Introduction

This Stylebook was compiled to help mechanical engineering students improve their technical communication skills. It is to be used as a guide for written technical presentations in all MAE courses. Please refer to it when writing technical reports and completing design projects.

A team of Mechanical and Aerospace Engineering (MAE) faculty compiled the conventions presented: Feng, Kluever, Krawitz, Weisbrook (chair), Whelove and Winholtz. The conventions represent generally accepted practices. The Department recognizes that there is more than one acceptable way to present information. In the interest of instruction and uniformity, however, adherence to these guidelines is expected for all work completed in MAE classes.

Stylebook Version 2.0 is available at www.missouri.edu/~mae/students/students.html. Consult this website for future updates.
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1. Guidelines on Report Formats

As a mechanical engineer, you will be required to write two primary types of documents: technical memos and full technical reports. The structure of each type follows. Other types of documents are also possible. Drafts are often double-spaced to provide room for comments on the text. Assignments in Writing Intensive courses should also be double-spaced unless your instructor says otherwise. Single-spacing usually is preferred for final versions of documents. For coursework to be reviewed by an instructor, double-spacing is usually preferable. Check with your instructor on the appropriate line spacing if you are unsure.

1.1 Structure of a Full Technical Report

A technical report includes several sections. Each section serves a specific purpose. Every report will not require each section. Consider which sections are appropriate for your report.

The ABSTRACT is often a one-paragraph summary of the whole report. It should state the problem, methods, and major conclusions. It should be concise and stand alone without reference to outside graphs, tables, etc. Symbols or equations are generally not introduced in the abstract.

The INTRODUCTION gives background information related to the project. It provides the rational or justification for the project, and should present the main technical issues involved. Customarily, the introduction ends with a general description of the report that follows – a sort of “road map” to orient the reader.

The MAIN SECTIONS are tailored according to the nature of the project. For example, if your project is analytical in nature, you may have a section on mathematical formulations and a section on the results of analysis or numerical simulations. If your project is experimental in nature, you probably will have a section on the instrument setup, a section on measurement procedures, and a section on results.

The CONCLUSION section should highlight the major findings of the project and/or conclusions from the research.

The ACKNOWLEDGEMENT section should give credit to those that you have benefited from in the course of the project, including its conception and the interpretation and/or presentation of the results. It should also include individuals or organizations that provided funding for the project.

The REFERENCE section should list publications or communications cited.

The APPENDICES should contain information that an interested reader might desire but which would interrupt the flow of the main text. Use appendices for derivations, for long tables of data, for background information that readers do not need to understand your major points, and for computer programs.
1.2 Structure of a Technical Memo

A technical memo is shorter in length than a full technical report. It is intended to convey why and how the study was performed, the results, and what was concluded. However, a technical memo does not supply fully the details of procedure and theory. Its focus is on the results and their implications.

A typical technical memo might contain the following sections:

The ADDRESS contains “Date:,” “To:,” “From:,” and “Subject:.” State this information clearly and simply.

The SUMMARY, if included, explains what was done and what was concluded. It should describe the question that the memo addresses and the answer to that question.

The INTRODUCTION or PROCEDURE describes the problem, the approach taken, appropriate theory, and experimental details, if applicable. Theory and procedures should be described only briefly, superficially if necessary. Include figures, if needed.

The RESULTS describe the solution to the problem in as much detail as needed for clarity. Include supportive figures and tables. Raw data, data reduction, or uncertainty calculations should be presented in the appendices if needed.

RECOMMENDATIONS, when needed, are included in a short section that states your recommendations or conclusions clearly and concisely.

The APPENDICES contain information that an interested reader might need but which would interrupt the flow of the main text. Use appendices for derivations, for long tables of data, and for background information that readers do not need to understand your major points.
2. Figures

All figures (graphs, charts, line drawings, photographs, etc.) should be numbered consecutively and have a caption below the figure consisting of the figure number and a brief title or description of the figure, as illustrated in Fig. 1-5. This number should be used when referring to the figure in text. The caption should be lower-case (except for the first word), like a sentence in the text. Figures should be referenced within the text as "Fig. 1." When the reference to a figure begins a sentence, the abbreviation "Fig." should be spelled out, e.g., "Figure 1 illustrates …" When mentioning a specific figure in the text it should be capitalized like a formal name. When speaking about a nonspecific figure, the term is not capitalized.

If the figure is embedded in the text, the figure caption should be set apart from the text by using italics, changing the font size by a small amount, using different margins, or changing the font.

