

Technical Report Writing

This article provides some general guidelines and "tips" for writing technical reports. Throughout the Mechanical Engineering curriculum you will be required to write formal reports--lab reports in ME 360 and ME 460; design project reports in ME 372 and ME 415; a capstone design project report in ME 490; and similar reports in other courses. Each of these reports has particular requirements established by the course instructor. However, the following rules for references, figures, tables, tense and voice, equations, etc., apply to all mechanical engineering writing. Specific instructions for ME 360 are spelled out at the end of this section.

How to Write a Report

All engineers must report their work, usually in writing. Skilled writers impress their readers favorably. Clear writing helps in preparing oral presentations. Follow the three rules given below for all reports, oral and written.

1. **Imagine your audience.** In ME 360, address your reports to a fellow student that has a background similar to yours, but is not in ME 360. Your reader relies on you for clear explanations.
2. **Be thorough and brief.** Include all the required sections (discussed below) and informative tables, equations, etc. Write a first draft, then edit carefully for redundancy, wordiness, clutter, etc.
3. **Organize for readability.** The question "Is the reader ready for this material?" guides the structure of the report. Overly detailed material, such as calculations, belong in the appendix.

Sections of the Lab Report

1. **Title Page.** Include the title of the lab, the author's name, the names of all lab partners, and the date. See the "Good Lab Report" in your ME 360 Manual for an example.
2. **Objective.** Describe in one or two sentences the purpose of the laboratory exercise: the "why." Be specific. Possible objectives are "to evaluate," "to verify," "to measure," "to compare," etc. Avoid non-engineering objectives, such as "to teach us" or "to show the student." In general, you will write a technical report where experimental results are compared to theory. The Objective section is written in the present tense.
3. **Background.** This section gives the reader information necessary to understand or appreciate the balance of the report. It puts things in focus by providing background and perspective. It should answer such questions as: Why was this done? How does this effort fit into the overall scope of things? The Background section is also used to relate your efforts to previous work done by yourself or others. For example, if your report covers electrical filters, then you should discuss a few (three to four) applications of filters. Applications that relate to mechanical engineering are preferred over generic engineering, technical, or consumer applications.

In a lab report, the Background section should also briefly describe the engineering theory used in the experiment and the analysis of its results. Any theoretically predicted results

of your experiment would also be included. Commonly used engineering equations (such as Newton's 2nd law, $\Sigma F = ma$) can be presented without attributing a source. However, equations taken directly from a textbook must be given proper reference. The Background section is written in the present tense.

Note that you may NOT reference the ME 360 Course Manual for ANY equations!

4. Experiment. Write what was done in the lab and how it was accomplished in chronological order. Imagine your group performing the experiment and describe what you did and what happened. Describe the experimental apparatus (including manufacturer and model numbers for equipment used) and include a diagram, sketch, or scanned photograph with any relevant dimensions. If you have built or used an electrical circuit in your experiment, show the schematic with resistor, capacitor, op-amp, etc., values used. This section should be complete enough for someone to duplicate the results of your efforts. Write the Experiment section in the past tense, since the experiment has already been done.

Note that "raw" data does not belong in the Experiment section – it belongs in the Appendix!

5. Results. Present the results in words, tables, and figures. Include a comparison of actual results to theory, if appropriate, and an analysis of sources of error in your experimental technique. Discuss the results from an uncertainty analysis and use it to guide your discussion. Think carefully: Do the sources of error you have defined adequately explain your experimental results? Cite "human error" only if you discuss exactly what is meant. Remember that *you never really know* the exact source of error. Always address any specific questions asked in your lab handout. Write the Results section in the present tense.
6. Conclusions. Restate and interpret the major results using numerical values when possible. Were the objectives of the lab or design project met? What can you conclude from the lab? Write the Conclusions section in the present tense.
7. References. Any material taken directly from another author must be referenced. See the section on References in the Writing Style and Format Requirements section. A minimum of three (3) references are required for ME 360 formal lab reports. The ME 360 Course Manual may ONLY be used as a reference for a figure posted on the ME 360 website and is not included in the three reference minimum.
8. Appendix. All portions of the appendix should be specifically mentioned somewhere in the main part of the lab report. The appendix should include
 - ◆ an outline of your appendix (continue page numbering from the main report),
 - ◆ a clear listing of your assumptions about uncertainty values,
 - ◆ an example / sample of each calculation required to generate your results - all necessary unit conversions required (these sample calc's are usually handwritten),
 - ◆ an uncertainty analysis for all results computed from a formula (including both experimental values and theoretical values that use measured values in a formula),
 - ◆ raw data sheets.

