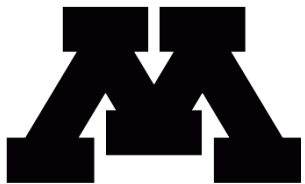


# From Problem Set to Design Proposal: Fostering Discipline-Relevant Writing (and Writing Instruction) in Mechanical Engineering

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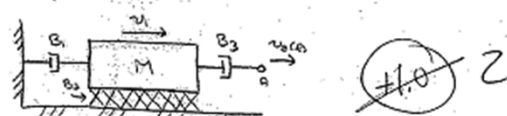


# What does Mechanical Engineering writing look like?


#3  
Problem 5

Statement: A velocity input  $v_2(t)$  is applied to point A in the mechanical system shown.

(a) Write the system's differential equation in terms of the velocity  $v_1$ . (b) What is the time constant  $\tau$  for the system? (c) Sketch the response when  $v_2(t) = 0$  for  $t < 0$  and  $v_2(t) = 10$  for  $t > 0$ . (d) Repeat parts (a), (b), (c) when the velocity input is replaced by a force  $f_2(t)$  applied at point A, with the positive sense to the right. Explain why the expression for  $\tau$  differs from the answer to part (b).



Solution:



(a)  $M\dot{v}_1 + B_1v_1 + B_2v_1 = B_3(v_2 - v_1)$   
 $M\dot{v}_1 + (B_1 + B_2)v_1 + B_3v_1 = B_3v_2(t)$   
 $M\dot{v}_1 + (B_1 + B_2 + B_3)v_1 = B_3v_2(t)$

(b)  $M\dot{v}_1 + B_1v_1 + B_2v_1 = f_2(t)$   
 $M\dot{v}_1 + (B_1 + B_2)v_1 = f_2(t)$   
 $M\dot{v}_1 + (B_1 + B_2)v_1 = f_2(t)$

(c)  $\dot{y} + ay = F(t)$   
 $\frac{1}{a} = \tau$   
 $\tau = \frac{1}{(B_1 + B_2 + B_3)}$   
 $\tau = \frac{M}{(B_1 + B_2 + B_3)}$

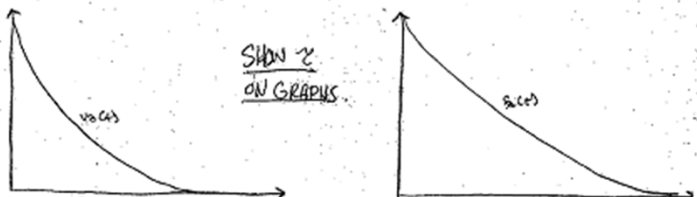
(d)  $f_2(t) = 0$  for  $t < 0$  and  $v_2(t) = 10$

$\dot{y} + ay = M$      $y_h(t) = K e^{-at}$   
 $y_p(t) = A$   
 $y_p + ay_p = M$   
 $A = M/a = y_p(t)$   
 $y(t) = K e^{-(B_1+B_2+B_3)t} + \frac{M}{(B_1+B_2+B_3)}$   
 $y(0) = K e^{-(B_1+B_2+B_3)0} + \frac{M}{(B_1+B_2+B_3)}$   
 $10 = K$   
 $v_1(t) = 10 e^{-(B_1+B_2+B_3)t}$

(e)  $f_2(t) = 0$  for  $t < 0$  and  $v_2(t) = 10$

$\dot{y} + ay = M$      $y_h(t) = K e^{-at}$   
 $y_p(t) = A$   
 $y_p + ay_p = M$   
 $A = M/a = y_p(t)$   
 $y(t) = K e^{-(B_1+B_2)t} + \frac{M}{(B_1+B_2)}$   
 $y(0) = K e^{-(B_1+B_2)0} + \frac{M}{(B_1+B_2)}$   
 $10 = K$   
 $f_2(t) = 10 e^{-(B_1+B_2)t}$

SHOW  $\tau$  ON GRAPHS.



$f_2(t)$  directly transmitted to mass, so takes place of  $B_3$  (resp.  $M$ ).

We need writing.