When the page layout permits, a figure embedded within the text should appear following the paragraph in which it was first cited, usually at the bottom or top of a page. If a figure is presented on a separate page, it should appear following the page in which it is first cited. More than one figure may be presented on the same page.

Fig. 1. Comparison of three models’ ability to predict fatigue crack growth rates at a constant driving force of $\Delta K = 22$ MPa$\sqrt{m}$ in 1080 steel specimens containing a residual stress field.
Fig. 2. Dimensions of compact tension specimens used for fatigue crack growth measurements.

Estimation of the Bond Energy for Copper

![Graph showing correlation between melting temperature and bond energy for various metals.]

- Actual Data
- Best Fit Line
- Estimate for Copper

Bond Energy for copper is estimated to be 345 kJ/mole.

Fig. 3. Correlation between the melting point of various metals and the bond energy. The correlation is used to estimate the bonding energy for copper.
Fig. 4. MURSI, the Missouri University Residual Stress Instrument, was used for measuring the thermal residual stresses in a WC-Cobalt composite.

Fig. 5. Three-axis control torque profiles for spin-stabilized satellite.
When plotting data, the independent variable should be plotted as the abscissa or x-axis and the dependent variable should be plotted as the ordinate or y-axis. This is illustrated in Fig. 4 where crack growth rate, the dependent variable, is shown as a function of the crack length, the independent variable. Figure 5 shows time as the independent variable, a common situation in dynamic systems, and torque is the dependent variable shown as a function of time.

The following points apply to figures that contain a graph or chart.

- Plots of experimental data should use symbols to represent the individual data points.
- The symbols should not be joined with a line. Plots of a function or best-fit curve to data points should be represented with lines without any symbols.
- Legends should be placed within the field of the axes of the graph.
- The axes on plots must each have a title with the units used enclosed in parentheses. Units may be omitted for non-dimensional quantities.
- Plots should be scaled so that the final digits in the numerical labels on the axes increment by one, two, five, or ten.
- The labels’ size should be reasonable compared to the size of the plot.
- The number of numerical labels should be reasonable for the plot. If they are too crowded the graph is difficult to read.
- The scales should also be chosen so that the data span a reasonable fraction of the axis length.
- Scale labels should be along the edges of the graph area and not through the middle of the graph area.
- Many times it is useful to put multiple data sets on the same graph when making comparisons rather than making multiple graphs.
- The use of E for exponentiation in graphs (e.g., 1.5 E –5) is undesirable but often necessary because the plotting software does not permit the more desirable use of superscripts (e.g., 1.5 × 10⁻⁵).
- Unless it has a clear purpose, the use of color should be avoided because it will generally not be reproduced in photocopying.
- Figures should fall within the same margins as the text.
3. Tables

Tables are used for reporting extensive numerical data in an organized manner. The reader should be able to understand them without referring to the text. It is seldom necessary to use a table for fewer than about eight items of data.

Table headings should be brief, but sufficiently detailed to explain the data included. The heading should be placed above the table. Number the tables in the order in which they are cited in the text. Capitalize Table, and the first word of the title, and put a period after the table number. If the report is presented in the conventional portrait format and the table is presented in the landscape format, the bottom of the table should be on the right when the report is compiled.

When the page layout permits, a table embedded within the text should appear following the paragraph in which it was first cited, usually at the top or bottom of a page. If a table is presented on a separate page, it should appear following the page in which it is first cited. More than one table may be presented on the same page.

A series of annotated examples is presented. Table 1 shows a tabulation of values with the same units. Table 2 shows a tabulation of values with different units. Table 3 shows tabulation of a large amount of related data. Notice that the cells are outlined due to the complexity of the table.

Table 1. Energies (in keV) of K emission lines of elements from magnesium (Mg) to calcium (Ca).

<table>
<thead>
<tr>
<th>Element</th>
<th>$K\beta_1$</th>
<th>$K\alpha_1$</th>
<th>$K\alpha_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mg</td>
<td>1.297</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Al</td>
<td>1.553</td>
<td>1.487</td>
<td>1.486</td>
</tr>
<tr>
<td>Si</td>
<td>1.832</td>
<td>1.740</td>
<td>1.739</td>
</tr>
<tr>
<td>P</td>
<td>2.136</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>S</td>
<td>2.464</td>
<td>2.308</td>
<td>2.306</td>
</tr>
<tr>
<td>Cl</td>
<td>2.815</td>
<td>2.622</td>
<td>2.620</td>
</tr>
<tr>
<td>A</td>
<td>3.191</td>
<td>2.957</td>
<td>2.955</td>
</tr>
<tr>
<td>K</td>
<td>3.589</td>
<td>3.313</td>
<td>3.310</td>
</tr>
<tr>
<td>Ca</td>
<td>4.012</td>
<td>3.691</td>
<td>3.688</td>
</tr>
</tbody>
</table>
### Table 2. Representative properties of composite fibers and matrices.

