**ME 322 – Mechanical Engineering Thermodynamics**

**Exam 2 (EES and Psychrometric Chart)**

Fall 2022

This is a non-collaborative take-home exam. Submit your own work.

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.*

I have read and understand the above statement.

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Signature Date

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Printed Name (no points, but make sure this is legible) Exam Score

**EXAM INSTRUCTIONS – PLEASE READ THIS CAREFULLY**

**You will have several days to complete this exam. You may use your notes, the online course resources, your computer (EES, Google, etc.) and pretty much any non-human resource you can find. There are several class periods that you can also ask questions.**

**You must write your own code. Working with other students or sharing code is not allowed and will result in an F for the entire course. This exam is only worth 5% of your course grade…it isn’t worth cheating on.**

**For each problem you do in EES, attach a PDF print from EES and make sure it has all the following:**

* **Equations (not the formatted equations)**
* **Solution**
* **Arrays (where necessary)**
* **Parametric Tables (where necessary)**
* **Plots (where necessary)**

# Problem 1:

You’re going to build a powerful V6 engine to put in your Suzuki Samurai and are leaning toward two varieties of GM 4.3L engine. All of the varieties are four-stroke gasoline spark ignition 6-cylinder engine that have a total displaced volume of 262 cubic inches. Use ‘air\_ha’ as the working fluid in an EES model to predict the power output of this engine in both configurations. For each version of the engine below make sure to build a complete array table of all 4 States with T, P, v, u, and s.

**Note:** The temperature of state 3 will be out of range. This is okay for predicting power output, but it will grossly miscalculate net thermal efficiency.

1. For the naturally-aspirated engine build the compression ratio is 10.0:1, and peak power is produced at 6250 rpm. Using 87 Octane fuel, the change in specific internal energy of the fluid in the cylinder (modeled as air\_ha) between states 2 and 3 will be 750 Btu/lbm. Inlet conditions for the engine are P[1] = 14.7 psia, and T[1] = 80 °F.
Use **Key Variables**: W\_dot\_net [hp], and MEP [psia].

Net Power Output \_\_\_\_\_\_\_ [hp] Mean Effective Pressure \_\_\_\_\_\_\_ [psia]

1. The supercharged/intercooled version of this engine will be nearly the same specifications, with just a few differences. Compression ratio is lowered to 8.0:1, and the inlet conditions for the engine are P[1] = 30 psia, T[1] = 175 °F.

Net Power Output \_\_\_\_\_\_\_ [hp] Mean Effective Pressure \_\_\_\_\_\_\_ [psia]

# Problem 2:

You purchase a house that has a heat pump with an earth-coupled isothermal source. However, the system lost its refrigerant. You have repaired the leak and are going to refill the system. Originally the system was designed to use R142b. However, due to the cost of R142b you are considering using Ammonia instead. Regardless of which refrigerant is used, at the depth of the heat source the earth’s temperature can be assumed to be constant year-round. This results in a year-round standard evaporating temperature of 55°F. Thermal energy from the condenser is available at 125 °F. The compressor has an isentropic efficiency of 90%. Assume pressure drops through plumbing are negligible. The refrigerant leaves the condenser with 8 degrees of subcooling and it enters the compressor with 15 degrees of superheat. The heating requirement for the house is 45,000 Btu/hr.

R142b Ammonia

1. Compressor power requirement [hp] \_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_
2. Mass flow rate of working fluid [lbm/hr] \_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_
3. Coefficient of performance for heating \_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_

# Problem 3:

You are designing a HVAC system for your house that is in a warm, humid climate. Air entering the HVAC system is at a dry bulb temperature of 95°F and 80% relative humidity. You would like the air circulating through the building to be similar to typical ambient conditions in Moscow, Idaho during the early summer, which is about a dry bulb temperature of 68°F and 50% relative humidity. You will use a cooling process (to remove moisture from the incoming air), then a heating process (to get the air to the desired temperature and humidity ratio). The incoming air flow rate to the HVAC system is 2100 cubic feet per minute. In this climate, the HVAC system will be operating for 8 hours each day. Answer the following questions:

1. Use the ASHRAE English Unit psychrometric chart (use the version posted on our Canvas site, under the “Homework Solutions” menu) to draw the process. On this chart, clearly draw and label:
	* Start point
	* End point
	* Path taken for these two processes.
2. Use the psychrometric chart to determine:
	* Change in specific enthalpy [Btu/lbm\_dry\_air] for the cooling section
	* Change in specific enthalpy [Btu/bm\_dry\_air] for the heating section
	* Change in humidity ratio from the initial state to the final state
3. Calculate the amount of liquid water that will be produced by this process over the 8 hours the HVAC system will be running:
	* Mass of water [lbm]
	* Volume of water [gallons]
	* What implications does this have on providing usable water in an environment where potable water may be hard to come by?