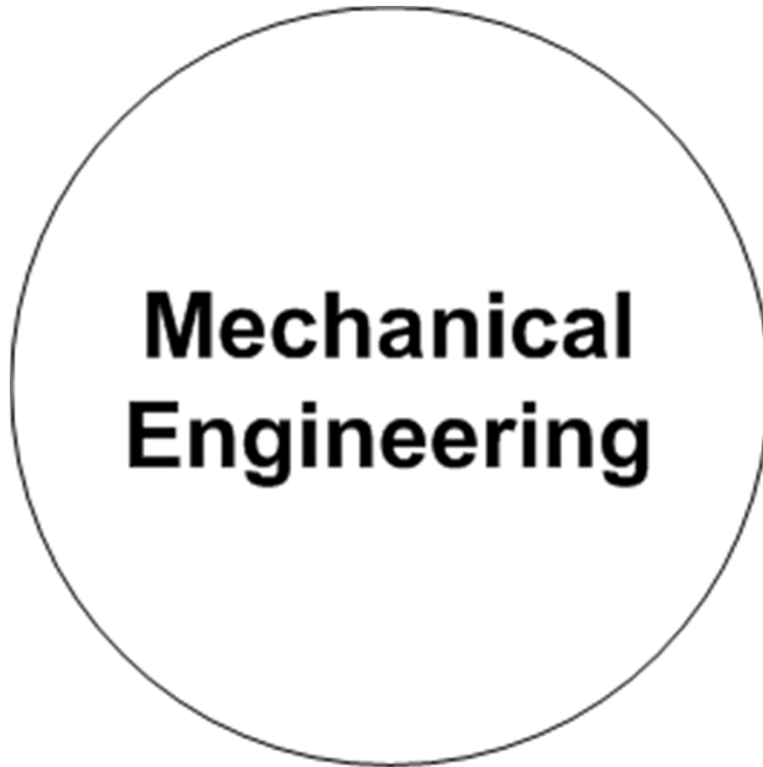
It is as much a process as a product.

But students think this is OK

EASE® - 5 SQUARES  
EASE® - 5 SQUARES  
EASE® - 5 SQUARES


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.

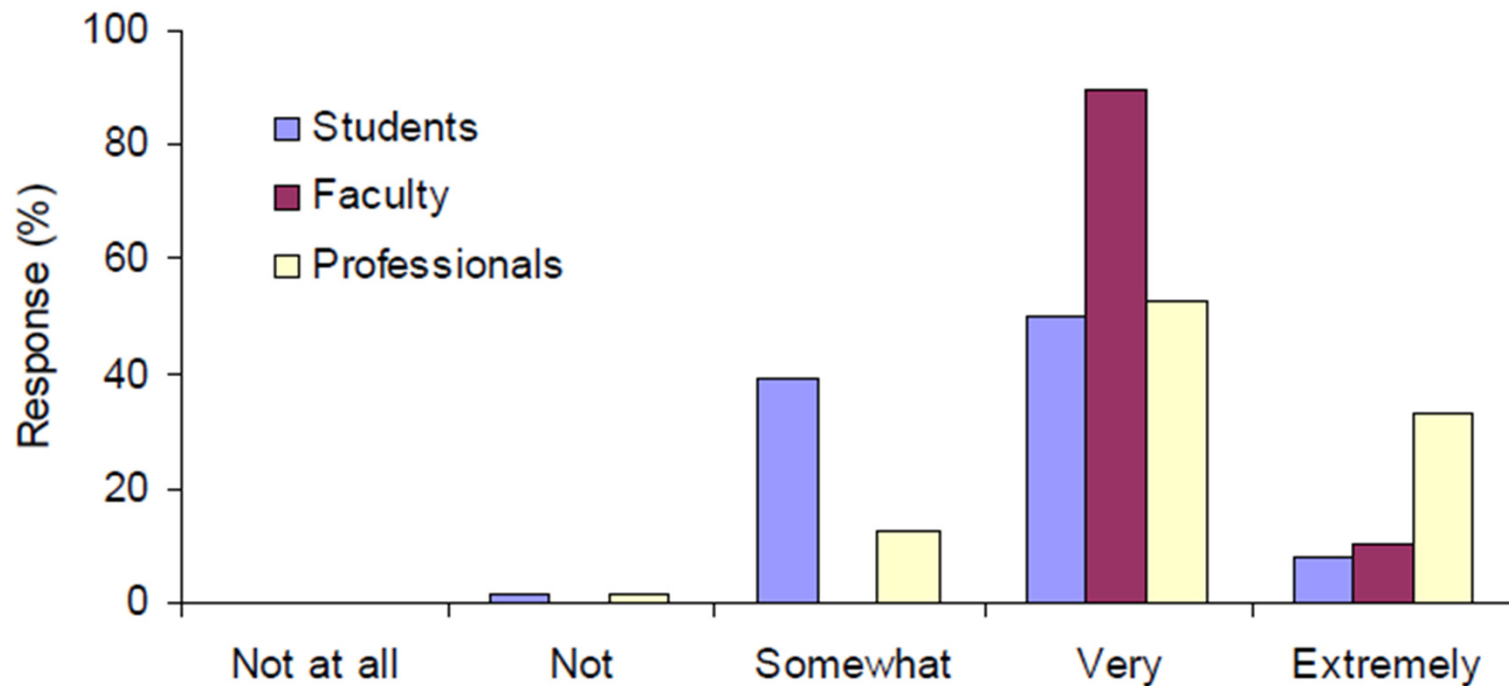
**Faculty:** How many pages of individual student writing, on the average, do you assign per course?



