From Problem Set to Design Proposal: Fostering Discipline-Relevant Writing (and Writing Instruction) in Mechanical Engineering

Ben Adams
University of Minnesota – Mechanical Engineering
adam0068@umn.edu
What does Mechanical Engineering writing look like?

We need writing.

It is as much a process as a product.
But students think this is OK

4-17) 1399 s
4-20) 53°C
4-27) 37.7°C
4-58) 33.7°C
4-64) 1091 s
WI isn’t quite enough
2007 Survey: Faculty didn’t consider problem sets as writing.

Faculty: How many pages of individual student writing, on the average, do you assign per course?

<table>
<thead>
<tr>
<th>Response</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 Pages</td>
<td>7%</td>
</tr>
<tr>
<td>1-5 Pages</td>
<td>14%</td>
</tr>
<tr>
<td>6-10 Pages</td>
<td>35%</td>
</tr>
<tr>
<td>11-20 Pages</td>
<td>14%</td>
</tr>
<tr>
<td>21-50 Pages</td>
<td>7%</td>
</tr>
<tr>
<td>51-100 Pages</td>
<td>7%</td>
</tr>
<tr>
<td>100+ Pages</td>
<td>14%</td>
</tr>
</tbody>
</table>

“[Prof] Durfee stated that if problem sets had been included on the survey, 100% of students and faculty would have identified them.” –M1 meeting minutes
2007 Survey responses to the importance of writing in Mechanical Engineering

Sample Sizes
Students (N=70)
Faculty (N=15)
Professionals (N=11)
2007 Survey: How are students doing?

Faculty: To what degree are you satisfied with the quality of writing you receive from your students?
2007 Survey: Please describe the most serious problems you see in student writing.

Students say:
- Maintaining coherence or “flow”
- Organizing ideas
- Using proper word choice

Faculty say:
- Creating an argument
- Organization
- Summary writing
- Audience Analysis
- Grammar, punctuation, spelling, mechanics
2007 Survey: Final Words

Faculty
“I would prefer if somebody else would do the teaching of writing.”

“Will need support for any of this.”

Students
What resources would be helpful to you?

<table>
<thead>
<tr>
<th>Specific writing guidelines</th>
<th>57%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Face-to-face tutoring</td>
<td>41%</td>
</tr>
<tr>
<td>Support from graduate TAs</td>
<td>39%</td>
</tr>
<tr>
<td>Instructor office hours</td>
<td>38%</td>
</tr>
</tbody>
</table>
The Result

Source: ME Student Writing Guide
me.umn.edu/education/undergraduate/writing
Guide Evolution

II Writing Styles

This section outlines the different types of writing found in the mechanical engineering program. The sections are presented in no particular order.

Homework Problem Sets

Description: A well-known writing style to any engineer is the problem. These are quite typical in style, a question is provided, and the student must use the information provided to answer it. This section will outline the rules of student documentation, assessment criteria, and examples.

Formatting: The deliverable is generally submitted handwritten or typed. Processing this document is not discouraging. The media should not prohibit clear and accurate documentation of the work. The same clarity of the deliverable in mind, it can also inhibit the clear reading and work.

The type of paper to be used is up to the preferences of the student. The use of paper with a dark background, such as Legal size, is discouraged. Detached spiral bound pages, including those with large text, should be avoided.

Perspective: Think of your audience. Will your instructor read what you submit? Will your peers review the work of other? The clarity of your writing and attention to detail are important.

No 2 pencil is the preferred writing instrument for this type of work. Writing with a mechanical pencil may be used by students who never make mistakes. The use of mechanical pencils is recommended to make corrections on a calculator, designing slides, or fabricating aluminum brackets. However, this may be indistinguishable. As a rule of thumb, black and blue ink color is recommended.

D.4 Solve & Evaluate Result

This section solves for the solution using the process already developed. It yields the final answer required by the problem.

Evaluate Result

This Section Contents

<table>
<thead>
<tr>
<th>Solve</th>
<th>Evaluate Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substitute Values in Equations</td>
<td>Check Units of Result</td>
</tr>
<tr>
<td>Show Units with Values</td>
<td>Sanity Check Result</td>
</tr>
<tr>
<td>Indicate Final Answer</td>
<td></td>
</tr>
</tbody>
</table>

Why?

You have to calculate an answer to satisfy the objective and you want to make sure.

Figure 6: Solve & Evaluate

Status Check

The problem is solved. The end result will be clear as well as the process that was taken for solving it. Nothing should be left to hand waving.
This guide will help you show your logic when completing a problem set, which will allow you to earn full points.

To begin, we first define what a problem set is.

### 1.2 A Problem Set defined

| Summary | A Problem Set completely describes and explains how to solve a technical problem.

