ME 322 – Mechanical Engineering Thermodynamics (Exam 1)

Fall 2022

THIS IS A TAKE-HOME EXAM. YOU HAVE SEVERAL DAYS TO WORK ON THIS EXAM, AND SEVERAL CLASS PERIODS WHERE YOU CAN ASK QUESTIONS. THE WORK PRESENTED ON THIS EXAM NEEDS TO BE YOURS, AND YOURS ALONE. PRESENTING SOLUTIONS FROM SOMEONE ELSE WILL RESULT IN A 'F' GRADE IN THE COURSE.

Please read the following statement:

Article II, Section 1 of the University of Idaho Student Code of Conduct states,

> *Cheating on classroom or outside assignments, examinations, or tests is a violation of this code. Plagiarism, falsification of academic records, and the acquisition or use of test materials without faculty authorization are considered forms of academic dishonesty and, as such, are violations of this code. Because academic honesty and integrity are core values at a university, the faculty finds that even one incident of academic dishonesty seriously and critically endangers the essential operation of the university and may merit expulsion.*

Passing on exam information to someone who has not taken the exam constitutes cheating on an examination. Such action is a violation of the University of Idaho Student Code of Conduct.

I have read and understand the above statement.

_____ _____

Signature Date

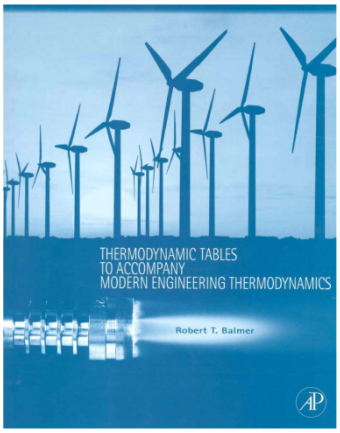
_____

Printed Name

EXAM INSTRUCTIONS – PLEASE READ THIS CAREFULLY

You need to show your work for each of the problems to get credit. If values from a table are cited, you need to indicate which table was used, and what inputs were used to find the value. Equations used should be written down, and the numbers used in those equations should also be shown. You should include units in your calculations, as many times there will be unit conversions necessary. You may work your problems on these pages, or work them on separate pages.

If you have questions about problems on the exam you should ask those of the instructor. You are not allowed to work with other people (in person, or online) on this exam. However, many problems on this exam are similar to past homework problems. You can certainly work with other students to make sure you know how to solve past homework problems. And remember that homework solutions are posted too.



Part 1: Calculations – 40 Points (10 points each)

1. You want to observe what happens when Ammonia passes through its critical point. You have a container with small windows on each side that is rated safe up to 2500 psia and 500 °F. The container has an interior volume of 3.0 in^3.
    a. What mass [lbm] of Ammonia needs to be in the container?
    b. To what pressure [psia] and temperature [°F] will you need to heat the contents of the container?
    c. What safety concerns would you have about doing this? (Sentence or two, or a few bullet points)

2. You have a rigid tank with a divider inside. When the divider is in place one side of the tank has 5 kg of an ideal gas inside, and the volume is 2.4 m^3. The other side has 7.8 kg of an ideal gas, and its volume is 1.9 m^3. Once the divider is removed, calculate the specific volume of the mixture.

3. You have 2.8 lbm of helium gas in a rigid, sealed container. The temperature of the gas is initially 45 °F and it is heated up until it reaches 130 °F. Calculate the change in Internal Energy [Btu] of the gas.

4. You have a gas in a container that starts at 2.75 ft^3 and is going to be compressed. The compression process will behave as if it has a polytropic exponent of n = 1.45. The gas is initially at 14.7 psia and will be compressed to 350 psia. Calculate the work [lbf*ft] required for this process.

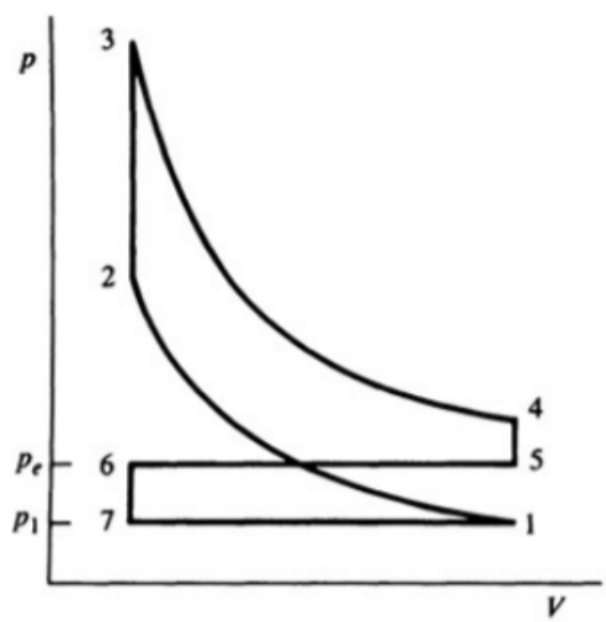
Part 2: Conceptual Problems – 35 Points

5. (5 points) What is the relationship between moles, mass, and molecular mass….
   a. In the SI system with mass in [kg] and moles in [kmol]?
   b. In the English Engineering unit system with mass in [lbm] and moles in [lbmol]?
   c. Calculate the molecular mass of an Ethanol molecule (C_2H_5OH) in [kg/kmol]
   d. Calculate the molecular mass of an Ethanol molecule (C_2H_5OH) in [lbm/lbmol]

6. (10 points) The little boiler unit in Dr. Dan's Rancilio espresso machine creates liquid water that is at 220 °F. What is the minimum pressure above atmospheric pressure that the boiler needs to be at? i.e. find the minimum p_{boiler} [psig] for making an espresso shot.

7. (10 points) While preparing to use the steam wand the little boiler unit in Dr. Dan's Rancilio espresso machine creates 2-phase water that is at 280 °F. What is the minimum pressure above atmospheric pressure that the boiler needs to be at? i.e. find the minimum p_{boiler} [psig] for making steamed milk

8. (10 points) The figure below shows an idealized engine cycle on a P-v diagram. The cycle operates as a Closed System. Determine the following:
   Note: You may choose to draw your own diagrams showing work for each process. If you want to do this, make 7 copies of the figure below and sketch the work for each process on those figures.
   a. Shade and label the Net Work for the cycle
   b. Determine if the Net Work is positive (work out) or negative (work in)
   c. Using information from above along with First Law, determine the relationship between Net Work and Net Heat for the cycle.



Part 3: Property Tables – 25 Points (5 points each)

For each of the problems in Part 3 you need to use the Balmer Thermodynamic Tables booklet to solve the problems. For each of these problems, make sure to include:

- Which table you got the information from.
- What inputs you used to determine which line(s) from the table to use.

9. (Really simple) Determine the specific enthalpy [Btu/lbm] of R-134a that is at 100 psia and 100 °F.

10. (Kinda simple) Determine the specific enthalpy [Btu/lbm] of R-134a that is at 100 psia and a quality of 0.80

11. (Not as simple) Use the Balmer thermodynamic tables to determine the quality of saturated ammonia when the temperature is 0 °F, and the specific volume is 2.25 ft^3/lbm.

12. (Harder) Determine the specific enthalpy [Btu/lbm] of saturated water when the temperature is 170 °F and the specific internal energy is 1000 [Btu/lbm]

13. (Kinda tough) You have water that is in the compressed liquid phase at 300 psia and 300 °F. Use your tables to determine an appropriate value for the specific internal energy [Btu/lbm] of water under these conditions. Also, explain your reasoning/method for getting to the number you chose.