ME 322 Exam 3 – Spring 2022

Part 1: Engineering Calculations (80 points)

1) (20 points) A particular steam turbine can handle a maximum of 1250 °F at the inlet. The exhaust pressure is 3 psia. Under ideal (isentropic) conditions, the maximum allowable liquid in the turbine is 5%. Calculate the maximum isentropic efficiency (in %) that would ensure that no liquid water was in the turbine.

2) (15 points) Saturated liquid Oxygen flows in to a valve. It enters at 500 psia, and leaves at 15 psia. Mass flow through the valve is 2 lbm/sec. Use EES and 'Oxygen' as your fluid to calculate the following:
    a. The quality of the Oxygen exiting the valve
    b. Temperature of the Oxygen exiting the valve (in °F)
    c. The change in entropy (in Btu/lbm-R)
    d. The isentropic efficiency of the valve

3) (15 points) You are now asked to model the performance of a device that will operate at the same pressures and mass flow as the problem above. This new device replaces the valve with a 'magic' isentropic device. Assuming the device operates at steady state, and PE and KE terms are insignificant, calculate how much power could be generated by the device (hp)?

4) (30 points) 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 R134a. However, due to the cost of R134a you are considering using R22 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 mass flow of the refrigerant is 750 lbm/hr. Compare the following between R134a and R22:

	R134a	R22
a. The power requirement [hp] of the compressor		
b. Rate of heat going into the house [Btu/hr]		
c. Coefficient of performance for heating		

Part 2: Short Problems using Thermodynamics Tables (20 points)

Problems 5-8 apply to a vapor compression refrigeration cycle that utilizes ammonia as the refrigerant. The saturated evaporating temperature is **-10 F** and the saturated condensing temperature is **95 F**. Saturated vapor exits the evaporator and saturated liquid exits the condenser. The mass flow rate of the refrigerant in the cycle is **300 lbm/hr**. Use your supplemental tables to find the following:

5) What is the enthalpy [Btu/lbm] of the fluid entering the evaporator?

6) What is the enthalpy [Btu/lbm] of fluid exiting the evaporator?

7) What is the refrigeration capacity [tons] of this system?

8) What is the DSC [°F] for this cycle?