Response	Percent
0 Pages	7%
1-5 Pages	14%
6-10 Pages	35%
11-20 Pages	14%
21-50 Pages	7%
51-100 Pages	7%
100+ Pages	14%

“[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

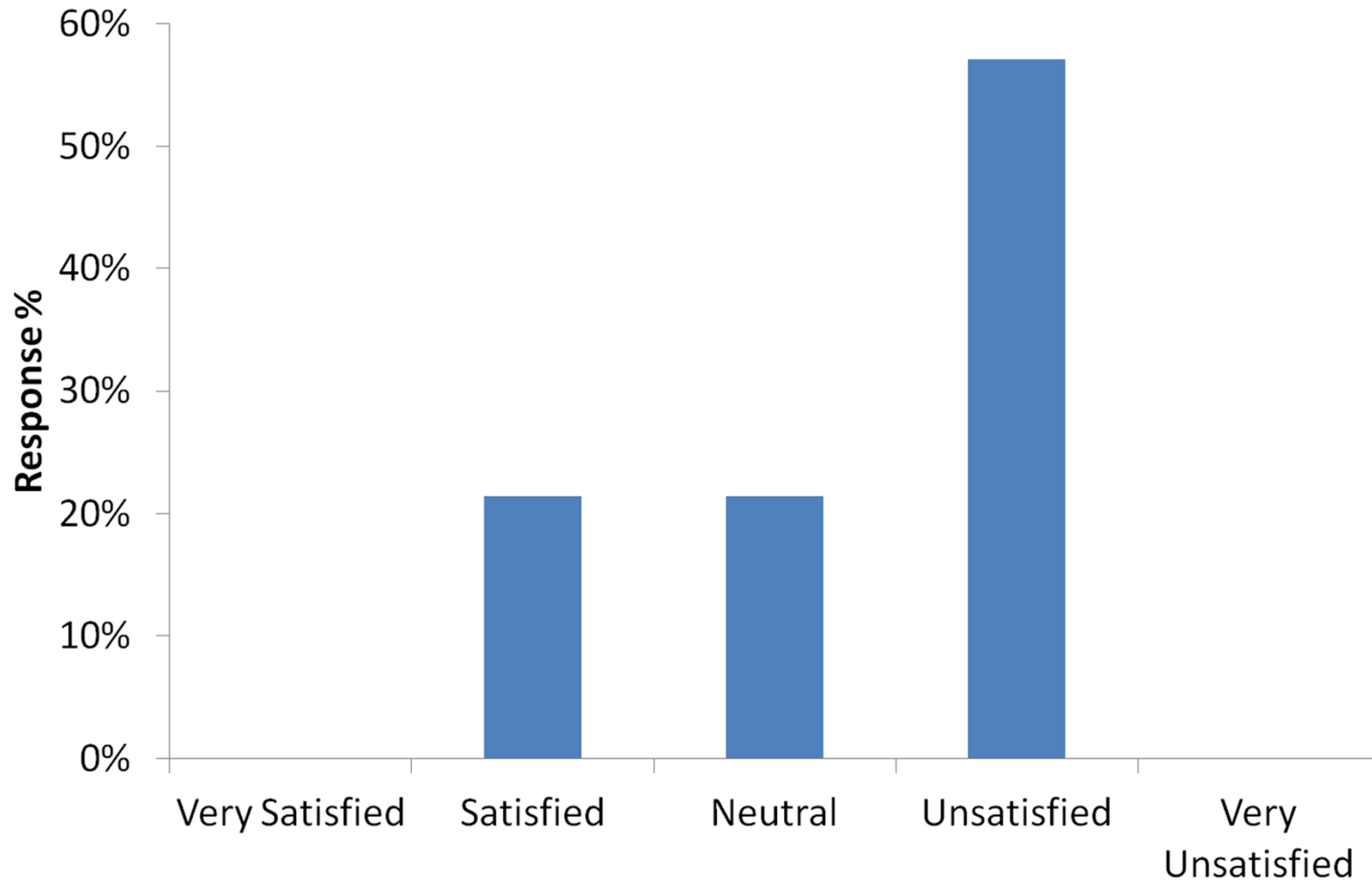
Students (N=70)

