

CHE 450: Technical Work-term Report Guidelines

1. Report Objectives and Measured Graduate Attribute Program Indicators

Through the submission of this written work report you will demonstrate your ability to:

- Communicate in a written format [7b],
- formulate a problem statement [2a],
- select and apply appropriate means of analysis to data and other technical information [5a, 5c], and,
- synthesize information from multiple sources to reach valid conclusions [3c].

The numbers in brackets indicate the numbers of the program indicators defined by the Faculty of Engineering to assess CEAB defined Graduate Attributes.

2. Suitable Content

Reports may be written on a wide variety of subjects provided that suitable technical content is included. Ideally, you should try to identify something related to your job responsibilities; however, this is not always possible.

Representative examples of suitable subject areas include:

- Experimental studies (including designing and performing experiments, data analysis, and conclusions).
- Detailed design of process equipment (e.g., reactor sizing, safety valve sizing).
- Analysis of aspects of business operations (e.g., analysis of the impacts of downtime or maintenance scheduling).
- Root-cause analysis (e.g., identifying the underlying problem causing some process mishap).
- Safety or environment analyses (e.g., HAZOP, lifecycle analysis).

If you are unsure your topic is suitable, contact the course coordinator, Eline Boghaert (eboghaer@uwaterloo.ca) for advice.

The report must contain technical analysis at an appropriate level for a 3B student. Please note that analysis in this context is not limited to the statistical analysis of data. Analysis

refers to the objective and detailed examination of something and an appropriate method depends on what is being analyzed. Technical analysis may include qualitative aspects and/or rely on engineering judgement.

3. Report Style

The objective of writing is communication. The work term report should be prepared as a formal technical report suitable for a business environment. Aim to write in a clear, concise style and communicate comprehensibly and unambiguously. Some tips:

- In terms of background knowledge base, assume the reader is another student in your class; thus, expect them to have general knowledge of chemical engineering but to lack specific knowledge of the report.
- Be precise and concise wherever possible. For example, do not write “some”, instead specify how many.
- Avoid exaggerated or unfounded claims and unstated assumptions.
- Use the active voice rather than passive voice when possible.
- Use formal language that avoids the use of slang, colloquialisms, contractions, and personal pronouns.

Waterloo Writing Works modules (<https://writingworks.uwaterloo.ca/#/>) provide instructions on some of the key rules for setting the tone of a technical report with detailed explanations and examples.

4. Report Structure

It is important the report is properly structured as a technical document. The typical sections of a good report are described below; your report may deviate from this structure or these headings. Note this is a technical report and not a lab report. Pay particular attention to the descriptions of each section, these highlight many common problems encountered in work-term reports. Report templates are available on LEARN in Latex, MS Word and LibreOffice. You are not required to use one of these templates. These templates may be helpful if you are unfamiliar with how to generate a table of contents, list of figures, list of tables, etc.

Page limit: the main body, including all pages from introduction to references, of the report should be no longer than 25 pages in length. If your report exceeds this length, consider what material can be removed, reformatted or would be better placed in an appendix.

4.1 Title Page

The report should include a title page including (in order): University of Waterloo, Faculty of Engineering, the title of the report, the name and location of your employer, your name, student ID number, previous academic term and program and the date of report preparation. Confidential reports should clearly indicate this on the cover page.

4.2 Letter (or Memorandum) of Submittal

Include a formal letter of submission with your report as the first page inside the front cover. This page should not be numbered. The letter of submittal must follow the format of a standard business letter. The letter should be addressed to the Chair of the Chemical Engineering Department and should be signed by you at the bottom. The body of the letter should include:

- The title of the report.
- Your previous academic term.
- Your employer, including company name, division/department/etc., location and supervisor.
- A brief description of the employer's activities as relevant to your employment.
- The purpose of the report.
- Acknowledgement of the source and explanation of any assistance received with the report; the letter must include the following statement: "*This report was written entirely by me* and has not received any previous academic credit at this or any other institution*". *if this statement is not true, you must modify it and explain specifically what was and was not written by you.
- A statement identifying whether the material is confidential, if required.
- Your name, ID number and signature.

4.3 Executive Summary

This is a self-contained summary of your work and should be approximately one page in length. It should state: i) what you did, ii) why you did it, iii) what you found (conclusions), and iv) what you recommend based on your findings. In business the executive summary is the most important part of any document, this may be the only part people will read.

