ME 322 – Mechanical Engineering Thermodynamics (Exam 1)

Fall 2021

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 FAILING 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

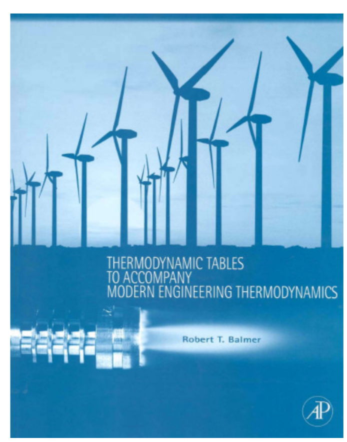
____

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 used, 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. You will scan and upload a PDF of your submission to BbLearn.

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.



Part 1: Short Calculations – 40 Points

You can do these by hand, or in EES. You just need to show your work.

1. 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.

2. You have 7.5 lb of Nitrogen gas in a rigid, sealed container. The temperature is initially -30 °F and it is heated up until it reaches 130 °F. Calculate the change in Total Internal Energy [Btu] of the gas.

3. You have 7.5 lb of Nitrogen gas that is initially at -30 °F and 100 psia. This gas is compressed at constant temperature until it reaches 250 psia. Assuming Nitrogen behaves like an Ideal Gas, calculate the work input [ft*lbf] required to do this.

4. You have liquid water in a clear, rigid, sealed container. It starts out at room temperature and pressure (68 °F and 14.7 psia). You put it on your stovetop and add heat – hoping to watch it boil. Your container has a pressure relief valve that will open when the pressure gets to 200 psia. Explain if you will or won't see the water boil before it reaches 200 psi.

Part 2: Property Tables – 30 Points

For each of the problems in Part 2 you need to use the Balmer Supplemental Tables. For your answers make sure you indicate which table was used, and what inputs and/or equations were used to find the value(s).

5. You have saturated water that is at 126 °F and has a specific internal energy of 757 [Btu/lbm]. At this state, what is the specific volume [ft^3/lbm]?

6. After going through a valve you have two-phase ammonia that has a specific volume of 1.5 ft^3/lbm and is at a pressure of 50 psia. Determine the temperature [°F]

7. You have a cylindrical container with interior dimensions that are 0.5 ft diameter and 1 ft tall. It is filled with water that is at 70 °F and 3000 psia. Calculate how many lbmol of water you have.
   Hints: At this pressure and temperature it is a compressed liquid, but you don't have any tables for pressures this low. However, the slides from Lecture 6 might have a useful tidbit of information. At the given state you need to find/calculate the density (or specific volume) and use the total volume to calculate the mass of liquid water. Once you have that you can use the molecular mass to find how many lbmol are in the container.

Part 3: Work and Power using EES – 30 Points

For this part of the exam you need to do the whole problem in EES. You will turn in a PDF print from EES (no screen captures) that shows your equations, and solution (with unit checking). You can choose to put your variables for p, T, and v in an array table, or label them with subscripts.

8. You're going to model the expansion process in a pulse-jet engine. We can model the expansion process as are (modeled as an ideal gas) undergoing an adiabatic polytropic expansion where the polytropic exponent is 1.3. The initial state is at 20 psia and 1500 °F, and it expands until it reaches 14.7 psia.

   There is 0.01 lbm of air in the system. For air you may use R_air = 53.34 [ft*lbf/(lbm*R] as the gas-specific gas constant.

   a. (10 points) Use the polytropic relationship to calculate the temperature at the end of expansion [°F].

   b. (10 points) Use Ideal Gas EOS to calculate the specific volume [ft^3/lbm] of the initial and final states. **Note:** You will need to use the *convert(___, ___) to get your units to come out correctly in EES.

   c. (10 points) Calculate the Work [ft*lbf] produced during the expansion process.