Writing Style and Format Requirements

Reports written for ME 360 will generally follow the style requirements of the APA (American Psychological Association) unless specifically contradicted in this handout. See the ME 360 website for a list of references to the APA style. Note that the ME 360 Course Manual is NOT WRITTEN IN APA STYLE, so it should not be used as a template.

Appearance

1. Word process the body of the report, from the title page through the conclusions. The appendix material may be neatly handwritten in either ink or pencil.
2. Figures should be embedded in the report, attached with spray adhesive or rubber cement, or scanned and inserted.
3. Use the 12 point Times or Times New Roman fonts for your text, figure captions, and table headings. Use a 12 point Arial or Calibri font for text in figures.
4. Use a one-inch margin on all four sides. Do not right justify the text.
5. Double-space all of the text.
6. Put page numbers on all pages, starting with 1 on the title page. Page numbers are placed one-half inch from the top edge and one inch from the right edge. Use the Header feature of Word to automatically place your page numbers.
7. A header identifying the lab report immediately precedes the page number on all pages: ME 360 Lab Report 0. Leave five spaces between this header and the page number.

Tense and Voice

1. Write in the passive voice: "Strain gages were used with a Wheatstone bridge to determine the bending stress in the cantilever beam."
2. Avoid -ing verbs with the passive voice (especially avoid the words "using" and "utilizing"):
RIGHT: *With* a Wheatstone bridge, . . . or A Wheatstone bridge *was used to* . . .
WRONG: *Using* a Wheatstone bridge, . . .
3. Use present tense for the Objective, Background, Results and Conclusions section and any time you state general rules or truths: "The relationship between uniaxial stress and strain is $\sigma = \epsilon E$."
4. Use past tense for the Experiment section. Tell what was done and what happened in your particular case.

Spelling, Punctuation, and Word Selection

1. Use a colon only where a period would fit.
2. Put a comma before the conjunction (and, or, but) in lists of three or more.
3. Set off the words "therefore," "however," with (a) comma(s).

4. Spell out contractions (cannot, is not, could not, etc.).
5. Use a plural verb for the word “data”: the data are (were); the datum is (was).
6. Do not write in first person [I, me, my]. The report should be objective. In the group reports it will be acceptable to use third person [we].
7. Second person pronouns are unacceptable--do not use the word “you” as in “You will see . . .”
8. Avoid non-technical language. Avoid the words “thing” and “stuff” as they relate no information.
9. Avoid the word “there” everywhere in the report. It does not carry any information. Choose more specific words.
10. Avoid referring to measurements by their units (“The psi in the cylinder was 34.”). Instead, use the dimension to refer to the measurement (“The pressure in the cylinder was 34 psi.”).

Labeling, Referencing, and Placement of Tables and Figures

Tables present numerical or textual material or information in a regular array. Figures present sketches, pictures, charts, graphs, etc. Put the independent values in the first column of a table and on the horizontal axis of plots when possible.

1. Mention each table and figure in the text before it appears in the report. Tables and figures should appear on the same page or on the next available page after they are mentioned. Do not leave large gaps at the bottom of a page if a figure or table will not fit. Continue the text and put the figure or table at the top of the next page.
2. Number and label each table and figure in order, e.g. Table 1, Table 2, etc., not Table 1.1, Table 1-2, etc. Tables are numbered independently of figures and not consecutively as one group.
3. Tables and figures are centered on the page within the one inch margins.
4. A modified version of the APA style for table headings and figure captions will be used in ME 360 & ME 460 as shown below (also see the examples in the “Good Lab Report”). Note that the table title and the figure number are *italicized* as shown below.

Table 1

Force Sensor Specifications

Figure 1. Experimental setup for filter test.

5. Title each figure and table. Note that table titles are placed above the table, while figure titles (these are called captions) are placed below the figure.
6. Acknowledge all figures taken directly from any source. Failure to do so is PLAGIARISM! Follow the example below. Note that the PowerPoint files that are available in ME 360 do NOT need to be referenced if you modify the drawings.

Figure 6. Opposed piston engine (Bell & Parker, 1997).