<table>
<thead>
<tr>
<th>Material</th>
<th>Elastic Modulus (GPa)</th>
<th>Ultimate tensile strength (MPa)</th>
<th>Density (g/cm$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Matrices</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Epoxy</td>
<td>5</td>
<td>60</td>
<td>1.2</td>
</tr>
<tr>
<td>Aluminum</td>
<td>70</td>
<td>250</td>
<td>2.7</td>
</tr>
<tr>
<td><strong>Fibers</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SiC</td>
<td>350</td>
<td>3500</td>
<td>3.2</td>
</tr>
<tr>
<td>B</td>
<td>400</td>
<td>2500</td>
<td>2.6</td>
</tr>
<tr>
<td>Kevlar</td>
<td>130</td>
<td>3800</td>
<td>1.4</td>
</tr>
</tbody>
</table>

### Table 3. 2001 ASME Egg CATapult Design Contest Results

<table>
<thead>
<tr>
<th>Team Number</th>
<th>Team Members</th>
<th>Design Scoring</th>
<th>Distance Scoring</th>
<th>Total Score</th>
<th>Place</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>Average</td>
</tr>
<tr>
<td>1</td>
<td>Partrick Devaney</td>
<td>5.00</td>
<td>4.50</td>
<td>3.75</td>
<td>4.417</td>
</tr>
<tr>
<td></td>
<td>Nathan Odle</td>
<td>4.50</td>
<td>4.00</td>
<td>3.75</td>
<td>3.917</td>
</tr>
<tr>
<td>2</td>
<td>Amber Roberts</td>
<td>5.00</td>
<td>4.75</td>
<td>3.75</td>
<td>3.917</td>
</tr>
<tr>
<td>3</td>
<td>William Clay Burkett</td>
<td>5.00</td>
<td>4.75</td>
<td>4.00</td>
<td>4.583</td>
</tr>
<tr>
<td>4</td>
<td>Ruben Lozano</td>
<td>4.00</td>
<td>4.00</td>
<td>3.25</td>
<td>3.750</td>
</tr>
<tr>
<td></td>
<td>Jeremy Peterson</td>
<td>2.00</td>
<td>3.50</td>
<td>2.75</td>
<td>2.750</td>
</tr>
<tr>
<td>5</td>
<td>Jim Hazelton</td>
<td>4.00</td>
<td>4.25</td>
<td>3.00</td>
<td>3.750</td>
</tr>
<tr>
<td></td>
<td>George Hacker</td>
<td>3.00</td>
<td>3.50</td>
<td>2.25</td>
<td>2.917</td>
</tr>
</tbody>
</table>
4. Equations and Nomenclature

4.1 Equations

All equations should be numbered and cited in numerical order in the text, including any appendices. Equations should be centered in the text and the equation number should be enclosed in parentheses and set flush right on the same line as the equation. All of the variables in an equation need to have been previously defined or defined immediately after the equation is presented. As an example, an oscillator consisting of a mass, \( m \), spring constant, \( k \), and damping, \( b \), is governed by the relation

\[
m\ddot{x} + b\dot{x} + kx = f(t), \quad (1)
\]

where \( x \) is the displacement and \( t \) is time.

Equations should be referenced within the text as "Eq. (4)" or "Eqs. (2) and (3)" or "Eqs. (1-6)." For example:

"From Eq. (1), it can be seen that an external force \( f(t) \) is applied to the mechanical system…"

When the reference to an equation begins a sentence, it should be spelled out:

"Equation (1) is the mathematical model of a mass-spring-damper system."

