Portland State University
Mechnical Engineering Department
ME 493: Senior Capstone Design III

Final Report Format

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Due: See Canvas

1 Final Report

Each team* will submit a final report to be graded by Capstone faculty. Teams will also submit a digital archive of design artifacts that includes CAD models, schematics, block diagrams, wiring diagrams, photographs, analysis code, code for digital controllers, analytical models and results, test data and analysis. Refer to the **Catalog of Design Artifacts** section for information on how to organize the information in your digital archive.

Submit your final report by uploading it to the Canvas Assignment. Submit your digital archive on a Google Dropbox attached to a PSU account. Make this link public and include it in the **Catalog of Design Artifacts** section.

The reports and links will be forwarded to your advisors at 10:00AM the day after it is due.

2 Report Structure

The final report will consist of a relatively brief narrative body and an extensive set of appendices. The page count for the body of the report will be determined by the number of tables and figures. Aim for a report body that is 15 to 25 pages long. The Advice on Content section (below) provides recommendations of page length for each section. The body of the report should not be 25 pages of dense prose.

The report has three main sections: Frontmatter, Body and Appendices. The outline for those sections is given below. Details follow.

1. Frontmatter
    - Cover page
    - Table of Contents
    - List of team members with description of their roles and primary contributions
2. Body
    - Executive Summary
    - Client/Market Requirements
    - Conceptual Design Summary
    - Subsystem Highlights
    - Performance Summary
    - Final Status
3. Appendices
    - Supplemental Images
    - Catalog of Design Artifacts
    - Concept analysis
    - System-level Requirements Matrix
    - Subsystem 1
        - Requirements Matrix or detailed engineering specifications
        - Design analysis
        - Performance
    - Subsystem 2
        - Requirements Matrix or detailed engineering specifications
        - Design analysis
        - Performance
    - Bill of Materials
    - ABET Objectives

3 Typographic Requirements

The body of the report should use 11 point or 12 point standard serif font such as Times New Roman, or Computer Modern Roman. Headings can be in sans serif font, such as Arial, Calibri or Helvetica. Lines should be single spaced or have a baseline skip of no more than 16 point. Top, left, right and bottom margins should be one inch.

Pages should be consecutively numbered starting with page 1 for the Executive Summary. The title page has no page number. The table of contents and list of team members can have a Roman numeral page numbers.

All Figures and Tables should have numbers and captions. All displayed equations should be centered and have a right-justified equation number in parenthesis. Do not label equations with "Equation". Figure 3.1 provides example as a guide to the use of displayed equations.

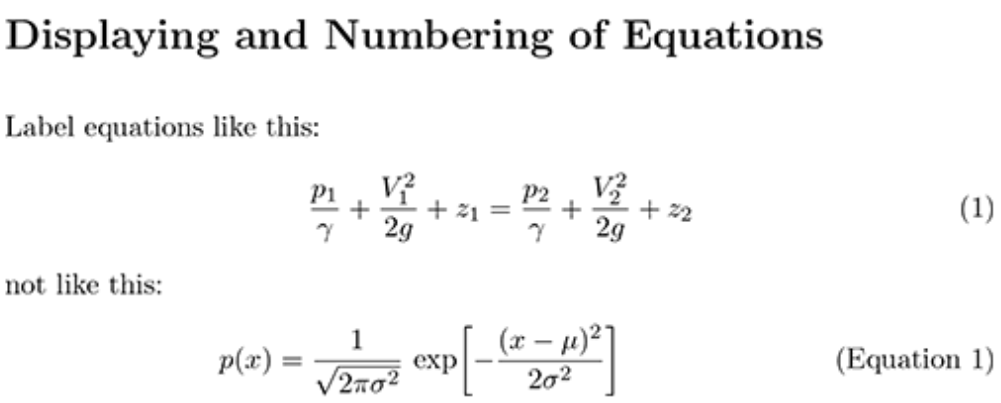

Figure 3.1: Demonstration of equation numbering

4 Style

For general advice on writing reports, consult the Civil Engineering Writing Project, and the Materials for Courses and Independent Study page on that web site. Although that web site is aimed specifically at the civil engineering profession, the Language Units are helpful to mechanical engineers.