APA Style Tables (from <http://web.indstate.edu/mary/tables.htm>)

- The first part of a table is the **table number**. Tables are numbered with Arabic numerals in the order of appearance.
- The next part is the **table title**. The table title should be upper and lowercased, centered, and double spaced below the table number. The title should be *italicized* as well. Double space again after the table title before the actual table begins.
- Next is the **first horizontal line** of the table, which separates the table title from the column headings.
- Use upper and lowercase letters in the **column headings**. The column heading is the label which is centered over each column. Column headings are not boldface, italicized, or underlined.
- A **second horizontal line** separates the column headings from the **table data**. Table data must be in the same style and size font used for the report's text. It should also fit within the boundaries of the page's margins.
- The table is ended with a **final horizontal line**. Any **table notes** should follow this last line, being designated by *Note*. and followed by a period.
- These three horizontal lines are the only lines which are required for an APA style table. In some cases additional horizontal lines may be used for clarification (American Psychological Association, 2001).
- Strict APA style does not allow the use of vertical lines. Check with your instructor if you want to use vertical lines in a table.
- In ME 360 we will single-space the table data. In strict APA style the entire table is double spaced, just like the rest of the paper.

Correct APA style table (modified slightly for ME 360):

Table 1

Desired and Actual Frequencies for Low Pass Filter Experiment

| Desired Frequency (Hz) | Actual Frequency (Hz) | Desired Frequency (Hz) | Actual Frequency (Hz) |
|------------------------------|-----------------------------|------------------------------|-----------------------------|
| 10 | 8 | 800 | 800 |
| 15 | 16 | 1500 | 1600 |
| 30 | 32 | 3000 | 3200 |
| 80 | 80 | 8000 | 8000 |

Incorrect APA style table (too many horizontal lines, vertical lines, Arial font):

| Table 1. | | | | |
|---|------------------|--|-------------------|------------------|
| Desired and actual frequencies for low pass filter experiment | | | | |
| Desired Frequency | Actual Frequency | | Desired Frequency | Actual Frequency |
| (Hz) | (Hz) | | (Hz) | (Hz) |
| 10 | 8 | | 800 | 800 |
| 15 | 16 | | 1500 | 1600 |
| 30 | 32 | | 3000 | 3200 |
| 80 | 80 | | 8000 | 8000 |

Formatting Figures and Graphs

1. You may not use scanned or copied figures taken directly from any lab handout or course notes in your ME 360 lab report. You may modify PowerPoint file drawings posted to the ME 360 website.
2. All figures should be neatly drawn, either by hand or by computer. All plots of data must be computer generated with Excel, Matlab, or an equivalent program.
3. Plot the independent variable along the abscissa ("X axis") and the dependent variable(s) along the ordinate ("Y axis").
4. Use appropriate scales for each axis: Divisions of 1, 2, 5, 10, or multiples are preferred. Avoid awkward fractions along labeled divisions (computer programs are particularly bad about this). Show 0 on the scale unless this would compress the data unnecessarily.
5. Label the horizontal axis across the bottom of the plot, and the vertical axis along the left hand edge. A "secondary" vertical axis is sometimes provided along the right hand edge.
6. Label each axis with units as well as variable names. If you are plotting two or more variables along the ordinate, use multiple scales (or log scale) if a single scale would compress one set of data excessively.
7. Use similar scales for plots of similar data (perhaps the same experiment run with two different settings).
8. Align each figure so that it reads normally or from the right-hand edge of the page, (i.e., the page should be bound along the left or top side).
9. Plot theoretical relationships along a smooth line or curve, without individual data points (since any point along the curve is equally valid).
10. Plot empirical relationships with individual data points and smooth curves of the appropriate mathematical type. For example, a plot of measured resistance vs. displacement for a potentiometer would use a "best-fit" straight line, since this is the expected relationship.
11. Draw measured data not supported by theory or empirical formula as distinct data points without any lines. Make data points large enough to be easily read.

Some specific comments about graphs in Microsoft Excel

12. Use the X-Y (*Scatter*) plot option for most of your plots--not *Line* plot (which equally spaces X axis data). The only exception to this rule is when no independent variable exists. An example of this case would be plotting the experimentally measured resistance of several resistors.
13. The default placement of the X and Y axis can be changed on the Format Axis – Scale option under “Value (X or Y) axis Crosses at ____”.
14. See the ME 360 website (www.me.ua.edu/me360) for additional comments on using Excel in your lab reports.

