Student Writing Guide

Problem Sets

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Fall 2011. Version 2.0

This writing guide has been developed for the Department of Mechanical Engineering by Ben Adams and Professor Will Durfee of the ME department, with the support of Pamela Flash, director of Writing Across the Curriculum. Financial support for developing this guide came from the Writing Enriched Curriculum project, (www.wec.umn.edu).

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This guide will show you how to write a problem set.

1. Before you begin

If you understand the purpose of your writing before you begin, your problem set will turn out better. This section describes background information and the purpose of a problem set.

1.1 Why this is important

You will come across problems such as the following very often in your mechanical engineering coursework:

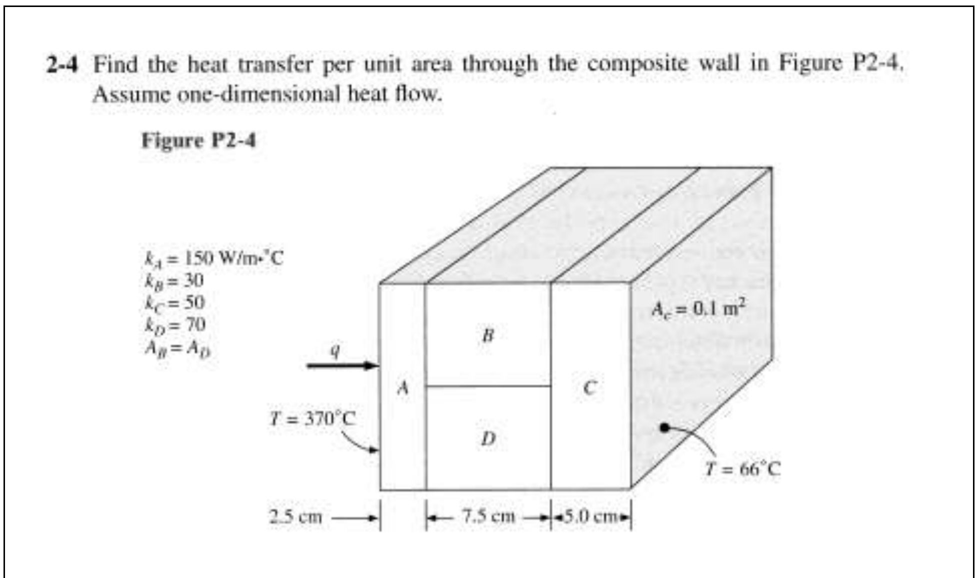
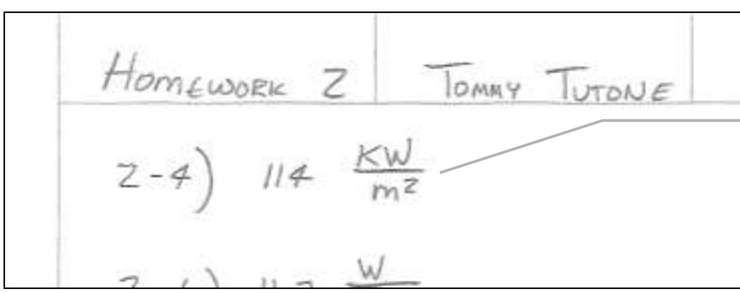

2-4 Find the heat transfer per unit area through the composite wall in Figure P2-4. Assume one-dimensional heat flow.

Figure P2-4

Source: Holman, J. (2010). Heat Transfer 10th Edition

However, the very **worst** answer you can submit to a homework problem is:



Numerically correct, but no logic shown. (few pts)

The reason is that the grader doesn't care what your answer to the problem is. Instead, the grader wants to know the logical thought process you used to get there.

In engineering practice, problems are seldom as simple and straightforward as an engineering textbook. However, if we can verify the **logic and assumptions** you use to deduce a textbook answer, we can grow your professional skills.

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 the logic and assumptions you made to solve a textbook engineering problem.

1.3 Audience & Purpose

Audience (Who is reading this)	• The course TA • Yourself (for future reference)
Purpose (What it's supposed to do)	• To solve the problem in the first place • To communicate to the TA your logical reasoning and engineering application skills.