The style of the report should be formal, but that does not mean it should be dull. To be formal

- avoid using slang;
- do not use texting or other social media abbreviations;
- write with complete sentences organized in to paragraphs;
- follow the structure – the headings and sequencing – given in this assignment description;
- do not use the first name of your sponsor or faculty coach.

To avoid being dull, use precise language and use the active voice. Writing in the active voice does not necessarily mean using first person pronouns. Refer to the Active and passive voice section of the Civil Engineering Writing Project.

5 Advice on Content

The following sections provide advice on what to include in each section of the report.

5.1 Frontmatter

Cover or title page should have

- The project name,
- The title of the report, i.e. "ME 493: Final Design Report",
- The sponsor name,
- The date (due),
- Names of team members.

Table of Contents

On a single page, list the main sections of the report and the starting page number of each section.

Team Member Roles and Contributions

In one page or less, list each team member, their roles and primary contributions. Each team member should be able to show how they did work that was indispensable to the success of the project. Use a table or paragraph format.

5.2 Body Components

The body of the report should provide a reader with an overview of the key requirements of the project, how the design team arrived at their solution, and give objective and quantitative evidence for how well the solution meets or exceeds the requirements. The body of the report should be authoritative and complete, while also being easy to read. To attain that balance, choose a limited set of key details to include in the body. Taken together the key details should give a complete view of the final design. Leave the documentation of lesser, but important details in the appendices. At appropriate points in the body of the report, refer the reader to specific sections of the appendix for more information.

Do not assume the reader is familiar with Capstone, prior reports submitted by your team, or even mechanical engineering. Do include technical documentation appropriate for reading by a mechanical (or electrical or civil) engineer, and also provide sufficient context that a reader without engineering training (such as your client or a potential investor or customer) can at least understand how your final design works and why it does, or does not, meet the client requirements.

Tell us about your successes and creativity. At the same time, do not sugarcoat aspects of your project that do not meet the requirements. The goal is to find a balance in candidly discussing the strengths and weaknesses of your final design. You should give a realistic assessment of your design that would allow a client or internal engineering manager to decide whether to make additional investments in another round of engineering design, or even mass production for sale to consumers.

Wherever possible, provide concrete, quantitative evidence to support descriptions of your design decisions and to document performance of your final design. At the same time, be careful not to overwhelm the reader with excessive detail. Use the appendices provide additional details that support claims made in the body of the report.

5.2.1 Executive Summary – One page

The goal of the Executive Summary is to present a terse, self-contained description of the important outcomes of your project. The Executive Summary should explain what you did, why you did it (customer requirements) and how well the final result met the project goals. A good Executive Summary will spark interest in the reader without requiring the reader to dig through the body of the report to find important, high-level information.

It is not easy to write a good Executive Summary. Like other parts of the Body of the report, you should allow time to revise and rewrite the Executive Summary.

For the final ME 493 report, the Execute Summary is one page in length with headings and content for three items.

1. Project Objective Statement
2. Final status of design project
3. Key performance metrics

You can use some bulleted or numbered lists, but the bulk of the executive summary should be written in complete sentences organized into paragraphs. Use single-spaced text in the same font and with the same margins as the rest of the report.

The **Project Objective Statement** should be one sentence using the format described in ME 492.

The **Final status of the design project** (1) lists key client market requirements, (2) describes the conceptual design chosen to meet those requirements, and (3) briefly identifies the primary subsystems that constitute the design. Given the one-page limit for the Executive Summary, you will need to be brief and focus on the most important aspects of each of the three items (requirements, conceptual design, subsystems).

The **Key Performance Metrics** sections briefly summarizes the concrete and quantitative evidence of whether or not your design meets the key client requirements. The key client requirements are the most important system-level performance measures from your system-level Requirements Matrix. If your design does not meet key requirements, say so. In order to keep the Executive Summary limited to one page, you will not be able to give detailed explanations of the key performance requirements, but those requirements should be described in a way that is understandable to your sponsors, other students in the Capstone course, and experienced engineers from local industry.