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?


<b>Specific writing guidelines</b>	<b>57%</b>
Face-to-face tutoring	41%
Support from graduate TAs	39%
Instructor office hours	38%

# The Result

Student  
Writing  
Guide




UNIVERSITY OF MINNESOTA  
Mechanical  
Engineering




Problem Sets

Student  
Writing  
Guide



UNIVERSITY OF MINNESOTA  
Mechanical  
Engineering



Lab Report

## How to Write a Design Report

### Table of Contents

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### I. Before you Begin

You need to understand what you are doing before you can write a good report.

**Definition:** A design report documents the solution to a unique problem.

**Purpose:** to communicate the solution to a problem.

**Audience:** anyone who has to implement your design, understand your design, or reference it to solve their own unique problem. Typically, this is the project client. While the client may be familiar with the project, the report is still written as though the client is new to the project.

Undergraduate Writing Guide: Design Report 1

Source: ME Student Writing Guide  
[me.umn.edu/education/undergraduate/writing](http://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 engineering problem. These are quite typical in style; a question is provided source, and the student must use the information provided documentation to answer it. This section will outline: the required student documentation, assessment criteria, and examples.

**Formatting:** The deliverable is generally submitted handwritten. Processing this document is not discouraged. The media should be clear of the deliverable in mind. For example, while word processing up spelling and neatness issues, it can also inhibit the clear reading and work.

The type of paper to be used is up to the preferences of the student. Do not prohibit clear and accurate documentation of the work on disheveled pages, including detached spiral bound pages, are to be avoided.

**Perspective:** Think of your audience. Will your lead trust your skills if you submit a neatly worked solution on an illegible string of symbols on a coffee stained napkin?

No. 2 pencil is the preferred writing instrument for this type of work. A marker may be used by students who never make mistakes. The writing instrument is left to the student's preference; however, the presentation material or make an otherwise legible written indistinguishable. As a rule of thumb, black and blue ink colors

Mechanical Engineering WEC Style Guide Third Rev 0711

## Description of Problem Solving Components

"A problem well-posed is a problem half-solved."<sup>3</sup>

### Define the Problem

The problem here is restated with words in conceptual form. It gives a high-level view of the problem and will allow anyone unfamiliar with the problem a clear understanding of it.

### Decompose the Problem

The problem is taken from its qualitative statement above to some basic concepts. A visual representation of the problem usually comes in handy. A free body diagram, theoretical background to a design problem, and reverse engineered product are all examples of these. This is generally the most difficult step.

### Plan the Approach

The tools to be used in solving the problem are presented here. These might be useful equations, experiment methodology, or a presentation outline... anything which will get from the knowns to the final product.

### Solve the Problem

The approach designed in the previous method is executed. This might be making calculations on a calculator, designing slides, or fabricating aluminum brackets. This is the manifestation of the problem solving process.

### Evaluate the Result

The problem solving process is never perfect. It can only get close. Assume the problem has mistakes and verify the work. If the units are incorrect, a designed life jacket doesn't float, or a resume is 5 pages long, a recheck is needed.

This methodology to problem solving is sometimes difficult to see. To put these in real terms, use your engineering skills and solve the following problem of a mechanical engineering grad student using the above method.