The Mechanical Engineering Department recognizes that writing is not something performed after the fact, but rather, it is an iterative, thought development process in which you formalize your hypotheses and work toward a solution.

1.4 Why write a Problem Set well?

Mechanical Engineering Faculty **expect** students to communicate clearly and effectively in their ability to identify, formulate, and solve engineering problems.

(ME Undergraduate Educational Objectives)[1]

"The problem set is the most ubiquitous form of **writing** our students do."
- Professor Will Durfee, Mechanical Engineering Faculty Member

What students say:

> "I like it because it allows us to understand the math concept better when we have to show our work." -ME Student, 2007 WEC Survey

[1] ME Undergraduate Educational Outcomes & Objectives are available on the ME website on the education tab. (ME Home > Education > Undergraduate Education > Educational Objectives/Outcomes)

1.5 Problem Set Elements

A problem set is created using these defining characteristics. Each of these is illustrated in the example problem set.

Name, Title, Page Number, & Date
A problem set requires Name, Title, Page Number, and Dates. These are essential elements of professional formatting.

Self-Supporting Document
A problem set can stand on its own. You are presenting enough information for the reader to understand the logic you used to find a solution. You must reference textbook equations and principles you use as you apply them.

Narration
A problem set is a narration of the solution to a problem. A narration is a coherent story which describes a series of events from the beginning to end. As you solve, write short narrative comments between equations and sketches to transition the reader through your logic.

Technical Writing
A problem set is information-oriented and purpose driven. It is concerned with the communication of logic (logos) from one individual to another. It does not include elements of style commonly found in creative writing, such as: allusion, foreshadowing, and drama. Those are used to elicit emotion (pathos) from the reader.

Persuasive
A problem set is trying to make the audience believe that you know how to solve this problem.

2. Problem Set Organization

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

Section	Contents
Problem Definition	**Restate and define the problem.** • Sketch Problem • List Given Quantities • Define Variables • Use Name, Title, Page Number, & Date
Objective	**State your Objective.**
Model[2]	**Translate the real-world problem into engineering terms.** • State Assumptions
Narration	**Describe your logic as you apply it.** • Show Governing Equations • Use Variable Form • Cite Equation Sources
Solve	**Substitute values into variables and get a numerical answer.** • Indicate Final Answer
Evaluate	**Check your work.** (often not shown) • Check & Show Units • Sanity Check Result

