ME 322 – Mechanical Engineering Thermodynamics
EES Exam 1
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.

_____ _____
Signature Date

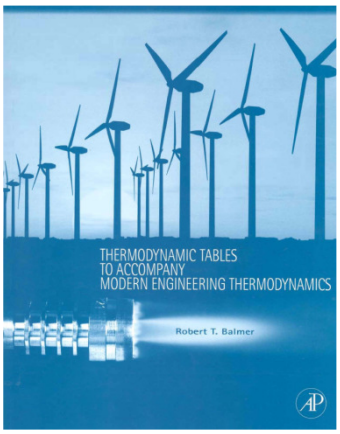
_____
Printed Name (no points, but you'll want to make this legible)

EXAM INSTRUCTIONS – PLEASE READ THIS CAREFULLY

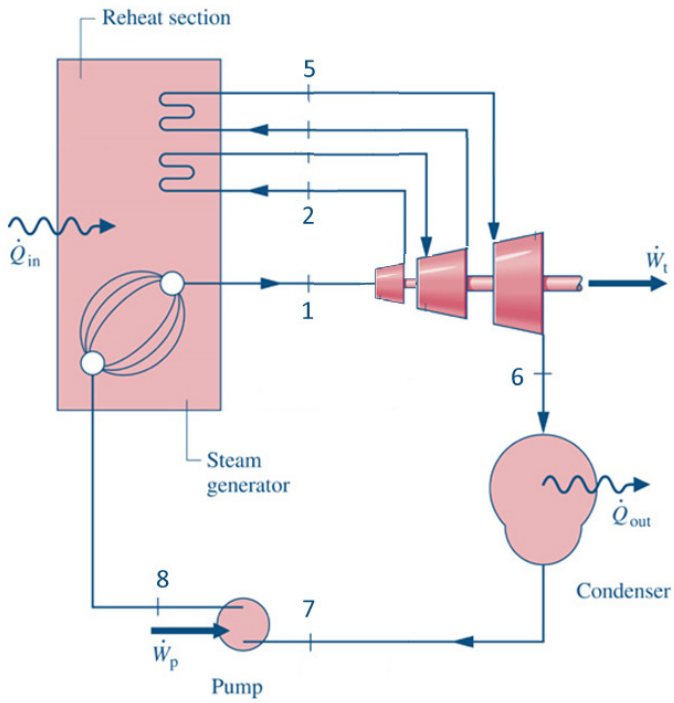
You will have several days to complete this exam. You may use your notes, the online course resources, your computer (EES, Google, etc.) and pretty much any non-human resource you can find. You are not allowed to collaborate with other students/engineers on the exam. However, if you have a strong need to collaborate with others on this exam, you may discuss the exam at great lengths with anyone currently pursuing a humanities degree at the UI.

There will not be partial credit for the questions on this exam. Either you get the answer (within reasonable rounding error), or you don't. Take your time. Validate your answers with some back-of-the-envelope calculations. Make sure your answers make sense.

This is a 100 point exam



Write your answers in the space below
For each problem attach a printout from EES (showing your code, solutions, and parametric table) as an appendix behind the exam



1) (50 points) A steam power cycle that incorporates two reheat legs is shown in the figure above. Steam from the boiler enters the first turbine stage at 1400 psia and 1100 °F. The steam leaves the first turbine stage at P[2] and then enters the reheat section of the boiler where it is reheated back to 900 °F (assume no pressure drop). The steam then enters the second turbine stage, and leaves at P[4] to a second reheat where it increases temperature to 750 °F. It enters the third turbine stage where it expands to 5 psia. The working fluid is a saturated liquid at 5 psia when it leaves the condenser. Each stage of the turbine has an isentropic efficiency of 90% and the pump has an isentropic efficiency of 80%. The net power output of the cycle is 175,000 hp.
You will build a parametric table that explores ranges for both P[2] and P[4] as a means to maximize plant efficiency. Initially, explore P[2] from 300 psia to 100 psia in increments of 50 psia (5 values), and at each value of P[2], explore P[4] from 150 psi to 50 psia in increments of 25 psia (5 values). To explore all possibilities, you will have a parametric table that has 25 runs in it. From this analysis, what P[2] and P[4] should be used for optimal efficiency?
Remember:
- Q_dot_in includes more than just the heat between states 8 and 1.
- Make sure to include your parametric study in the printout from EES

Optimal P[2] _____ Optimal P[4] _____

Net Thermal Efficiency optimal P[2] and P[4] (5 significant figures) _____

2) (25 points) Saturated liquid Propane enters a valve at 375 psia and leaves at 15 psia. Mass flow through the valve is 150 lbm/hr. Use EES and 'Propane' as your fluid to calculate the following:
   a. The quality of the Propane exiting the valve [dim or %]
   b. Temperature of the Propane exiting the valve [°F]
   c. The change in entropy of the Propane [Btu/lbm-R]

a._____ b._____ c._____

3) (25 points) Now imagine you can replace the valve in question 2 with an isentropic device that can extract mechanical power from the (2-phase) flow while achieving the same pressure drop. Calculate how much power could be generated by the device [hp], assuming the device operates at steady state, and the PE and KE terms are insignificant.

Magic Device Horsepower _____