Writing the Final Report

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Mechanical Engineering 4054: Design Projects

THE BASICS

A substantial final report documenting your design is due from each group at the end of the semester. The report describes the design and the process through which you arrived at the design. The specific content will vary from group to group depending on what deliverables came out of your project. The general guidelines outlined here, however, should apply to all groups. There are no rules on the length of the report. The right length is the one that describes your work fully and concisely.

The four most important jobs that the report must accomplish are (1) to describe the problem statement, (2) to describe the design alternatives, (3) to describe the chosen concept, and (4) to describe the detailed design. Organize the report so that these four appear in order. Do not plunge right into a description of the detailed design without first presenting the big picture of the chosen concept. Do not describe the chosen concept without providing the reader with a clear description of the problem statement.

Be professional. You should be proud of the finished product and want to show it off at job interviews and elsewhere. Consider it part of your professional design portfolio. Be very careful with your writing. Sloppy writing will get you nowhere fast in the real world. Remember all of the things you learned in elementary, middle and high school about organization, sentence structure, grammar, punctuation, tense and spelling. Be professional in your choice of words. Remember that if you write like a seventh grader, the reader will think you design like a seventh grader. Strive for beautifully crafted writing. Make yours the best report in the class.

DUE DATE

See the course schedule for when and where the reports are due. No extensions allowed. Hint: Make multiple backups as you write so that a disk failure will not cause you to miss the deadline.

COPIES

Turn in two copies, one of which will go to the project advisor, the other to the course coordinator for filing in the ME4054 archives. Discuss with your project advisor whether his or her copy will be returned to the group. You should also make one report copy for each group member to retain in your personal engineering portfolio for future use in job interviews and the like.

FLYER

With your report, include one single-page, black and white flyer which describes your project. The flyer should be on standard 8.5x11 paper, portrait orientation, 1.0 in. minimum margins on all sides, and all in black and white. Do NOT bind the flyer into the report. You may use any format you like, but the flyer must contain the following elements: (1) project title, (2) semester and year project was undertaken, (3) names of team members, (4) name of sponsoring company, if any, (5) name of project advisor(s), (6) a graphic or drawing which best describes your completed design, (7) a 100-200 (no more, no less) word description of your project objectives and your final design. We use the flyers to document and market the U.

NOTEBOOKS

Your project notebooks are due at the same time as the final report. The team needs to determine the logistics so that the notebooks get to the advisor directly.

SAMPLE REPORTS

We keep old ME 4054 reports (past five years) in the file cabinets in Room ME 316 (the TA Office Hour Room). Feel free to browse through them to get an idea of what worked and didn't work in the past. Please do not take the reports from the room. They are the only copies we keep and cannot be replaced. Enforcement of this rule is based on trust alone.

THE AUDIENCE

Write your report as if it were the document you would love to have had when you started out on the project. That is, you are writing to your peers who have some engineering expertise but who are not familiar with the project. Thus, it is extremely important to set the scene with a good description of the problem statement.

WRITING STYLE

Use a professional style and remember that "professional" does not mean "stuffy." Your audience is your peers so no need to impress us with big words. Feel free to use first and third persons which can help bring the report to life. Use active voice phrases like, "The team conducted several brainstorming sessions..." rather than, "Several brainstorming sessions were conducted."

Pay attention to tense. Most of your report should be in past tense because it describes work you did. Descriptions of the problem statement should be in present tense because the problem still exists.

Take some care in the writing of the report. Most important is that you convey your description of the design in a clear and concise manner. Think about organizing your material to enhance the clarity of your message. Excellence in basic composition skills are a must, including word choice, sentence structure and paragraph development. Be vigilant with grammar, punctuation and spelling. Errors in these basic mechanics of writing are extremely distracting and can greatly reduce your professional credibility.

FORMAT

Use a word-processing application. Eleven or twelve point serif (e.g., Times) font is recommended with larger, bold font for section headings. Number sections and subsections. Use just the right amount of white space to separate sections. Look at professional reports or books for ideas on style. Double space with ample (1.25" left and right, 1.00" top and bottom) margins on all sides. Number each page in one sequence (i.e. do not reset the numbering at chapter starts), including those in appendices. Use either indentation or a blank line to mark new paragraphs, not both. There should be a consistent style that all authors should use for font, headings and margins. Please copy double-sided to save some trees, but insert blank, numbered pages so that major sections always start on the right hand side. Make your report visually pleasing, an important part of communicating the information.