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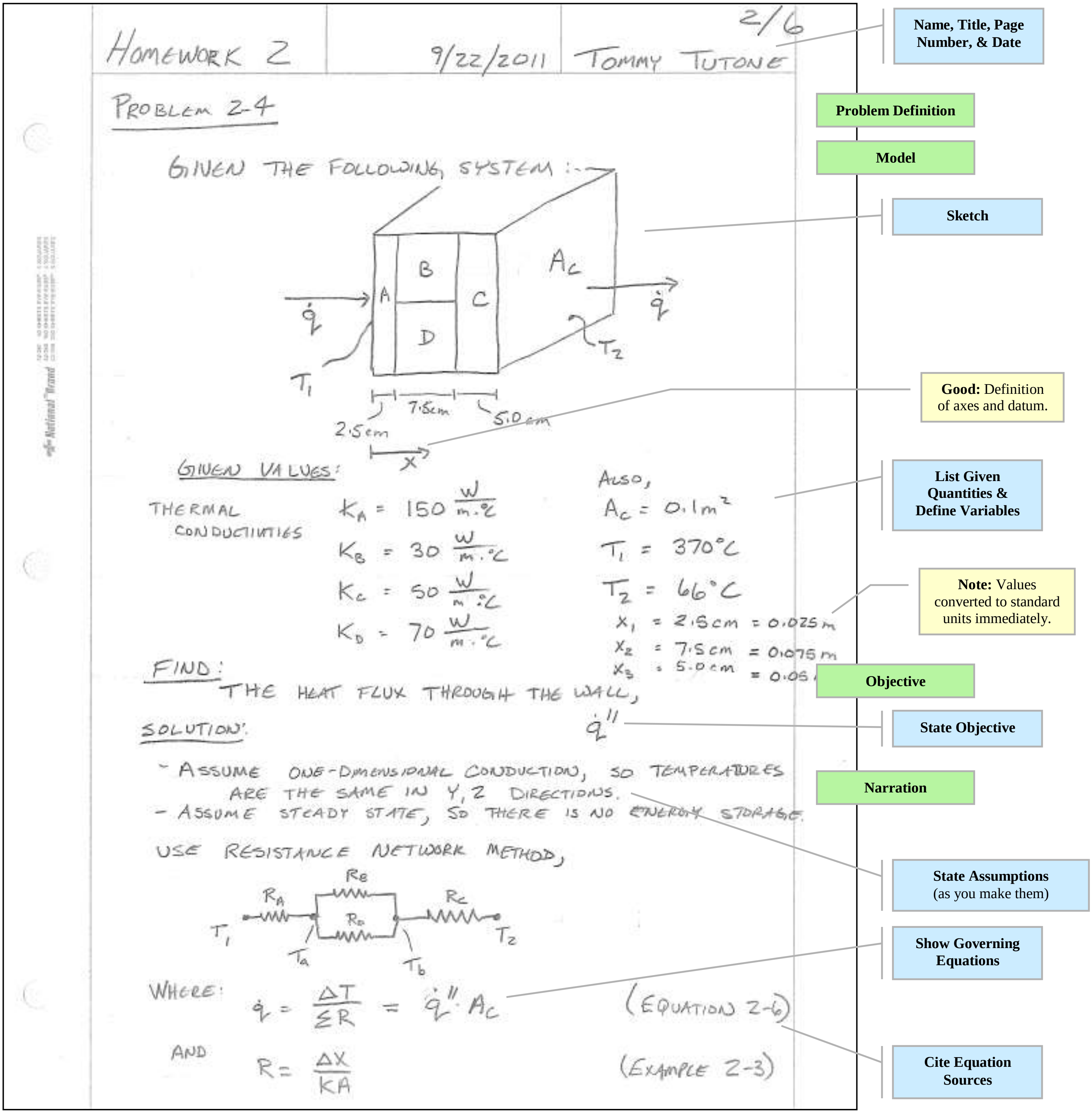
[2] *"A well posed problem is half done."*
A substantial portion of any problem is understanding what the problem is (**problem statement**) and how to represent it in engineering terms (**model**). When making the model, such as converting a 2x4 stud wall into four elements of varying thermal conductivity,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

3. Annotated Example

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



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PROBLEM 2-4 cont TOMMY TUTONE

THE SUM OF RESISTANCES IS:

$$\Sigma R = R_A + \frac{1}{\frac{1}{R_B} + \frac{1}{R_D}} + R_C$$

WHERE SECTIONS B & D ARE COMBINED LIKE PARALLEL RESISTORS.

I'LL FURTHER ASSUME B & D HAVE EQUAL AREAS $= \frac{1}{2} A_C$.

COMBINING EQUATIONS,

$$\dot{q}'' A_C = \frac{T_1 - T_2}{\frac{x_1}{K_A A_C} + \frac{1}{\frac{1}{\frac{2x_2}{K_B A_C}} + \frac{1}{\frac{2x_2}{K_D A_C}}} + \frac{x_3}{K_C A_C}}$$

CANCELLING + SIMPLIFYING,

$$\dot{q}'' = \frac{T_1 - T_2}{\frac{x_1}{K_A} + \frac{2x_2}{K_B + K_D} + \frac{x_3}{K_C}}$$

SUBSTITUTING VALUES,

$$\dot{q}'' = \frac{370°C - 66°C}{\frac{0.025\,m}{150\,\frac{W}{m°C}} + \frac{2(0.075\,m)}{(30+70)\,\frac{W}{m°C}} + \frac{0.05\,m}{50\,\frac{W}{m°C}}}$$

$$= 113900\ \frac{W}{m^2}$$

$$\boxed{\dot{q}'' = 114\ \frac{kW}{m^2}}$$

Note: Use small sentences to narrate your solution.

Good: Description of your logic for the equations you have chosen.

Note: Assumptions may be made and shown as you go, not just at the beginning.

Solve

Substitute Values

Show Units!

NOTE: Including units has kept you from using x in [cm] instead of [m].