Note that it is not a teaser to make the reader interested in the main report. The summary should describe the work done, conclusions and recommendations; it should not describe what can be found in the report. For example, do not write "*conclusions and recommendations are made based on the experimental findings*" but do write "*the experimental results showed a 12% reduction in energy consumption*" or "*it is recommended that a full-scale trial be performed using the new formulation.*"

Do not simply copy and paste the conclusions and recommendations from the main body of the report. The summary should be a thoughtful description of the most important aspects of your work. Therefore, you may choose to highlight the most important findings and possibly omit more minor ones.

4.4 Table of Contents and Lists of Tables and Figures

You must include a table of contents listing all main sections and subheadings, with page numbers. The list of tables and list of figures should include the titles, note the entire caption, with page numbers. Number these pages with Roman numerals.

4.5 Nomenclature

This is an optional section. If the report is very heavy on mathematical variables or if there are many acronyms throughout the report, including nomenclature may be helpful to the reader.

4.6 Introduction

Provide the reader with a brief introduction (1 to 2 pages) to your work. Describe the problem or project and clearly state the objective(s) of the report. This is an introduction to your specific work and not to the general area. At the end of the introduction, the reader should have a clear idea of what you have set out to do and your motivation for doing it.

4.7 Literature Review/Background Information

Provide sufficient background and theory to allow your analysis to be understood. Tailor the literature review to the work you are doing. For example, if your study concerns a proton exchange membrane fuel cell (PEMFC), you may wish to mention that other types of fuel cells exist and perhaps briefly explain why you are focused on this type, but there is no need for a detailed description of every type of fuel cell. The information presented should be relevant to the report and should not be general knowledge. Succinctly present any technical material necessary for the reader to understand the report.

It is expected that care will be demonstrated with respect to academic integrity throughout the report; in particular, appropriate paraphrasing and proper citation of published works is required. Excellent literature review resources are available through the UW Library's subject guide at <http://subjectguides.uwaterloo.ca/chemeng>.

4.8 Materials and Methods

Describe what you did and what materials you used. Be precise, complete and concise. Your description should allow someone else to repeat your work. Relegate long, tedious information (e.g., software screenshots, lists of experimental apparatus) to an appendix. If you have done an experimental study, look in a scientific paper to get a feel for the usual style. Do not include long descriptions or images of obvious techniques or equipment – we all know what a glass beaker looks like without seeing a photograph. You can use citations to established procedures, for example: DNA was extracted from the stool samples following the procedures described by Dumpman et al. (2016).

Be precise in your descriptions. If you rely on data from the plant, describe exactly where it came from – somebody might want to check on your project in two years and they want to be able to find the same data for comparison. If you get information from a particular person, include their title and department as well as their name: “Bob” might resign, get fired, get promoted, retire or transfer to the Timbuctoo plant, but if this happens to “Sally the Production Line Operator” then *your* successor can find *Sally’s* successor.

4.9 Results and Discussion

Results are the objective outcome of your experiment; these are factual statements of your data and findings. Discussion is your interpretation of these results in the context of your work and that of others. In many instances the results and discussion from one experiment motivate the following experiment. Keeping these sections together allows for a logical transition from one experiment to another. In PD 11 you were asked to present separate “Results” and “Discussion” sections, you may do this for CHE 450 if this is more appropriate for your work.

Begin with clear a statement of the problem being solved in the report and the requirements, criteria, or constraints necessary to know whether the problem is solved through the rest of your analysis. Give a clear and concise written presentation of the results of your analysis. Make use of figures and tables and refer to every figure and table somewhere in the text. Your job is to present this information to the reader and guide the reader through your interpretation. Remember that you have taken one or more courses on statistics; if you have data, use your knowledge and skills in this area.

4.10 Conclusions and Recommendations

What can you conclude from your work? Conclusions are established based directly on your results and discussion. They can be based on quantitative or qualitative analysis. No new results should be presented in the Conclusions section. Conclusions are often very specific. Do not feel that you need to make wide-ranging generalizations – it is unlikely that you can

reach profound conclusions in a report describing perhaps only one project out of several accomplished during a work term. Do not expect to have a large number of conclusions based on a short study. Be realistic about your work: take pride in it but do not overstate its significance. For example, if your work has been based on adhesive formulation, perhaps you have improved the performance of a particular adhesive for a certain application. It is unlikely that you can apply this result to all adhesives in general or conclude that all steel fabricators should abandon welding and start using your product.

Describe the recommendations based directly on your analysis and conclusions as presented in the report. Do not make broad recommendations that are not justified by the analysis and conclusions. Note: recommendations may be negative (e.g., do not proceed further with this project in its current form). In general, recommendations may be to implement something (e.g., do a full-scale trial of your new formulation), to do more work in the area (try and specify what could be considered), to apply the approach to other areas (again, specify if possible), etc.