Serif fonts (e.g., Times or Times Roman) are generally easier to read for long reports. Sans serif fonts (e.g., Helvetica) can be effective for chapter and section headings, however.

BINDING

Reports should be spiral bound with a clear acetate sheet on the front so you can see the cover sheet and cardstock on the back. The "Spiral" binding service provided by Kinko's is one possibility

VISUALS

As engineers, you have the gift of being able to communicate through visuals as well as through words. Annotated line drawings which describe the problem statement and design concepts can replace many words. Take care in the design of the drawings. If hand-lettered, use guidelines. Make sure they are not cluttered. Add a descriptive caption below each figure. A good caption is not merely a figure title, but explains the figure.

One of the first things to appear in the body of your report should be an illustration which best describes the overall project. This will be of tremendous help to the reader for understanding the scope of the design.

Use sketches to illustrate design concepts, prototypes, and experimental setups. Be confident in your ability to sketch by hand. Many times a hand sketch conveys more information than a sketch produced by a computer-based drafting package.

When designing a figure, think about overall context. For example, if you are responsible for a rack and pinion steering mechanism, include two line drawings, one a simple isometric or perspective view of the entire vehicle with a cutaway showing the location of the rack and pinion, and a second showing the rack and pinion itself. Neither of these should be formal, dimensioned working drawings (although the latter might include one or two key dimensions for scaling), save those for the appendix.

PLOTS

Plots are a great way to present test data. Please take care in formatting the plot so it is readable and informative. Look in books or journals if you are unsure of the format. Use a computerbased plotting package if possible. Pay attention to line and data point weights. The data should not be lost in an over abundance of grid lines. Use clear labels and add a descriptive caption. The figure number and corresponding caption should be located below the figure.

SOURCE INFORMATION

If your design reached a point where you use (or recommend) specific components such as motors, bearings or materials, include complete information about the component. This means listing the part name, part number, company name and company address. If you have a lot of components, include the information in an Appendix. If you purchased a part through a distributor, include the distributor name, address and telephone number. This information will be of invaluable help to those who follow up on your project.

COORDINATING THE JOB

Your document will have multiple authors so it pays to do some planning so that the sections will come together as a single work. A good report reads like it was the work of one author even though many have contributed. We recommend that each group appoint an editor whose job is to coordinate the writing of the report. The editor will develop the report outline, check that each group member has a writing assignment, generate and circulate style guidelines for the report, integrate the sections and edits and circulate draft versions of the report for editing by group members and (hopefully) one or two outsiders. The project advisor should not be the first person to read the completed report as a whole.

Each team member should be assigned the job of editing the work of one other team member. When editing, read the draft section carefully and be liberal with the red pen. Have group members grade each other for writing style. Having someone outside the group read a draft of

the report is an excellent way to check whether you have done a good job communicating the information.

The group should agree on a date that draft sections are due for others to read. Having each group member commit to the deadline will ease the last minute crush. "I stayed up all night," is no excuse for a poor report.

REPORT ORGANIZATION

Some of the sections are described in more detail below. The specific content of the sections between the dashed lines will vary depending on your particular project. Also, you do not have to keep these names for subsection headings. Feel free to modify to fit your needs.

Cover
Executive Summary
Table of Contents
Contributions (who wrote which sections or pages)
Glossary (optional)
Problem Definition

- What the problem is
- Customer needs
- Product Design Specification (design requirements)

Concept Design

- Concept generation process
- Concept Alternatives
- Selection process
- Final concept(s) and rationale

Design Description

- Detailed description
- Supporting analysis

Design Evaluation

- Prototype construction details
- Test procedures and methods
- Test results
- Discussion

Conclusions and Recommendations

- Strengths/weaknesses of the design
- Recommendations for improvement
- Reflections on the design process

References
Appendices

COVER PAGE

Should contain:

- Project title
- Date
- Team members
- Project advisor

We encourage you to be inventive with the front page. Consider including an illustration or a graphic which best defines the project. Experiment with size and style of title. Use your graphic design abilities to create a cover that is both professional and wants to make the reader turn the page. Think about using color in the figure. Be careful; going overboard with graphic design can make your report look silly and amateurish.