"It seems whenever I go to my desk drawer to get scotch tape the roll is almost empty; however, I'm constantly buying it."

### Define the Problem

The grad student's scotch tape is disappearing.

### Decompose the Problem

Scotch tape doesn't magically disappear, nor does it evaporate. The only way for the scotch tape roll to get smaller is for someone to use it. Since the grad student

ME Student Writing Guide

## 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.

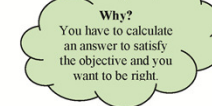
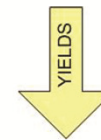
This Section	Contents
Solve	<ul style="list-style-type: none"> <li>Substitute Values in Equations</li> <li>Show Units with Values</li> <li>Indicate Final Answer</li> <li>Check Units of Result</li> </ul>
Evaluate Result	<ul style="list-style-type: none"> <li>Sanity Check Result</li> </ul>

Keep track of your units as you substitute. Using unit reduction will mitigate equation errors.

Box, circle, underline, or highlight the end result. The audience is keenly interested in this.

Unit checks are a great way to check your work. If there are any problems, they will likely manifest here.

Ask yourself, "Does this answer make sense?" If the answer seems excessively high or low, recheck your work. You probably missed something.



Handwritten calculation showing unit reduction:

$$W = \frac{1}{2} (70 \frac{\text{KN}}{\text{m}}) (200 \frac{\text{m}}{100 \text{ cm}})^2$$

$$W = 1.4 \text{ KN m} \Rightarrow \boxed{W = 1.4 \text{ KJ}}$$

**Solve & Evaluate Checklist**

- Substitution: Neat & Logical? ✓
- Units on all Values? ✓
- Indicated Final Answer? ✓
- Unit Check (unwritten)
- Sanity Check (unwritten)

Figure 4: 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.

June

July

August



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 a problem to solve a text
---------	--

### 1.3 Audience & Purpose

Audience (Who is reading this)	<ul style="list-style-type: none"> <li>The course Textbook</li> <li>Yourself (for learning)</li> </ul>
Purpose (What it's supposed to do)	<ul style="list-style-type: none"> <li>To solve the problem</li> <li>To communicate reasoning and solution</li> </ul>

The Mechanical Engineering Department recognizes that engineering is not a fact, but rather, it is an iterative, thought driven process. You develop 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. (ME Undergraduate Educational Outcomes & Objectives)

"The problem set is the most ubiquitous form of writing in engineering." - Professor Will Durfee, Mechanical Engineering

What students say:

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

<sup>1</sup> ME Undergraduate Educational Outcomes & Objectives are available at: [ME Home > Education > Undergraduate Education > Education Outcomes](#)

ME Student Writing Guide

## 2. Problem Set Organization

Each of the Problem Set sections is described in the table below.

Section	
<b>Problem Definition</b>	<p><b>Restate and define the problem</b></p> <ul style="list-style-type: none"> <li>Sketch Problem</li> <li>List Given Quantities</li> <li>Define Variables</li> <li>Use Name of Problem</li> </ul>
<b>Objective</b>	<p><b>State your Objective</b></p> <ul style="list-style-type: none"> <li>State Assumptions</li> </ul>
<b>Model<sup>2</sup></b>	<p><b>Translate the real world engineering terms into a model</b></p> <ul style="list-style-type: none"> <li>Show Governing Equations</li> <li>Use Variable Names</li> <li>Cite Equation Sources</li> </ul>
<b>Narration</b>	<p><b>Describe your logic</b></p> <ul style="list-style-type: none"> <li>Show Governing Equations</li> <li>Use Variable Names</li> <li>Cite Equation Sources</li> </ul>
<b>Solve</b>	<p><b>Substitute values and solve for numerical answers</b></p> <ul style="list-style-type: none"> <li>Indicate Units</li> <li>Sanity Check Result</li> </ul>
<b>Evaluate</b>	<p><b>Check your work</b></p> <ul style="list-style-type: none"> <li>Check &amp; Show Units</li> <li>Sanity Check Result</li> </ul>

<sup>2</sup> "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 showing your engineering assumptions. Textbook problems often do this for you and show the model you should use directly, as in the following example.