Depending on your work you may prefer to divide conclusions and recommendations into two separate sections.

4.11 List of References

List the references used in preparing the report. Note: you must provide a list of references (where each reference is specifically cited in the text), as distinct from a bibliography (where you do not make specific citations in the text). See further information below.

4.12 Appendices

Place information that is not essential to the report in an organized set of appendices. Assume appendices will not be read, but you are providing the information in case a detailed review or check of your work is required. Suitable information for appendices would include tables of raw data, detailed technical information, sample calculations, MSDS, step-by-step experimental procedures, etc. Each appendix **must** be explicitly referred to in the main body of the report (e.g., “a HAZOP was performed using the company’s standard list of guidewords (provided in Appendix E)”, or “raw data are provided in Appendix C and sample calculations in Appendix D”).

5 Report Format

Different companies and journals have different guidelines regarding font size, line spacing, margins, etc. For the purposes of CHE 450 use something that is professional in appearance. The following were recommended for PD 11 and are used in the provided template:

- 12-point serif font (Times New Roman).
- One-inch margins on all four sides of the paper.
- While double spaced was recommended in PD 11, single spaced looks more professional and was used in the provided templates.

Note that underlining was for typewriters; if you are writing on a new-fangled personal microcomputer, try **bold** or *italic* instead (these were not available on mechanical typewriters).¹ The only exception is for hyperlinks.

If you include equations in your technical report, note that math variables should be in italics, but operators and units are upright. For example: $r = 10 \text{ cm}$.

Chemical elements and compounds are not proper nouns and should not be capitalized (i.e., sodium chloride, not Sodium Chloride).

5.1 Guidelines for Numbers and Associated Units

Make sure that you always write units; values are meaningless without units. Formatting guidelines for numbers and their associated units are as follows:

- Note there should be a space between the number and the unit.
- The exceptions to the rule above are the percentage and degree signs, except where the degree sign is used as part of another unit. For example, there is no space between the number and symbol in 10% and 30° but there is a space between the number and unit for 30 °C.
- Use a non-breaking space to keep a unit with its value on the same line.
- For SI units never add an “s” to indicate a plural (10 kg not 10 kgs).
- The abbreviation for mole is mol. Format it like any other unit (i.e., 10 mol not 10 mols).
- Kelvin does not have a degree symbol (10 K).

5.2 Page Numbering

Although the title page and letter of submittal do not have numbers printed on them, you still count them, as a result the Executive Summary will usually be page iii. All other pages before the body of the report should be given a page number in Roman numerals.

The body of the report starts with the Introduction. Label the Introduction as page 1. The remainder of the report is numbered sequentially.

¹ If you disagree with this, try and find underlining used for emphasis in a textbook. Or in any book, newspaper or magazine (excluding advertisements for car dealerships and discount furniture stores).

5.3 Section Numbering

Divide the content into logical sub-sections with numbers (1.1, 1.2, etc.). Number subsections down to at most level three (e.g., 1.3.2).

5.4 Tables and Figures

All tables and figures should have a professional appearance. Tables and figures should be numbered sequentially as they appear in the text (Table 1, Table 2; Figure 1, Figure 2, ...); numbering can be reset in each section if the section number is also included (Table 2.1, etc.). Each table and figure must be referenced in the main body of the report.

Provide a caption for each table (above the table) and figure (below). The caption should include the figure number, title and a short description. The caption should be sufficiently detailed to allow the reader to understand the information in the figure/table without consulting the text. Things to consider when writing figure captions:

- If your figure has scale bars, the figure caption should specify the size of the scale bar.
- If your figure has a graph, the title of the figure should communicate the main conclusion the reader should draw. For example, do not use the title: A graph of X vs Y. The reader can easily look at the axis and see that you have a graph of X vs. Y. Instead use the title: There is a linear relationship between X and Y. (Assuming that this is what you determined from the data.)
- For statistical analysis that includes error bars indicate what these error bars represent. For example: Error bars represent SEM ($n = 3$).
- For statistical analysis that reports significant differences using an asterisk, indicate what hypothesis test was performed and the level of significance. For example: Paired t -test. $*P < 0.05$, $**P < 0.01$, $***P < 0.005$.

In the list of figures and list of tables you should include the number and title, but not the full description.

6 References

The purpose of a reference is to provide weight to statements that you have made and to acknowledge the work of others (this is good professional practice, as well as common courtesy). The list of references provides the reader with enough information to enable them to find the document you are citing.

