University of Portland Donald P. Shiley School of Engineering Standard Engineering Problem Solving (Homework) Format

"We are what we repeatedly do. Excellence, then, is not an act, but a habit." - Aristotle

Purpose of this Format

Calculations performed by engineers become permanent records that substantiate their decisions. As such, **it is essential that an engineer's written work be clear and understandable**. It is critical that engineering students develop a habit of communicating work effectively. By following the format described below in assignments, design work, and other technical works, students will **learn the** <u>habit</u> of **producing professional quality documentation.** It is critical that students develop a habit of *always* using this format; therefore, homework not following this format will be penalized appropriately.

- Homework should be on 8.5" x 11" paper. The writing should be neat and legible. All pages must be placed in order and stapled.
- If using engineering paper, write on only one side of the paper.
- Pages must be stapled together in the upper left-hand corner.
- Your name, course number, course title, assigned problem numbers, submission date, and page number must be at the top of first page. Your initials and page number must be at the top on all subsequent pages.
- Problem format: Each problem must include the following:
 - 1. *Purpose*: A brief sentence describing the purpose of the problem (explains why the analysis is being conducted). Example: "*Determine the location and magnitude of the maximum stress in the beam to assist with material selection.*"
 - 2. *Given*: Brief description of all information provided in problem statement. Use neat sketches, schematics and free body diagrams as appropriate.
 - 3. *Assumptions*: If any assumptions are made, clearly indicate them. If none are made, state so. This is your opportunity to explain the limitations of any analysis you conduct. Explain what conditions are required for the analysis to be valid. **Never** just plug numbers into an equation, you must understand the limitations of the equation! Stating assumptions communicates those limitations.
 - 4. Solution: Show all details of calculations including variables! Every step of the solution must include units and cancel them as appropriate (never numbers by themselves)! Provide brief explanations to explain your work. Cite equation numbers used (unless otherwise stated, it will be assumed equation numbers are from the course textbook). Example, show the equation with variables (and equation citation), then numbers with units, then the answer: $F = m^*a = 5kg^*9.8m/s^2 = \underline{49N}$ eqn. 1-1; Hibbeler.
 - 5. *Final Answer*: <u>Underline</u> the final answer. It must include proper units, correct number of significant figures (typically 2 or 3), and the quantities calculated.
 - 6. *Explain the answer*: a <u>brief</u> explanation of the significance of the answer is often appropriate. May discuss: Is it reasonable? Does it answer the question posed in the purpose statement? How do the assumptions affect the conclusion?

Example of how to apply the standard problem solving format. Consider the textbook question:

A projectile is aimed horizontally at a target 100 feet away. The projectile hits the target 4 inches below the aiming point. What was the initial velocity of the projectile?

Example of what NOT to do – please NEVER submit an assignment as follows:

<u>Question</u>: A projectile is aimed horizontally at a target 100 feet away. The projectile hits the target 4 inches below the aiming point. What was the initial velocity of the projectile?

Answer:

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4=0.5*32.2*12*t<sup>2</sup>
t=0.143889
v=100/0.143889 = <u>694.98 ft/sec</u>
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Notes: The math is correct but this communicates almost nothing. Also, even though the math is correct, the answer is WRONG!!!! (see discussion on the next page).

Example of what should be submitted based for the same textbook question:

<u>Given:</u>

- projectile with horizontal initial velocity
- aimed at a target 100 ft away
- strikes 4 inches below the target



Find: initial velocity of projectile

<u>Assumptions:</u> $a_g = 32.2 \text{ ft/sec}^2$; lift and drag aerodynamics forces are negligible

Solution:

First determine the time required for an object to drop 4 inches. That is the time required to travel the 100 feet, therefore velocity can then be directly calculated.

Time to drop 4 inches:

 $y = y_0 + v_{y0}^* t + 0.5^* a_g^* t^2 \quad (eq \ 4.1, Physics by Halliday)$ 4in = 0 + 0*t + 0.5*(32.2ft/sec²)*(t²)*(12in/1ft) 4in = 193.2in/sec²*t² t = $\{4in/(193.2in/sec^2)\}^{1/2}$ = 0.1439 sec

horizontal velocity = d/t = 100 feet / 0.1439 sec = 694.98 ft/sec = <u>700ft/sec</u>

convert: 700ft/sec *(1 mile/5280ft)*(60sec/min)*(60min/hr) = 477mph = 480mph

Explanation:

The answer is reasonable: 480 mph is fast, but well under the speed of sound in air. This analysis provides the average velocity but in reality the projectile will likely slow down as it travels through air (air resistance was neglected in this analysis). Therefore, the actual initial velocity must be somewhat greater than 700ft/sec (unless aerodynamic lift forces are not negligible).

Engineering faculty comment on this format:

Some students see this format as nothing more than added, non-valuable work....WHY BOTHER? It sure takes up more paper, is it worth it? YES! Not only does it greatly improve your communication skills, it can actually SAVE YOU TIME AND EFFORT! How?

- Including units, and <u>making sure the units work out correctly</u>, can **greatly reduce** the amount of mistakes made and reduces the time you spend trying to find mistakes. It really really does!
- Spend time by including units at every step but save time by using 4 significant figures in the analysis rather than 6 or more significant figures. Your answer typically should have 2 or 3 significant figures, why bother with 1000 times more precision in the analysis?
- Citing where equations come from will increase your efficiency when you review the homework for exams.
- Explaining what you are doing will increase your understanding and improve your problem solving skills and habits. Isn't that why you are in college?

Okay, fine, so communication and good habits are important, maybe the effort is worth it, but...

... why is the first answer of 694.98 ft/sec wrong?

A critically important thing to understand is that all engineering decisions **require interpretation!** No matter how carefully you analyze or test something, the results must be **interpreted**! Analysis NEVER is the answer – it only provided data for the engineer to interpret. The answer of 694.98 ft/sec is a very poor interpretation of the analysis – therefore, it is wrong. It communicates a ridiculous level of precision (5 significant figures implies an error of 1 part in 10,000). It neglects the precision of the "given" information and the error associated with the assumptions! But why is 694.98ft/sec wrong? Because it is misleading! If your answer is 694.98ft/sec then you do not understand what you are saying. Do you want to drive across a bridge that was designed based on misleading data or designed by engineers who don't understand what they are doing?