Indicate Final Answer

Evaluate

Evaluate your work: After you have solved a problem, it is very important to ask yourself, "Does this make sense?" This is expected of you, but often you do not show it on paper. At the minimum, it will help you find errors in your solution.

For example perform an order-of-magnitude comparison:

"This flux value is very high. A toaster consumes ~1 kW of energy –or— the solar constant on earth is ~1 kW/m^2. This value is two orders of magnitude larger. However, the large ΔT, small Δx, and large k values are all extreme and justify this flux value."

Or, perform a unit analysis by cancelling the units from your substituted values. Should energy be represented by meters?

Sanity Check

4. Writing Tips for Students

- Assumptions: It is good to lay out your assumptions before you begin, but often you don't make them until well into the problem. In that case, just describe the assumptions you make as you make them.

- Model: Modeling is the process through which a real world problem is turned into engineering equations you can work with. For example, a one-dimensional representation of an energy generating plate contacting a volume of water is a **model** of boiling a pan of water on the stove. In making this model, engineering assumptions (and therefore the validity of your solution) are shown.

- Even if you do not know how to solve the problem, begin by writing the problem definition and objective. Half of the reason you write a problem set is because it allows you to formalize your thoughts and proceed. The solution to the problem will follow.

- This guide outlines the important sections to have in a problem set. The actual headings and appearance can change. Your course instructor may have more stringent formatting requirements.

- Remember the audience. The reader is not just looking for the answer.

- A new problem is worth a new page.

5. More Examples

This example is from a student in ME3332. Used with permission.

