ME 200 Thermodynamics – Spring 2023
PREPARING FOR EXAM 2

I. Class Notes, Examples, and Quizzes

Review all class notes, examples, and quizzes**.** Do you understand all the concepts presented and discussed? Could you solve the examples and quizzes without looking at the solutions?

II. Homework Problems

Be able to solve all the homework problems without having to look at the solutions!

III. Previous Exam

One previous exam has been posted on your Brightspace site or your course site. Try to solve this practice exam in the time allotted for this 90-minute exam. Note Exam 2 is of 60-minute duration.

IV. Some Additional Practice Problems

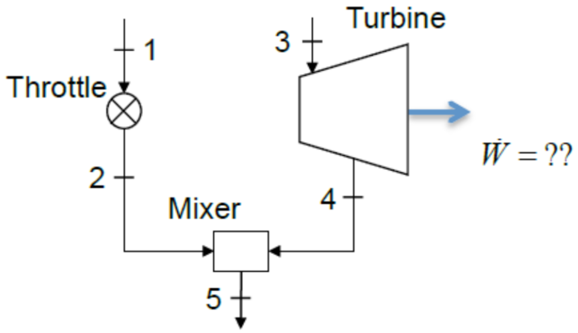
1. Answer the following short questions. Provide appropriate justifications.
   A. A steady flow of nitrogen gas in a constant diameter pipe experiences a decrease of temperature from 500 K to 400 K due to heat transfer and a decrease of pressure from 5 bar to 4.5 bar due to friction. What happens to the velocity of the nitrogen?
   a) increases, b) decreases, c) remains the same, d) can't tell

   B. Air treated as an ideal gas is flowing through a work producing turbine where the pressure is lowered at a constant temperature (isothermal process). If you neglect kinetic and potential energy changes, then what happens to the following quantities for the air flow stream between the inlet and outlet? <u>In each case, justify your answer with basic equations and/or property relations.</u>
   Enthalpy: a) increases, b) decreases, c) remains constant
   Density: a) increases, b) decreases, c) remains constant
   Heat Transfer: a) positive, b) negative, c) zero

   C. Water treated as an incompressible liquid is flowing through an adiabatic and horizontal nozzle and remains at a constant temperature (isothermal process). What happens to the following quantities for the water flowing through the device between the inlet and outlet? <u>In each case, justify your answer with basic equations and/or property relations.</u>
   Velocity: a) increases, b) decreases, c) remains constant
   Internal Energy: a) increases, b) decreases, c) remains constant
   Enthalpy: a) increases, b) decreases, c) remains constant
   Pressure: a) increases, b) decreases, c) remains constant

   D. Fluid is flowing through an isenthalpic throttling device (i.e., no heat transfer, no work, and no changes in kinetic or potential energy). What happens to the temperature of the fluid assuming the following fluid types for both inlet and outlet? <u>In each case, justify your answer with basic equations and/or property relations.</u>
   Ideal gas: a) increases, b) decreases, c) remains the same
   Incompressible liquid: a) increases, b) decreases, c) remains the same
   Saturated mixture: a) increases, b) decreases, c) remains the same

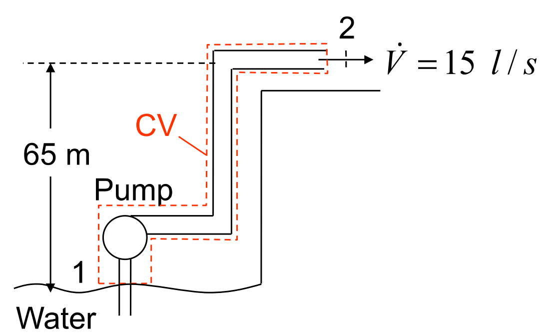
2. The figure below shows a portion of a cycle for producing power that utilizes water/steam as the working fluid. The components are a throttling device, a turbine, and a mixing device. Assume adiabatic devices with negligible changes in potential and kinetic energy. Do the following:
   a) Fill in the unknown data within the table below.
   b) Show the processes for water/steam on P-v and T-v diagrams with respect to saturation lines and including the state points with appropriate isotherms and isobars.
   c) Determine the power output of the turbine, in MW.