5.2.2 Client/Market Requirements – Two to three pages

This section is an updated version of the client/market requirements from your project contract and the Conceptual Design from ME 492.

List and describe the client (or market) requirements in more detail than in the Executive summary. You can use bulleted lists or tables so long as you also provide narrative introductions to the requirements. In other words, do not only use lists and tables.

The client requirements should correspond to your system-level Requirements Matrix. Provide concise background information such that a knowledgeable reader will be able to understand the client or market needs.

In addition to the Client/Market needs, describe the key performance measures. Refer to the system-level Requirements Matrix, which should probably be in the appendix so that it does not take up page space in the body of the report.

5.2.3 Conceptual Design Summary – Two to three pages

This section is an updated summary of the conceptual design.

Briefly describe the main conceptual features of your design. From a big-picture perspective, how – meaning by what mechanisms, and in what functional form – does your device function so that it meets the needs of your client.

In this final report, the conceptual design summary is an introduction to the subsystem highlights in the next section. Do not go into detail about options that your group did not pursue. However, any conceptual design issues that were resolved in during Spring (i.e. during ME 493) should be identified and changed. For example, if two or more options were pursued and one final option was chosen, include that information in this section. It would be appropriate to include a scoring matrix that summarizes your final conceptual design choice.

5.2.4 Subsystem Highlights - Three to six pages

The bulk of work in ME 493 is in the creation and integration of subsystems into a working whole. In this section, describe the key subsystems and how they operate together. Start with an overview of how you decomposed your conceptual design into subsystems.

Details about subsystems should be included in the appendix. Focus on a small (say 3 to 5) key subsystems in the body of the report. Use schematics, CAD models, photos, functional decomposition diagrams, tables or other means to show how the subsystems combine to form a complete solution to the design problem. Similarly, use schematics, CAD models, tables, etc. to show how subsystem components combine to provide a working subsystem.

Refer to CAD models, and subsystem documentation in the Appendices for details. Inclusion of CAD models and schematics in the body of the report is acceptable. However, you should be selective and not pad the body of the report with too many figures. As a rough guide, the body of the report should not have more than 40 percent of the page area occupied by graphics and tables.

5.2.5 Performance Summary - Three to six pages

In this section, describe the measured and objective performance of your design. Use tables, plots or other means to provide concrete evidence for how well you system or device meets the client or market requirements.

Of course you want to describe your successes, i.e. how your device or subsystem meets or exceeds the success measures from your system-level Requirements Matrix. You should also tell the reader if and how your device or system does not reach key performance targets. Your final report is an engineering document that describes your design as it is. Your report is not a marketing document trying to convince the reader that your design has features or performance characteristics that it lacks, or that it might have if your team had more time.

To demonstrate performance of your system, you may, and probably should, include measured, objective performance data for key subsystems. This will require judgement. Do not overwhelm the reader with data on every subsystem. Instead, use highlights in the body of the report and provide the complete subsystem performance information is the appendices.

5.2.6 Final Status - One to two pages

The final status section has two main purposes. First, provide a high level summary of the design work started in ME 492 and completed in ME 493. Without extensively repeating ideas from preceding sections, summarize the key achievements of your project.

The second purpose of the final status section is to make recommendations for continuing (or, if necessary, completing) the design work of your Capstone project. This is the only part of the report – and it should be relatively brief – that refers to what your group might have done if only you had more time. Better yet, briefly suggest the next steps for projects that build upon the work you have completed.

5.3 Appendices

The list of appendices is appropriate for most of the Capstone projects, especially those involved with the design of thermal, mechanical or electro-mechanial devices. Variations on this list of appendices are acceptable, but only with prior approval of the instructor. Schedule an online meeting to discuss your alternative model and bring an outline (one page maximum) of sections that you propose.

5.3.1 Appendix A: Supplemental Images

To keep the body of the report to a reasonable length, use the Supplemental Images appendix to provide additional images – CAD models, photos, performance plots – that will give the reader more detailed insight to the design.