6.1 Types of References

Good references should be authoritative and objective; they should be current (note: although this frequently implies they should be recent, this is not necessarily the case). Most

of your references should be primary sources (e.g., original research papers). Secondary sources (e.g., published review articles) are extremely useful resources in research and cited when they contain analysis, evaluation, interpretation, etc. Check the cited primary sources for other information you wish to rely on. It is acceptable to cite documents written to support engineering practice (including company and other handbooks, manuals, textbooks, etc.).

If you are relying on a conversation or other correspondence with an individual, this can be referenced as a “personal communication”.

Tertiary sources are similar to secondary sources but typically provide a general overview of a subject (for example, encyclopedias); these can be useful in beginning the process of research but are unsuitable as references. Do not cite Wikipedia because: i) it is a tertiary source and ii) authorship is anonymous and the review process opaque; therefore, the authority and objectivity of the information cannot be established. In case you are unconvinced, even Wikipedia^{2,3} agrees.

6.2 How to Reference

Place a reference anywhere that you have used facts, data, opinions, etc., from an external source. Citations in the text should either be numbered in order of appearance in square parentheses or follow the (author, year) format. See section 6.3 below for more details. You must include a list of references, where each reference is clearly cited in the text. Note that a bibliography, providing a general list of references but not specific citations in the text, is not acceptable.

Paraphrase the material you reference. It is not acceptable to reproduce verbatim from the cited works. In exceptional cases you may wish to quote from another author (if the specific words used are for some reason important or particularly powerful), in which case you should clearly indicate this via quotation marks or italics.

The exact reproduction of an image (without redrawing) from another source is acceptable, but the need for acknowledgement goes beyond a simple citation; in this case, you have actually taken someone else’s work and are presenting it in your report. In this case, write something like: *Reproduced from <<author, year>>. Copyright <<holder>>, <<year>>*. Do not write “reproduced with permission” unless you have sought and received permission. Note: the copyright holder is generally the publisher and not the author (there are exceptions, for example, authors of Master’s and PhD theses retain copyright to their work). Note, if you

² See http://en.wikipedia.org/wiki/Wikipedia:Academic_use

³ In this special case, I consider citing Wikipedia to be acceptable!

have re-drawn the figure or typed the data into your own table, then just cite in the usual way.

The UW library maintains a page about reproducing copyrighted works, see: <http://www.lib.uwaterloo.ca/copyright/>

6.3 Citation Style

You have two basic choices for citations, either number each reference sequentially as it appears in the report or use an (author, year) style. For the list of references, adopt a clear and consistent format. You should be familiar with the IEEE format from first-year courses and with the APA format from PD 11. These are briefly summarized below, for further guidance you are advised to consult the library's webpage at: <https://lib.uwaterloo.ca/web/dictionaries-encyclopedia-and-more/citation-style-guides>.

Using reference management software is strongly encouraged, information is available on the library webpage at: <https://uwaterloo.ca/library/research-supports/reference-management-software>.

6.2.1 Numbered Citation Styles

Number the citations in the order they appear in the document. In the main text, these should appear in a consistent style; typically, this is in square parentheses either in-line with the regular text [12] or superscripted.^[12] Multiple references are separated by a comma for two references [12,13] or an en-dash for a sequence.^[12-14] The list of references should be in the same sequence as in the text, formatted in a consistent style.

6.2.2 (Author, Year) Citation Styles

Write the last names of the authors and the date of publication in round parentheses. List one or two names only (Grove, 2013) or (Grove and Smith, 2013); if the publication has three or more authors use et al. (abbreviated Latin *et alia*, and others) (Grove et al., 2013). If you have stated the name of the author, then include only the date in brackets; for example, according to Grove et al. (2013), ... If you are citing multiple papers from the same author(s) and year, you can distinguish these by adding letters after the year. For example, (Grove, 2013a) and (Grove, 2013b). The list of references should be in alphabetical order by last name (note in the list of references, include all author names and do not use et al.).

6.2.3 Formatting the List of References

The list of references will be either in the order of appearance in the text if using numbered citations or in alphabetical order if using (Author, Year) citations. For each reference you must give enough information for the reader to locate the referenced source. You must give the authorship (for webpages, this may be the company) and a date (for webpages, you may only be able to provide the date accessed). For detailed examples of what information to

include for different types of sources see the library's website of citation style guides: (<https://lib.uwaterloo.ca/web/dictionaries-encyclopedia-and-more/citation-style-guides>).