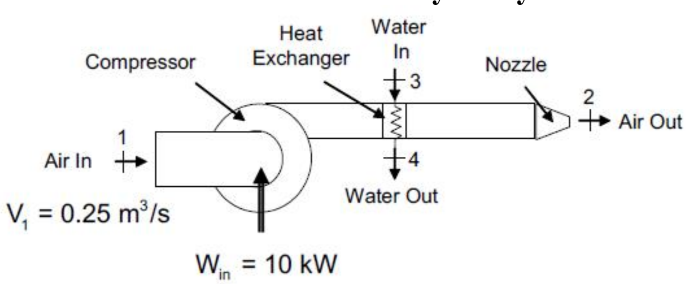
State	$\dot{m}$ (kg/s)	T (°C)	P (kPa)	h (kJ/kg)	x
1	100	130	1000		
2			6		
3	1000	320	1000		
4		80	6		
5			6		

3. Consider steady-state pumping of water as shown in the figure with D_1 = 10 cm, D_2 = 15 cm, $T_2 = T_1 = T_{atm}$ = 20°C, and $P_2 = P_1 = P_{atm}$ = 101.3 kPa. Assume adiabatic pump and piping.

   Find the pump power required, in kW.

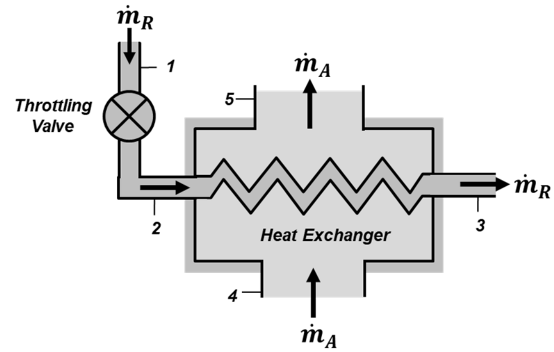


4. The system shown below draws air at negligible velocity from a room at 100 kPa and 21°C (State 1) and produces a high velocity jet of air at 30 m/s and 21°C (State 2) for cleaning manufactured parts. The system includes a compressor for raising the air pressure, a heat exchanger for cooling the air, and a nozzle for producing the high velocity. In order to cool the air, liquid water enters the heat exchanger at 10°C (State 3) and exits at 16°C (State 4) and is at a constant pressure of 300 kPa. The volumetric rate of air is 0.25 m^3/s at State 1 and the power input for the compressor is 10 kW. Do the following:
   a) Find the mass flow rate of air, in kg/s.
   b) Determine the required water flow rate, in kg/s.
   Hint: Choose the entire device as your system.



state	T (C)	P (kPa)	V (m/s)
1	21	100	~0
2	21	100	30
3	10	300	-
4	16	300	-

5. Air flowing through a duct at a mass flow rate of 1000 kg/hr and 30°C (State 4) is cooled to 20°C (State 5) using a heat exchanger that employs R-134a as a coolant. Before entering the heat exchanger, saturated liquid R-134a at a pressure of 9.0 bar (State 1) expands to a pressure of 3.6 bar (State 2) through a throttling valve. Assume that R134a leaves the heat exchanger as a saturated vapor (State 3) without pressure drop. Do the following:



   a) Depict the process that the refrigerant undergoes on a *P-v* diagram with respect to the saturation dome.
   b) Determine the temperature of the refrigerant leaving the heat exchanger, in °C.
   c) Find the mass flow rate of refrigerant, in kg/hr.

   For air: R = 0.287 kJ/kg-K, c_v = 0.72 kJ/kg-K, and c_p = 1.01 kJ/kg-K

6. A rigid tank with a volume of 1.0 m^3 initially contains H_2O at 0.07 MPa and 100°C. It is filled from a steam line at 0.70 MPa and 200°C. The tank is filled until there is 90% liquid on a volume basis. The tank is maintained at 100°C during the process.

   Calculate the heat transfer to maintain the tank at constant temperature, in MJ.

Selected Answers

2. a)

State	$\dot{m}$ (kg/s)	T (°C)	P (kPa)	h (kJ/kg)	x
1				547.16	N/A
2	100	36.16		547.16	0.1638
3				3094.4	N/A
4				2650.0	N/A
5	1100	36.16		2458.8	0.9554

b) 444 MW

3. -9.50 kW

4. a) 0.296 kg/s; b) 0.392 kg/s

5. b) 5.8412°C

6. -2092 MJ