EXECUTIVE SUMMARY

Two pages (max) for the busy executive who will read no further. Your job is to condense all of the design into two pages. Make sure the most important parts of the problem statement, your design and your recommendations are here. Imagine that your report goes to the CEO along with 20 other reports. She has no time to read 21 50-page reports and will make a decision to fund one of them based on what she sees in the Executive Summary. The ES contains a summary of the substance of the report and should be more than a "go look in the report for the substance." Probably the most important part of the report. Do it last, but leave yourself plenty of time.

CONTRIBUTIONS

List all members of the team. Under each team, describe the contributions that each team member made to the project, and the sections of the report that each team member helped to write. Give yourself credit since this section will be used to help assign your grade. ALL team members should sign this page. By doing so, all team members may claim authorship to the final report and can take credit for all the hard work they did during the semester.

GLOSSARY

The group should agree on a consistent use of terminology to describe the design, particularly for technical terms. Each new term should be either described when introduced or included in a Glossary section that appears in the front of the report. If appropriate, define terms through an annotated drawing.

MAIN BODY

The specifics here will depend on your particular report. Take care in organization and always keep the reader aware of the big picture. Convince the reader that a design process was followed.

The Problem Definition section provides the complete background to the project. This is an important section of the document since you set the reader up with what you are doing and why you are doing it.

The Concept Design section describes how you developed alternatives (brainstorming, patent search, talking to experts....), what your alternatives were (if you had 50 concepts, briefly describe all 50 in an appendix), how you narrowed down to a reasonable number of alternatives, and the process used (e.g., Pugh methods) to select one or two of the final concepts.

The Design Description has complete details on the design. Describe your final, as-built design. Don't even go into earlier approaches. Start this section with a drawing or series of drawings (3-D preferred) which best represents your completed design. If humans interact with your design, or if your design is part of a larger system, include the human or system in at least one of the drawings so the reader can understand how the design works in context. If appropriate, supplement your drawings with photographs, but when formatting the report, use a process for including photographs where quality of the images will be maintained when the report is duplicated. If you want to see good examples of how to describe a design, look at the build-it-yourself projects in any issue of *Electronics Now* or *Popular Electronics* (available at your local magazine store). Notice how the writer in those articles describes both how the design works and how to construct the project. Also notice the complete bill of materials which enables someone the writer will never meet to build the project .

Design Evaluation shows how you tested your design or prototype to verify how well it worked. Under Design Evaluation, include reactions from your client, assuming you had sufficient time to do a pilot test of your product with its intended client.

CONCLUSIONS AND RECOMMENDATIONS

If not done so in the main body, here is where you assess your design, even if it is a paper one. Discuss the strengths and weaknesses of the design. Consider manufacturing issues. Discuss product cost, both for a single prototype and for a production run. Discuss what should be done next either by another student team and/or by the company sponsor. In addition, this section should contain some reflections on the design process. Were you satisfied with the process? Did

you stick to your original plans? How would the team improve the process if assigned to another project?

REFERENCES

Reference citations should have a standard format that engineers can understand. Citations should be in the text and references listed in a section titled "References" that appears at the end of the report but before the appendices. Do not use footnotes for citations. Here are two suggestions for citation style:

First, you can cite by author name and year (Durfee, 93). For multiple citations, separate by semicolons (Durfee, 93; Mantell, 92). If citing a vendor product sheet or a data book, use the vendor's name in the citation (PMI, 94). In the reference section, list the citations alphabetically by author's last name. Here are three fanciful examples, one for a journal article, one for a book and one for a vendor data sheet. Journal and magazine names and book titles should be italicized or underlined.

Durfee, W., How to design good, *Journal of Good Engineering Design*, vol 15, pp 30-40, 1993.

Mantell, S., *How to Design Great*, ABC Publishers, Minneapolis MN, 1992.

PMI Electric Motors, Motor Data Sheet, 1994.

A second method for citations is to number the references in alphabetical order and cite by number [1]. If multiple citations, separate with commas [2,3]. The reference list is then formatted as above but with the numbers added.

[1] Durfee, W., How to design good, *Journal of Good Engineering Design*, vol 15, pp 30-40, 1993.

[2] Mantell, S., *How to Design Great*, ABC Publishers, Minneapolis MN, 1992.

[3] PMI Electric Motors, Motor Data Sheet, 1994.

This method is used by many journals, but has the disadvantage of being harder to add references and coordinate with multiple authors while still getting the numbering straight. Other citation formats are possible. Look in books and journal articles for ideas.

