured points normally contain errors which should not be transferred to the lines. It is usually more appropriate to fit a continuous relationship (for example a straight line, quadratic polynomial or exponential function) to approximate the experimental data and then plotting that relationship (as shown in Figure G.1). The legend, an annotation or the text of the report must explain what the precise

meaning is of what was plotted and, if applicable, how the continuous relationship was obtained.

An exception to the previous guideline is, for example, when there are so many data point that the markers will obscure neighbouring data points. In such cases drawing straight lines between data points, without markers, may be appropriate. Again it is important in such cases to explain the meaning of the graph in the text.

The type of function used to fit curves to discrete measurements must also be chosen with care. In engineering, the ideal is to use a physical or mathematical model of what was measured to determine the type of function. For example, experience has shown that for low Mach numbers and high Reynolds numbers, pressure drop in a duct is proportional to velocity squared. Physics also show that the pressure drop should be zero when the velocity is zero. One would therefore fit the function $y = C x^2$ to measurements of pressure drop vs velocity. High order polynomials will be used very rarely since they do not occur in physical laws. However, an example where it may be appropriate to use a high-order polynomial is when fitting a curve through high accuracy physical property data that vary smoothly (for example c_p vs T).

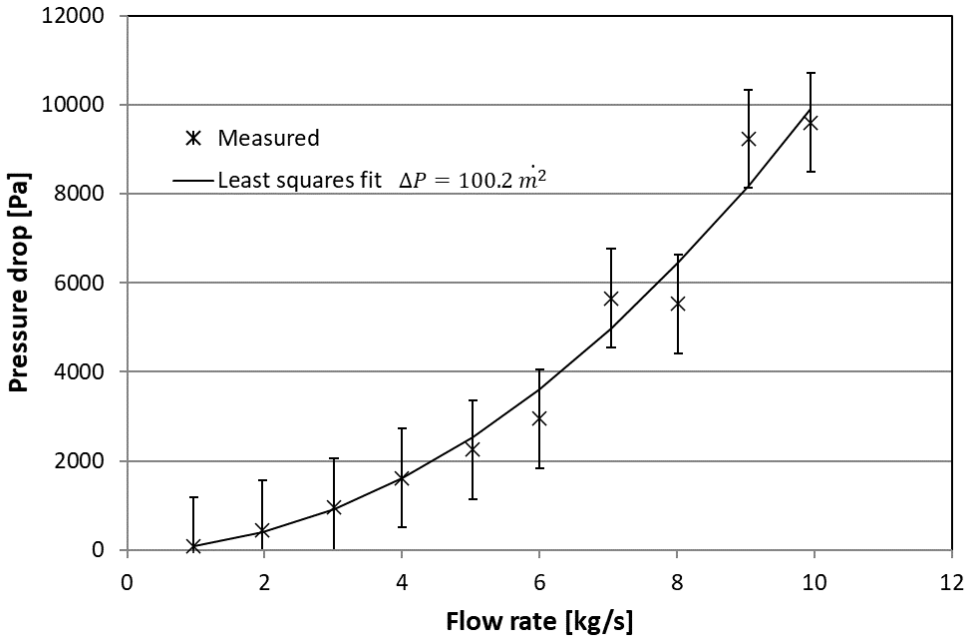

Figure G.1: Orifice Pressure Drop vs Flow Rate

Figure G.2: Performance Fractions per Year

G.3 Statistical Symbols

Some symbols are used to convey statistical properties and those that occur most often in technical documents are considered here.

Error bars are used to show an estimate of the measurement error or uncertainty in each measured data point. Figure G.1 shows vertical error bars, indicating the uncertainty in the y-values. If the x-values also contained uncertainty, then horizontal error bars should be added.

The exact meaning of the error bar should be conveyed in an annotation, the caption or the report's text. Typically the error bars represent one standard deviation (which is only appropriate if the errors are normally distributed) or a confidence interval (for example 95%). The error bars will help the reader to determine whether differences between measured data points are significant or smaller than the uncertainty.

Box-and-whisker plots convey more complete statistical information and are appropriate where a large number of samples are reduced to a single symbol. Figure G.3 shows a plot created using Matlab's "boxplot" command. The box symbol shows the median (the bar near the middle of the box), upper quartile and lower quartile (the top and bottom of the box) of a data set. The whisker can be added to show any one of a number of additional measures of the spread of the data, for example the minimum and maximum values, or the 2^{nd} and 98^{th}

percentiles. The width of the box can also be used to represent the number of data points in the sample used for that box. The report's text or an annotation must convey the exact meaning of the box and whisker.