The body of the report can, and probably should contain several images. However, images should not constitute more and 40 percent of the total page area of the body.

All images in the appendix must have a Figure number and caption. Ideally each image in this appendix should be referenced in the body of the report. For example,

Figure B.3 through B.8 in Appendix B show part details and an exploded assembly view of the muffler bearing subsystem. Figure B.9 is a photograph of the dealy-bob mounted on the doohickey controller bracket.

5.3.2 Appendix B: Catalog of Design Artifacts

Provide a list of design artifacts included in the digital archive that is submitted with the report. The digital archive should be organized into folders (directories in the file system) and the file names should be descriptive of the contents.

The logical structure of your digital archive is somewhat subjective. However, there should be a structure. In other words, do not just copy all of your files into a single folder on the USB drive.

One way to organize the digital archive is by type of content. For example you could use the following folder structure, where the order is subjective,

- CAD models, schematics, block diagrams
- Wiring diagrams
- Photographs
- Analysis code, data acquisition code, code for digital controllers
- Analytical models and results
- Test data and analysis
- Sponsor documents
- Team communications (meetings)
- Prior reports

Alternatively you could organize the archive to parallel the design process.

- Client/market requirement
- Conceptual design documents
- Subsystems
- Performance Measurements
- Final design
- Sponsor documents
- Team communications (meetings)
- Prior reports

Use the preceding outlines as suggestions or starting points for organizing your archives.

5.3.3 Appendix C: Concept Analysis

Provide detailed documentation for the evaluation of design concepts. This section should be an edited version of the concept selection options and analysis from the Progress Report submitted at the end of ME 492. Additional concept selection work completed since the end of ME 492 should also be included here. Do not include the entire final report from ME 492.

5.3.4 Appendix D: System-level Requirements Matrix

Include the final version of the system-level Requirements-Measurements matrix. Values in the Requirements Matrix should be consistent with customer requirements and performance measures discussed in the body of the report.

5.3.5 Appendix E: Subsystem 1

Include documentation for the first major subsystem.

- Requirements Matrix or detailed list of engineering specifications
- Design analysis: analytical models and results that guided your design choices
- Performance: quantitative results demonstrating that this subsystem meets requirements

5.3.6 Appendix F: Subsystem 2

Include documentation for the second major subsystem.

- Requirements Matrix or detailed list of engineering specifications
- Design analysis: analytical models and results that guided your design choices
- Performance: quantitative results demonstrating that this subsystem meets requirements

Include as many subsystems that were given a detailed treatment. There should be more than two! Talk to me in advance if you are having trouble with the number and identification of subsystems.

5.3.7 Appendix X: Bill of Materials

Bill of materials for your final design manufacturing requirements.

5.3.8 Appendix Y: Engineering Analysis

Location of all engineering analysis performed. This appendix is expected to be large and sub-Appendices and sub-sub-Appendices are acceptable.

5.3.9 Appendix Z: ABET Objectives

Please use 1 separate page per learning outcome to document the accreditation requirements. Note that missing or poorly done accreditation documentation would have a negative impact on your report's grade.

ABET Learning Outcome-1

Document "an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics"

In one page identify at least THREE cases in which your team used the knowledge of math, science, or engineering to solve a relatively complex problem or answer a relatively difficult question. Refer to the pages in the report for finding the details.

ABET Learning Outcome – 6

Document "an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions"

In one page identify ONE case in which your team used a designed experiment (like those you learned in ME 488) to solve a problem or answer a question that required experimentation. In your report you must indicate how the data was collected and analyzed, and indicate the final conclusions. Refer to the pages in the report for finding the details.

Note: If your team did not do any experimentation, omit the documentation for Outcome-6

ABET Learning Outcome – 7

Document "an ability to acquire and apply new knowledge as needed, using appropriate learning strategies"

In one page identify ONE case in which your team had to learn a new subject on your own to solve a problem or answer a question not covered in your regular math, science, or engineering classes. Explain what the subject was, how you approached the problem, and what resources you used to learn about the subject or gather needed information.