Formulas and equations should be created to clearly distinguish capital letters from lowercase letters. Care should be taken to avoid confusion between the lowercase letter “l” ("ell") and the number “1” (one), or between zero (0) and the lowercase letter “o.” All subscripts, superscripts, Greek letters, and symbols should be clear. Double subscripts should be avoided. An equation with acceptable subscripts is

\[
Q_1 = A_1\dot{x}_u + \left( \frac{V_h + A_1\dot{x}_u}{B} \right)\dot{p}_1, \quad (2)
\]

Boldface type should be used for vectors (rather than overbars or arrows) and matrices; scalar values should be in italics. These typeset rules hold for variables and constants whether they appear in equations or in the text. An equation with vectors, matrices and scalars is shown below:

\[
\dot{x} = Ax(t) + Bu(t). \quad (3)
\]

In Eq. (3), the vector \( x \) and matrices \( A \) and \( B \) are in boldface type. The scalars time \( t \) and input \( u(t) \) are in italic type.
The following are set in non-italic type: sin, cos, tan, log, etc. A derivative of a quantity can be indicated by either an overdot or prime [see Eqs. (1-3)]. Multiple overdots (in excess of two) should be avoided.

In some cases, a formal report may require a nomenclature section, which lists all variables and constants in alphabetical order (capital letters first, followed by lowercase letters), followed by Greek symbols, with subscripts and superscripts last, identified with headings. Definitions of each quantity should appear in the nomenclature list. For example,

4.2 Nomenclature

Following equations, symbols should be defined in the order of appearance. Examples follow.

\( A(t) = \) system matrix in state-space representation
\( a = \) radius of rotor
\[ \vdots \]
\( z = \) displacement of equivalent mass
\( \beta = \) magnetic field strength
\( \phi = \) magnetic flux

Subscripts
\( ss = \) steady state
5. Citations

5.1 Text Citations

Within the text, references should be cited in numerical order according to their order of appearance. The numbered reference citation should be enclosed in brackets, for example:

It was shown by Prusa [1] that the width of the plume decreases under these conditions.

In the case of two citations, the numbers should be separated by a comma [1,2]. In the case of more than two references, the numbers should be separated by a dash [5-7].

5.2 Reference Lists

References to original sources for cited material should be listed together at the end of the paper; footnotes should not be used for this purpose. References should be arranged in numerical order according to the sequence of citations within the text. Each reference should include the last name of each author followed by his initials.

References to journal articles, papers in conference proceedings, or any other collection of works by numerous authors should include:

- Last name of each author followed by their initials.
- Year of publication.
- Full title of the cited article enclosed in quotation marks, if used.
- Full name of the publication in italics.
- Volume number (if any) in boldface (Do not include the abbreviation, "Vol." within the reference.).
- If needed, inclusive page numbers of the cited article.

References to textbooks, monographs, theses, and technical reports should include:

- Last name of each author followed by their initials.
- Year of publication.
- Full title of the publication in italics.
- Publisher.
- City of publication.
- Inclusive page numbers of the work being cited.

- References to electronic sources should include: Last name of each author followed by their initials (if known).
- Full title of the complete work (if applicable) in italics.
- Any version or file numbers.
- The date of the document or last revision (if available).
• The protocol (e.g., “http”) and the full URL.
• The date of access in parentheses.

References to personal communications, including email, should include:

• The last name of the source of information followed by initials.
• Professional title (if applicable).
• The date(s) of the conversation(s).
• The location (city and state) of person providing information.
• The words “personal communication” in parentheses.

5.3 Sample References


6. Common Issues

The following is a list of guidelines governing issues that often arise in technical writing:

1. Subscripts, superscripts, Greek symbols, and equations should all be word-processed.
2. Don’t use a caret in place of superscripting for exponents, e.g., \(10^6\) not \(10^6\) or \(1E6\).
3. You should be careful not to imply more precision than is justified by giving too many significant digits in numbers. Round numbers to their appropriate precision. While physicists can carefully measure the speed of light to be \(2.99792458 \times 10^8\) m/s, you are unlikely to measure a material’s yield strength to be 52,384 psi. Round it to 52,400 psi unless you can justify a higher precision.
4. Units should be in physically useful quantities, e.g., MPa, not \(10^6\) Pa; and cm not furlongs.
5. The words for atomic elements are not capitalized, e.g., silver not Silver.
6. There should be a space between values and units, e.g., 100 MPa not 100MPa
7. A degree symbol is not used for temperatures in Kelvin, e.g., 273 K.
8. With degrees centigrade or Fahrenheit, there is a space before the degrees symbol, e.g., 25 °C or 90 °F. For angular measurement in degrees there is no space, e.g., 45°.
9. Use leading zeros, e.g., 0.16%, not .16%.
10. Don’t define a symbol or abbreviation unless you intend to use it subsequently, e.g., don’t write “friction stir welding (FSR)”, unless you use “FSR” later in your paper.
11. Double spacing a document is often appropriate for drafts and academic assignments so that there is room for comments and editing.