Equations

1. Provide the reference for all equations taken from another source, including a textbook or a handout. Embed the reference in the text, do not put the reference on the same line as the equation:

“Bernoulli's equation for incompressible flow is given by Equation 15.2 of Beckwith, Buck, & Marangoni (1982) as

$$\frac{P_1 - P_2}{\rho} = \frac{V_2^2 - V_1^2}{2g_c} = \frac{(Z_2 - Z_1)g}{g_c} \quad (1)$$

2. Define all symbols immediately after they are first used:

Mechanical output power is calculated from the formula

$$P = \tau\omega \quad (2)$$

where

P is the power (typically horsepower or watts),
 τ is the torque (typically ft-lbf or N-m), and
 ω is the angular velocity in RPM (revolutions per minute).

3. Number each equation sequentially in parentheses as shown. The equation can then be referenced by number: "Equation (2) was used to compute motor power output."
4. Center equations, and number them along the right margin, e.g., see example 2.
5. Refer to a numbered equation with a capital E: Equation 1. If you use the abbreviations "Eqn" or "Eq." and "Eqns." or "Eqs.," do so consistently.
6. Place each equation on a separate line. Unless the equation is universally well known or very short, division should be shown on two separate lines. Note the ambiguity in the first two examples below and the clarity of the third.

Not acceptable: $Y_{\max} = 3 \cdot Pa^4 / 16 \cdot E \cdot t^3 \cdot (1 - \nu^2)$ (4)

Not acceptable:
$$Y_{\max} = 3P_a^4 / 16Et^3(1 - \nu^2) \quad (5)$$

Acceptable:
$$Y_{\max} = \frac{3P_a^4}{16Et^3(1 - \nu^2)} \quad (6)$$

7. Equations should be generated using the Equation Editor that is included with Microsoft Word.

References

All references must be specifically mentioned in the text of your report. References are cited in two different places: in text as part of the information within a sentence; OR in text parenthetically not as part of the sentence's direct information [in which case they are put into parentheses]; AND in the references section. If a reference is cited by authors' names in the text, the date should immediately follow in parentheses. The date only has to be stated the first time it is mentioned within a paragraph. When it is mentioned again in the next paragraph, the date must be restated. The names are separated by "and." If a reference is cited parenthetically, the names and date are put in parentheses together. The names are separated by an ampersand (&). In the references section, the names are also separated by an ampersand.

Here are the two ways reference citations can appear in text: 1) "... Wheeler and Ganji (1996) give the equation for gain as ..." or 2) "Gain is the ratio of output amplitude to input amplitude (Wheeler & Ganji, 1996)." Note that both authors and dates are given in each style. Spell out the names for one or two authors. For three or more authors, name all of the authors the first time ("Cuttino, Woodbury, and Parker (1996) described a process for group writing of reports."), but use "et al." for all subsequent references ("Cuttino et al. (1996) also described ...").

Several examples of references using the APA style are listed below. References number 5 (Degelman & Harris, 2000) and number 6 (A guide for writing research papers, APA style, n.d.) listed below can be consulted for additional examples. The APA style for reference listings requires that references be listed alphabetically with a hanging indent format as shown below and in the "Good Lab Report." Note that strict APA style requires the reference list to be double-spaced, but single-spacing the entries with a double-space between entries is used in ME 360/460.

Example for a book listing:

Franklin, G. F., Powell, J. D., & Emani-Naeini, A. (2002). *Feedback control of dynamic systems* (4th ed.). Upper Saddle River, NJ: Prentice Hall.

Example for an article or chapter in an edited book:

Norton, H. N. (1997). Transducers and sensors. In D. Christiansen (Ed.), *Electronic engineers' handbook* (pp. 13.1-13.50). New York: McGraw-Hill.

Example for a magazine article:

Viterna, L. A. (1998, July). Hybrid electric bus. *Power Conversion and Intelligent Motion*, 24, 38-47.

Example for a journal article:

Parker, J. K., Bell, S. R. & Davis, D.M. (1992). An opposed piston engine. *Journal of Engineering for Gas Turbines and Power*, 115, 734-741.

Example for a web document on university program or department Web site (with copyright):

Degelman, D., & Harris, M. L. (2000). *APA style essentials*. Retrieved May 18, 2000, from Vanguard University, Department of Psychology Website: http://www.vanguard.edu/psychology/index.cfm?doc_id=796

Example for a stand-alone web document (no author, no date):

A guide for writing research papers, APA style. (n.d.). Retrieved October 13, 2008, from <http://webster.commnet.edu/apa/>

Note that web addresses can be and should be divided so that the type continues to the right margin. They can be forcefully split after a period or a slash only. The “shift-Enter” option in Word (instead of the “hard” Enter) often works well to force a split in a desired spot without causing other formatting problems.