### 1.3 Audience & Purpose

| Audience (Who is reading this) | • The course Teacher
• Yourself (for study)

| Purpose (What’s supposed to do) | • To solve the problem
• To communicate reasoning and logic

The Mechanical Engineering Department recognizes that you may not have a complete understanding of the problem after the fact, but rather, it is an iterative, thought-developing mindset, where you continuously test your hypotheses and work toward a solution.

### 1.4 Why write a Problem Set well?

Mechanical Engineering faculty expect students to demonstrate the ability to identify, formulate, and solve engineering problems.

“Problem sets are the most ubiquitous form of writing we do.”
- Professor Will Durfee, Mechanical Engineering

What students say:

“I like it because it allows us to understand the material and our work.” - ME Student, 2007 WEC Survey

---

1 ME Undergraduate Educational Outcomes & Objectives are available at [ME Home > Education > Undergraduate Education > Educational Outcomes](ME Home > Education > Undergraduate Education > Educational Outcomes).

---

### 3. Annotated Example

Below is an example problem, with its components labeled and explained.

#### Section

| Problem Definition | Restate and describe the problem (Problem statement), as needed.
• Sketch Pictorial Representation
• List Given Quantities & Define Variables
• Use Names

| Objective | State your objective(s) and engineering terminologies.

| Model | Translate the restated problem into an engineering terminology.
• State Assumptions

| Narration | Describe your solution, as needed.
• Show General Equation
• Use Variables
• Cite Equations

| Solve | Substitute values to find numerical answers.
• Indicate confidence

| Evaluate | Check your work.
• Check & Show Units
• Sanity Check Result

---

2 “A well posed problem is half done.” A substantial portion of any problem is understanding what the problem is (problem statement) and how to represent it in engineering terms (model). When making the model, such as converting a 2x4 stud wall into four elements of varying thermal conductivity, you are making and solving your engineering assumptions. Textbook problems often do this for you and show the model you should use directly, as in the following example:
Do they use it? – Survey 2012

Have you used the student writing guides to help you write lab reports, problem sets or design reports in any course you have taken?

- Yes: 45
- No: 14

“I found the guide for writing formal lab reports extremely helpful and have had it open while writing almost all of my lab reports.”

“I glanced at the writing guide...but it seems unnecessarily long ... with sections that aren't directly pertinent to the lab report (such as the section called "Why Write Well?").”
Next Step - Bubble Up Instructional Change

5-Minute workshops are a quick and simple way to teach. The organizational theme is roughly three minutes of directed, individual, critical thinking, followed by two minutes of pointed discussion. The activity should result in a teachable moment where the object is clear.

4.1 “Communicating an Estimate”
Organize a small-group activity to be performed quickly in lecture or lab. The goal is to get students thinking about the communicative function of a problem set.

<table>
<thead>
<tr>
<th>Objective</th>
<th>To teach students the necessary parts of a problem set by asking them to communicate a problem solution.</th>
</tr>
</thead>
<tbody>
<tr>
<td>When to Use</td>
<td>Just before or after the first problem set is due.</td>
</tr>
<tr>
<td>Method</td>
<td>Perform an estimation problem in groups. Write the solution to this problem to convince someone else you are correct. Then discuss as a class what you need to communicate this effectively.</td>
</tr>
<tr>
<td>Pedagogical Rationale</td>
<td>When the students are asked to communicate a solution themselves, they’ll organically discover that all the parts are necessary, and not just an academic exercise.</td>
</tr>
<tr>
<td>Example</td>
<td>These are example steps you might take for this activity.</td>
</tr>
<tr>
<td>Group Work (5 min)</td>
<td>• Pick a problem, such as “How many ping pong balls would it take to fill this room?”</td>
</tr>
<tr>
<td></td>
<td>• Divide class into groups of two or three.</td>
</tr>
<tr>
<td></td>
<td>• Ask each group to write down the solution to this problem in a way that would convince another group it’s correct.</td>
</tr>
<tr>
<td></td>
<td>• Exchange papers between groups.</td>
</tr>
<tr>
<td></td>
<td>• Ask each team to critique the work.</td>
</tr>
<tr>
<td>Class Discussion (2 min)</td>
<td>• Ask the class what parts they needed for to understand what the other students were thinking.</td>
</tr>
<tr>
<td></td>
<td>• The list will include all parts, except for the problem statement, because it was understood by all there.</td>
</tr>
<tr>
<td></td>
<td>• Ask for the estimated values and write them on the board.</td>
</tr>
<tr>
<td></td>
<td>• Based on the values you recorded, emphasize how the validity of the estimate depends on what they wrote (model, calculations, estimated values), not the final numerical value.</td>
</tr>
</tbody>
</table>