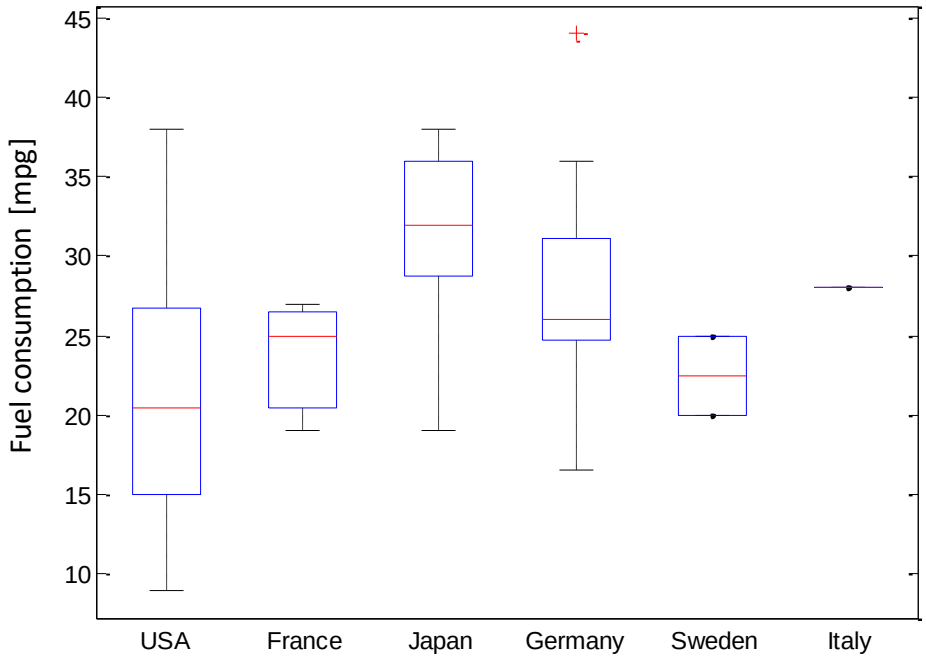

Figure G.3: Car mileage, grouped by country

G.4 Layout

This section lists a variety of guidelines for the layout of graphs:

The text of the axes' labels, axes' numbers and annotations must be about the same size as the report body's text.

The axes of a graph must be labelled. The units of the numerical values of the axis should be included in the axis label. The number of digits in the numerical values next to the axis should reflect the number of significant digits and the limited resolution of a graph. For example, if the increment in the numbers along an axis is 10 or more, then it would not make sense to give numbers such as 200.00. The units used for the labels should also reflect the effective resolution, for example rather than using increments of 1000 W, using 1 kW would be more appropriate. Note that the default settings in commonly used software often do not adhere to this guideline.

If more than one data set is shown in a graph, then the graph must have a legend describing each data set.

Data to be compared (for example different sets of experimental data, or experimental data vs analytical results) should be combined in the same graph so that the reader can make a direct comparison. The quantity of information in any one graph, however, should be limited so that the different symbols can be distinguished clearly.

The majority of technical readers intuitively expect the independent variable to be given on the x-axis, with the dependent variable on the y-axis. If this layout is not used, it should be pointed out in the text of the report.

When only the relative values of the properties in a graph are important, an axis' maximum and minimum values can be chosen to provide the clearest portrayal of the data. However, if the absolute values are important, then it is preferable that the axis clearly shows where the zero value is.

The thickness of lines representing data in the graph should be just thick enough to be clear in a pdf and printed version of the report. The default line thicknesses in Excel, for example, are suitable for Powerpoint presentations, but much too thick for use in a report.

The caption of a graph, as for any figure, must be given below the graph. The caption added by some software, such as Excel, above the figure must be cropped or suppressed.

Colour lines generally aid in interpreting the data, but colour may only be used when black-and-white versions of the document will never be used. If there is any doubt, it is best to use both colour and shape (for example solid and dotted lines, different symbols and different hatchings).

Two-dimensional graphs can be read with a fair precision, but three-dimensional graphs cannot be read as accurately. If reading precise values is important, then adding grid lines to a two-dimensional graph will be useful.