PREPARATION OF HOMEWORK PROBLEMS

The following applies to the preparation of all problems, unless instructions to the contrary are given. Each of the 5 sections described below must be included in your homework write up. You will be graded on both your ability to solve the technical problems and your ability to communicate that solution.

1) **Problem Statement.** Restate the problem in your own words and include the following information:

   - **Known/Given:** Briefly state the important known or given information. This requires that you read the problem carefully and think about it.
   - **Find:** State **concisely** in your own words what is to be determined. (i.e. how do you know when you are done?)

2) **Assumptions.** State any idealizations or assumptions needed in performing the solution. Form a record of how you modeled the problem by listing all simplifying assumptions and idealizations made to reduce the problem to one that is manageable. Any assumption used to simplify the analysis will also limit the scope of validity of the solution! Remember to discus the limits of validity of your solution (caused by your assumptions) in the final discussion section (described below). Typically at this point in the analysis you should state how you intend to determine the physical properties that will be used in your solution. (e.g. "assume ideal gas" or "use steam tables in appendix A for all properties")

3) **Sketches & Property Diagrams.** Draw a diagram of the system, including system boundaries (control surfaces) and if relevant, draw a suitable process diagram. If energy is involved, show energy transfer across the boundary or control surface by specifically labeled arrows. Indicate any energy or mass storage changes within the system. Don't view your initial schematic as a static entity. Remember to update it frequently as the solution progresses and more information is learned.

   - You should decide whether a closed system or control volume is appropriate for the analysis, and then carefully identify the boundary and show it on your figure.
   - Record all property values you are given or that you anticipate may be required for subsequent calculations (a tabular format is often very useful for this, leave blanks for properties that you think you will need to look up as the solution proceeds).
   - Sketch appropriate property diagrams (P-v, T-v, T-s), locating key state points and indicating, if possible, the processes executed by the system.

4) **Solution.** Decide what physical laws (i.e. first law, second law, conservation of mass, etc.) will be used to solve the problem, and what general form of these is best suited to the particular problem (i.e. system or CV form). Write down the most general form of the equation first then use your assumptions to simplify it to the form you will actually solve. Note the effect of each assumption on the equations as you simplify them. Explain why terms can be ignored in the governing equations. **Use words to describe your solution methodology.**

   Some Helpful Tips:

   - You should work with variables in your equations for as long as possible before substituting numerical values (this will make your solution more generally applicable and hence more valuable).
   - When you have the equations in final form, check that you have enough equations to solve for the number of unknowns that you are dealing with. If not, go back and see what other physical relations or extra information you can apply to eliminate unknowns. (i.e. can you fix any system states and then find other properties on the steam tables? Does the process followed by the system give you any additional equations like $P_1V_1=P_2V_2$?) Only when you are sure that you have enough information (equations, relations) to solve for the number of unknowns should you substitute numerical values into your equations and perform your final calculations.
   - Be sure to indicate where values used in your calculations come from (e.g. the properties of nitrogen

were taken from table 3.54 on page 544 of …).

- Be careful with numerical calculations. Make sure that consistent units are employed on every term in the equation. Check units!
- The final answer should be clearly marked (boxed) and must have appropriate units and a reasonable number of significant figures.
- Consider whether the magnitudes of the numerical values are reasonable and the algebraic signs associated with the numerical values are correct. Make sure no physical laws are violated (e.g. no negative masses, nothing moving faster than the speed of light etc.) and that common sense seems to be satisfied.

5) Discussion. Conclude the problem with a brief discussion of the significance of the results, the significance of any idealizations you made, and any conclusions you can draw. Ask yourself if the answer is reasonable.

- Specify the limits of validity of your calculation (remember to refer back to your assumptions) and an estimate for the accuracy of the solution (e.g. "we used empirical correlations that are only accurate to within 10%, hence our answer cannot be expected to be more accurate than this…").
- Note potential sources of error (e.g. "we had to estimate the properties of water at –150 °C since no value is given in the steam table…") and possibly weak assumptions (e.g. "the above analysis is founded on the assumption of a frictionless piston, but as we all know this is an impossibility, hence the work calculated should be viewed as an upper bound of what a real system would produce…).
- Indicate how your solution could be improved (e.g. "by replacing ideal gas behavior with measured property behavior greater accuracy is possible…"). Or include statements about the broader significance of your solution (" by switching to this new cycle with higher efficiency the US could save 100000 barrels of oil a year…").

In "real life" it is this understanding of your solution and its ramifications that you are being paid for … the number that you produced, in and of itself is useless. Therefore the discussion is a critically important part of any solution. To reflect this the discussion section will be heavily weighted in the grading of the homework.

Other Comments:

- Don't include obvious arithmetic on the problem sheet but include all algebraic developments.
- The correct numerical answer may not be as important as the correct reasoning behind it, and the discussion of the significance of the answer.
- All assignments must be neat. If I can't read them I can't grade them.
- Note: Typical problem write-ups should be 1-2 pages. Use complete sentences!

ACADEMIC HONESTY and WORKING TOGETHER ON HOMEWORK:

1. *You are allowed to work together*. This is one of the best ways to learn (both for the "tutor" and the "learner"). However, ***you are not allowed to claim (or accept in any way) credit for work which you do not understand.***
2. If you work with *or help* others you MUST: 1) list their names 2) describe their contributions to the problem, *or aid you gave to them*. (e.g. "I showed Tom my solution" or "I went over section 2 of this problem with Ursula") If there is a part of an assignment that you do not understand, *but that you need to continue the problem*, you may (and should) include it in your write up ***But you MUST give credit to the source*** of the material (e.g. "I found this part of the solution online" or "Jane explained this to me but I still don't quite get it...").
3. A brief discussion of the contributions of each participant (including yourself) must be included in the discussion section.

Sources for this Methodology: M.J. Moran and H.N. Shapiro, *Fundamentals of Engineering Thermodynamics*, 4th Edition, John Wiley & Sons, Inc., 2000, p. 24. Prof. Dan Haworth and Prof. Dom Santavicca and Prof Brad Bruno.