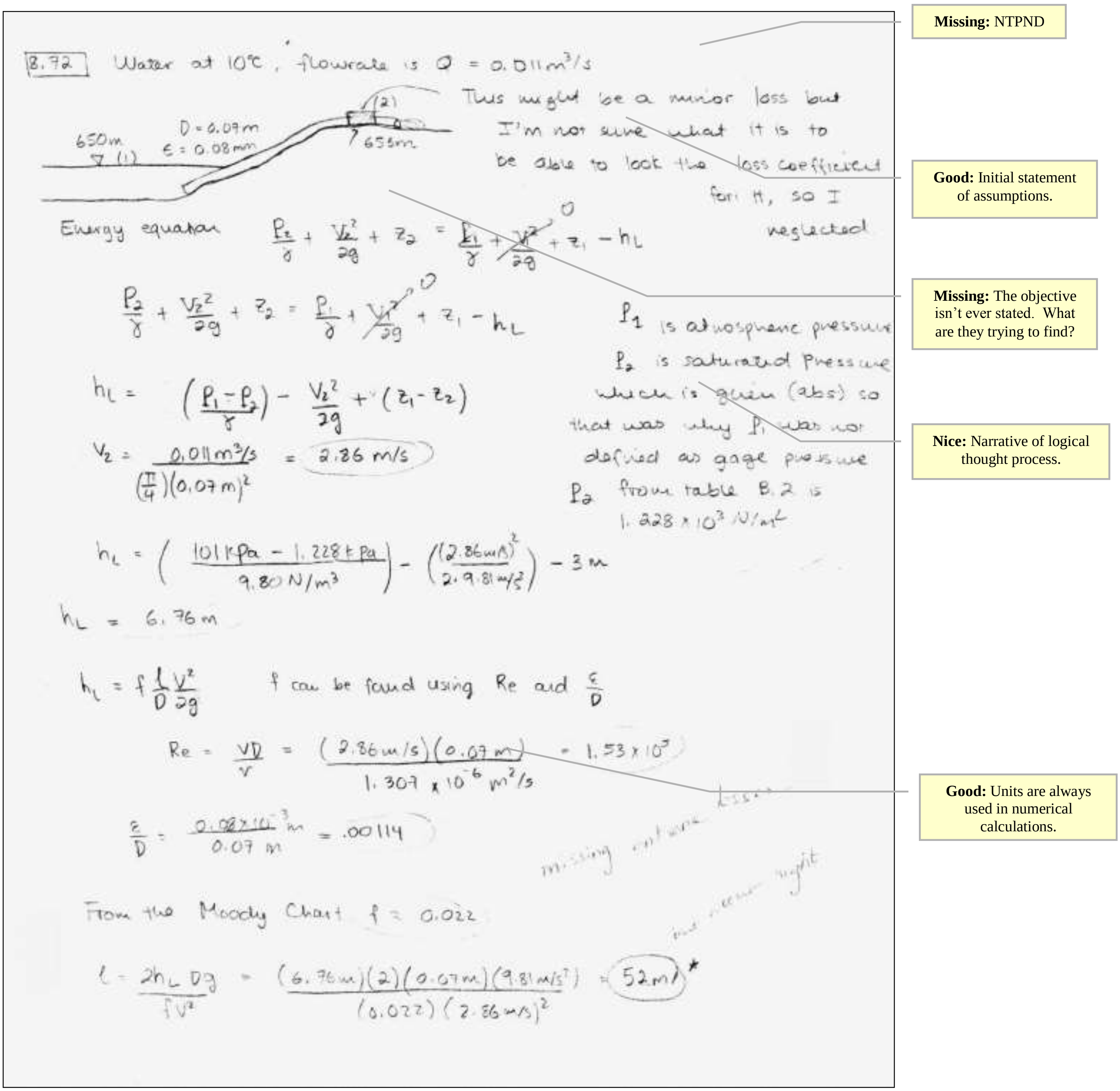


Figure 1: Example Problem 1

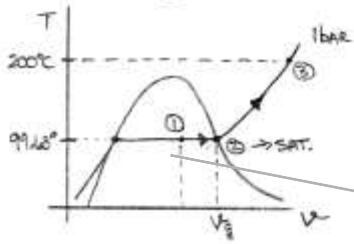
This example is from a student in ME3331. Used with permission.

JOE FINCH ME 3331 HWK#2 9-25-08 PAGE 4 OF 4

#3.54] WATER IN A PISTON/CYLINDER IS HEATED AT CONSTANT PRESSURE. GIVEN THE TEMPS, QUALITY AND WORK, FIND THE MASS IN KG AND THE HEAT TRANSFER IN KJ.

$T_1 = 99.63°C \quad p = 1\,bar \quad x = 65\%$ OR $.65$

$T_3 = 200°C \quad \Delta W = 300\,kJ$ → EXPANSION



1) $W = \int_{v_1}^{v_2} p\,dv = p(v_3 - v_1)$

$W/_{kg} = p(v_3 - v_1)\,m$

$m = \dfrac{W}{p(v_3 - v_1)}$

USE TABLE A-3 to FIND v_2 or v_g

$v_2 = 1.694\ m^3/kg$

USE TABLE A-4 to FIND v_3

$v_3 = 2.172\ m^3/kg$

2) USE INTERPOLATION TO FIND v_1

$v_1 = .65(1.694 - 1.0432\times10^{-3})$

$v_1 = 1.1004\ m^3/kg$

$m = \dfrac{300\,kJ}{100\,kPa\,(2.172 - 1.1004)\,m^3/kg}$

m = 2.8 KG

UNIT CHECK

$KG = \dfrac{kJ}{kN/m^2\,(m^3/kg)} = \dfrac{kJ \cdot kg}{kN \cdot m}$ ✓ ($kN \cdot m$ = J)

3) find u_1

$u_3 = 2650.7\ kJ/kg$

$u_1 = u_f + x(u_g - u_f)$

$u_1 = 1775.041\ kJ/kg$

$u_1 = 417.36 + .65(2506.1 - 417.36)$

4) 1ST LAW $\Delta U = \Delta Q - \Delta W$

$\Delta U = \Delta u \cdot m \qquad (u_3 - u_1)m = \Delta Q - 300\,kJ$

$(2650.7 - 1775.04)\,2.8 + 300\,kJ = \Delta Q$

ΔQ = 2751.85 KJ

Good: NTPND, and restatement of problem.

Good: Fundamental governing equations shown.

Nice: Sketch of process. This shows the engineering model used.

Good: Narration

Good: Clearly visible solution.

Clarify: Why are you finding U? I don't follow.

Clarify: Where did these values come from?

Good: Substitute values as last step.

Figure 2: Example Problem 2