Important: If you include images from the web or from a book or a magazine, be sure to cite the source; otherwise, it is plagiarism. Best way is to put in the figure caption something like, "Image (or figure) reproduced from ...". If you modify a figure, put, "Figure adapted from ...". If the image is from the web, use the URL as the citation. If there is no caption for the image in your report, put the citation in small text near the image, just like a newspaper gives credit for the

photographer or the creator of a graphic (go look at a newspaper if you don't know what this means).

APPENDICES

The appendices should include any supporting documentation related to the design that would interrupt the flow of information if included in the main body of the report. Material which appears in appendices may include: parts drawings, assembly drawings, detailed bill of materials, vendor data sheets, calculation results, long equation derivations, software source code and test results.

Each appendix is numbered and appears in the table of contents. Each appendix should start with a few sentences describing what the appendix contains, unless it is obvious such as a vendor data sheet. Avoid appendix inflation when possible. For example, when including data sheets, only include those portions that were relevant to your project. If a data sheet lists many part numbers or part options, be sure to circle the one you selected for your design.

Have the following Appendices (order is not important):

1. Complete Bill of Materials (BOM) for your final (as-built) design and/or prototype. The BOM includes at a minimum the following for each part: (1) component name, (2) complete model or part number, (3) price, (4) the name of the manufacturer who makes the part, (5) distributor (where you bought it from). Similar information should be documented for services you used (e.g., a professional machine shop) or purchased (e.g., a software package). To create a complete BOM, draw an imaginary control volume around your project. Everything inside that control volume (including the duct tape) should be on the BOM. A spreadsheet is generally the best way to format a BOM. At the bottom of your BOM chart, include the address and telephone number of all sources (manufacturer, distributer, hardware store...).
2. List (or collection of drawings) of ALL the ideas you came up with during concept generation. If applicable, sort the list by category
3. Supporting calculations and analyses
4. Key catalog or data sheet pages of components
5. Pro/E drawings
6. - ?? Anything else you think is important.

All appendices should be referred to in the body of the report. If you can't find a place to do this in the report, the material probably is not worth including as an appendix.

SOME SUGGESTIONS

1. Use past tense in the report.

2. Edit, then proof your report carefully before submitting. Spell checkers catch the obvious errors, your eyes and ears can catch the rest. The very best way of doing a final edit is to read the report out loud to yourself and/or to a team mate. If it sounds good to the ear, the writing is probably OK. If it sounds odd, figure out why. Neither your advisor nor the course coordinator will mark up your drafts with editing comments; that's your job.
3. Take your report to the On-Line Writing Center, even if you think your writing skills are fine. The OWL will make you an even better writer.
4. Avoid using a story or chronological approach in your report ("first we did this, then we tried that, then we finally decided on this").
5. Have plenty of figures and drawings to explain and support your design.
6. Start the report with a simple drawing which shows the final design. If it's a product that is closely coupled to the user, show a person using the device in the drawing.

PHRASES AND WORDS WHICH SHOULD NOT BE IN YOUR REPORT

Here's a list of favorite words, phrases and punctuation errors that tend to crop up in the work of novice report writers. You can probably add your own. Let's eliminate them from all 4054 output.

Phrase to Eliminate	Suggested Replacement
plugged into the equation	placed into the equation
figure out	determine
junk	[eliminate]
figure 2-8	Figure 2-8 [capitalize]
Fig. 2-8	Figure 2-8
appendix 1	Appendix 1 [capitalize]
a lot of	considerable
cheap	inexpensive (or low cost)
assumptions had to be made	assumptions were required
can't	cannot
didn't	did not
to quickly design	to design quickly
The first thing	First,
a couple of	two
OK	[eliminate]
in order to	to
fairly	very

very	[try dropping]
looked at	considered
fairly good	good
decided upon	determined
in between	between
significantly	[try dropping]

SPELLING

There should be NO spelling errors. One spelling mistake drops your professional credibility down to near zero. Enough said.

CHECK LIST

[ ] No spelling or grammatical errors

[ ] Two spiral bound copies

[ ] One project flyer with each copy (not bound in)

[ ] Delivered on time

[ ] All team members have survived the final push

Durfee, Will. Writing the Final Report, Mechanical Engineering 4054: Design Projects, 10 Dec. 1999. University of Minnesota. 12 Feb. 2003.