ME Student Writing Guide

### 3. Annotated Example

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

**Homework 2**      9/22/2011      TOMMY TUTONE      2/6

**PROBLEM 2-4**

GIVEN THE FOLLOWING SYSTEM :-

**GIVEN VALUES:**

THERMAL CONDUCTIVITIES

$K_A = 150 \frac{W}{m \cdot ^\circ C}$   
 $K_B = 30 \frac{W}{m \cdot ^\circ C}$   
 $K_C = 50 \frac{W}{m \cdot ^\circ C}$   
 $K_D = 70 \frac{W}{m \cdot ^\circ C}$

ALSO,

$A_C = 0.1 m^2$   
 $T_1 = 370^\circ C$   
 $T_2 = 66^\circ C$   
 $x_1 = 2.5 cm = 0.025 m$   
 $x_2 = 7.5 cm = 0.075 m$   
 $x_3 = 5.0 cm = 0.05 m$

**FIND:** THE HEAT FLUX THROUGH THE WALL,  $\dot{q}''$

**SOLUTION:**

- ASSUME ONE-DIMENSIONAL CONDUCTION, SO TEMPERATURES ARE THE SAME IN Y, Z DIRECTIONS.
- ASSUME STEADY STATE, SO THERE IS NO ENERGY STORAGE.

USE RESISTANCE NETWORK METHOD,

WHERE:  $\dot{q} = \frac{\Delta T}{\sum R} = \dot{q}'' A_C$  (EQUATION 2-6)

AND  $R = \frac{\Delta x}{KA}$  (EXAMPLE 2-3)

Name, Title, Page Number, & Date

Problem Definition

Model

Sketch

Good: Definition of axes and datum.

List Given Quantities & Define Variables

Note: Values converted to standard units immediately.

Objective

State Objective

Narration

State Assumptions (as you make them)

Show Governing Equations

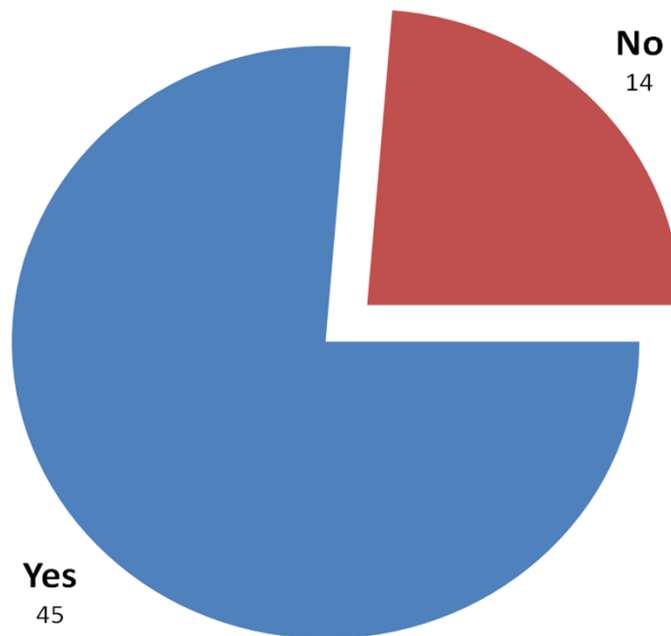
Cite Equation Sources

ME Student Writing Guide      Problem Sets - 7

Problem Sets - 6

# 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?



“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

Student  
Writing  
Guide – TA Supplement



Problem Sets

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.

Objective	To teach students the necessary parts of a problem set by asking them to communicate a problem solution.
When to Use	Just before or after the first problem set is due.
Method	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.
Pedagogical Rationale	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.
Example	<p>These are example steps you might take for this activity.</p> <p><b>Group Work (3 min)</b></p> <ul style="list-style-type: none"> <li>• Pick a problem, such as “How many ping pong balls would it take to fill this room?”</li> <li>• Divide class into groups of two or three.</li> <li>• Ask each group to write down the solution to this problem in a way that would convince another group it’s correct.</li> <li>• Exchange papers between groups.</li> <li>• Ask each team to critique the work.</li> </ul> <p><b>Class Discussion (2 min)</b></p> <ul style="list-style-type: none"> <li>• Ask the class what parts they needed for to understand what the other students were thinking.</li> <li>• The list will include all parts, except for the problem statement, because it was understood by all there.</li> <li>• Ask for the estimated values and write them on the board.</li> <li>• 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.</li> </ul>