**ME 322 – Mechanical Engineering Thermodynamics Exam 2**Sample Calculation Problems

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.

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Signature Date

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Printed Name

**EXAM INSTRUCTIONS – PLEASE READ THIS CAREFULLY**

**This is a take-home exam covering the same topics as the in-class Exam 2.**

**I know that many of you will talk to each other about the exam. However, let me be very clear about this: The work presented on your exam needs to be yours, and yours alone. This doesn’t mean just the calculations have to be yours. The thought process, and problem solving need to be yours. You need to be able to answer any “why did you do this?” kinds of questions related to your solution. If asked about any answers on your exam, you need be able to solve them in front of me. The purposes for giving you a take-home version of this exam are:**

* **Make sure you are fluent in core thermodynamics concepts and abilities that will be required to complete this course, and that will be used in future classes.**
* **Demonstrate your current level of understanding of thermodynamics topics through Lecture 18.**

**For questions in the calculation section:**

* **Perform calculations on engineering paper. They don’t need to be documented as full engineering solutions, but they should be clear, and easy to follow.**
* **Show which equation(s) is/are used, and how you made that choice. In many cases, you will need to derive a specific equation from a general one**
* **Show what numbers are going in to the equations used (including units)**
* **If numbers are pulled from a table, reference what table was used, and what inputs generated the value you selected (for instance, Table C.7a @ T=115 °F 🡪 hf = 49.63 Btu/lbm)**

**For questions in the multiple choice section, circling the correct answer is not enough to earn points for the problem. You must also show how you got to that answer. This may include calculations, or justifications.**

# Part 1: Engineering Calculations – 70 Points

1. (25 points) You are going to heat 3.5 lbm of Ammonia at constant pressure of 247 psia from a saturated liquid to a saturated vapor. Calculate how much heat (Btu) will be required to do this.
	1. Classify this system as open, closed, or isolated.
	2. Write the appropriate version of First Law of Thermodynamics, then simplify it for this specific case.
	3. If necessary, use ancillary equations to find values for unknowns in the First Law equation.
	4. Find values (from tables), necessary to solve the equation(s).
	5. Calculate the value of Q required for this process.
2. (20 points) Air enters the compressor at 14.7 psia and 60 °F, and leaves at 119.0 psia. For this calculation, assume the process is reversible and adiabatic (which means isentropic).
	1. Calculate the outlet temperature (in °F) of the air using the assumption that specific heats are constant over the temperature range.
	2. Calculate the outlet temperature (in °F) of the air using the assumption that specific heats are not constant over the temperature range.
3. (25 points) You are going to fill an initially empty Acetylene tank (C2H2) tank until it reaches 250 psia. The tank is rigid, and wrapped in adiabatic insulation. The tank is connected to a supply of Acetylene that stays at a constant 500 psia and 75 °F through the filling process. Additionally, the specific heats for Acetylene at 100 °F are: cp = 0.35 Btu/(lbm °R), and cv = 0.27 Btu/(lbm °R)
4. Simplify the equations below as they pertain to this problem.

$$\dot{Q}-\dot{W}+\sum\_{i}^{}\dot{m\_{i}}\left(h\_{i}+\frac{V\_{i}^{2}}{2g\_{c}}+\frac{g}{g\_{c}}z\_{i}\right)-\sum\_{e}^{}\dot{m\_{e}}\left(h\_{e}+\frac{V\_{e}^{2}}{2g\_{c}}+\frac{g}{g\_{c}}z\_{e}\right)=\frac{d}{dt}\left(U+KE+PE\right)$$

$$\sum\_{i}^{}\dot{m\_{i}}-\sum\_{e}^{}\dot{m\_{e}}=\frac{dm}{dt}$$

1. Use substitution, then separate and integrate the equation to get rid of the time derivatives.
2. Simplify the equations for this system, noting things like the tank is initially empty. Box your final answer of the governing equation for this system.
3. Assuming constant specific heats (given in the problem statement), use the calorific equations of state to solve for the final temperature (°F) of the Acetylene gas in the tank after it is filled.
4. Over this temperature range, how much error do you get by assuming specific heats are constant? (i.e. how much does the specific heat change? Or, how does your answer change if you use specific heat values at T2, or some intermediate temperature?)

Part 3: Multiple Choice – 30 Points

**You must show your work on each of these problems to get full credit. This might include things like: equations used, sketches, unit conversions, an explanation of why you chose the answer, etc.**

1. A home freezer is operating with a condenser temperature of 25 °F and an evaporator temperature of 95 °F. What is the maximum theoretical COP for this freezer?
a) 0.357
b) 1.36
c) 6.93
d) 7.93
2. Four devices (Carnot heat engine, real heat engine, heat pump, and refrigerator) operate between the same high and low temperature thermal reservoirs. What is the order of the most efficient device to the least efficient device?

a) Heat pump > Carnot engine > Refrigerator > Real engine
b) Heat pump > Refrigerator > Carnot engine > Real engine
c) Carnot engine > Refrigerator > Heat pump > Real engine
d) Carnot engine > Heat pump > Refrigerator > Real engine

1. According to your supplemental tables, the specific volume of R-134a at 500 psia and 50 °F is most nearly:
a) 0.0200 ft3/lbm
b) 0.0657 ft3/lbm
c) 0.7871 ft3/lbm
d) 0.0127 ft3/lbm