ROSE-HULMAN
INSTITUTE OF TECHNOLOGY

Name ______________________________

ME301 – Applications of Thermodynamics

Circle section:
01 [10 am, Lui] **02** [11 am, Lui]
03 [10 am, Thom] **04** [11 am, Thom]
05 [11 am, Danesh]

Exam 2

Oct 27, 2022

Rules:

- Closed book/notes exam.
- Help sheets allowed. (Two 8-1/2 x 11" sheet of paper, one side, handwritten; may not contain worked out example problems)
- Maple, Excel, and MATLAB are allowed on your laptop, but nothing may be prepared before the exam.
- Either open property tables (from your textbook) or open Property Calculator Programs on your laptop.

Instructions:

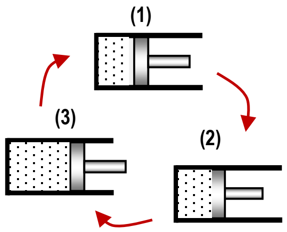
- Show all work for complete credit.
- Work in symbols first, plugging in numbers and performing calculations last.

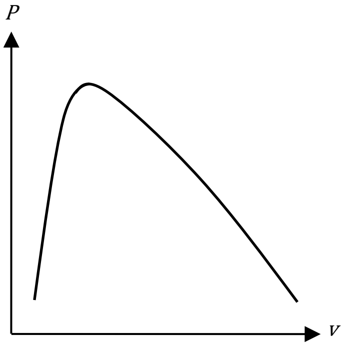
Problem 1	________/ 50
Problem 2	________/ 50
Total	________/100

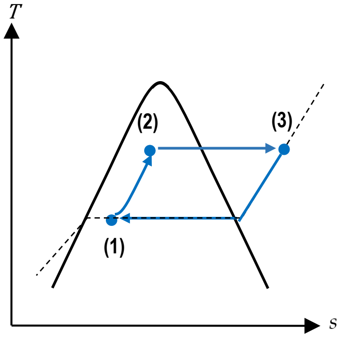
PROBLEM 2 [50 points]

A closed-system/periodic cycle using water as its working fluid can be modeled as consisting of the following three steps:

(1)→(2) Constant-volume heat addition
(2)→(3) Constant-temperature expansion
(3)→(1) Constant-pressure heat rejection







State	T [°C]	P [kPa]	v [m^3/kg]	u [kJ/kg]	x
1		80			0.40
2					
3					NA

	q_{in} [kJ/kg]	w_{in} [kJ/kg]
1→2	450	
2→3		-1000
3→1	Don't calculate	

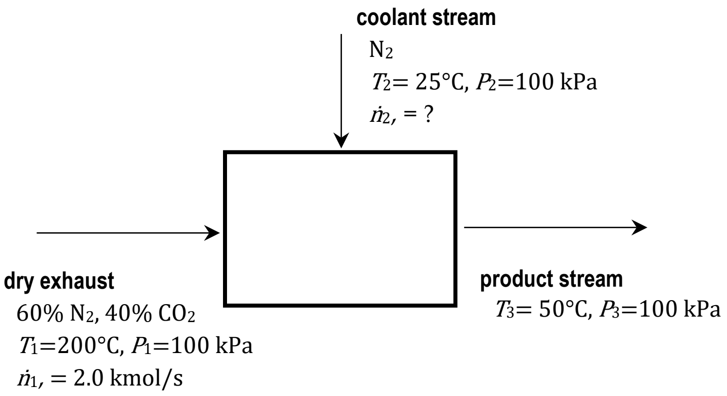
(a) The T-s diagram for the cycle is shown. Draw the P-v diagram relative to the two-phase dome with properly labeled isotherms.

(b) Find the unknown values of heat transfer per unit mass, $q_{A \to B}$, and the work per unit mass, $w_{A \to B}$ for each process in the cycle.

(c) Find the cycle efficiency.

PROBLEM 2 [50 points]

A flow of $\dot{n}_1$=2.0 kmol/s of a dry exhaust at T_1=200°C and P_1=100 kPa mixes with a stream of pure nitrogen at T_2=25°C and P_2=100 kPa in an adiabatic mixing chamber. The molar composition of the dry exhast is 60% nitrogen and 40% carbon dioxide. If the product stream exits the chamber at T_3=50°C and P_3=100 kPa, determine



(a) the molar flow rate of the coolant N_2 stream, $\dot{n}_2$, in kmol/s and
(b) the rate of entropy generation inside the mixing chamber, in kW/K.

Assume all gases behave as ideal gases with variable specific heats.

Extra work for Problem _______

Extra work for Problem _______

Length

1 ft = 12 in = 0.3048 m = 1/3 yd
1 m = 100 cm = 1000 mm = 39.37 in = 3.2808 ft
1 mile = 5280 ft = 1609.3 m

Mass

1 kg = 1000 g = 2.2046 lbm
1 lbm = 16 oz = 0.45359 kg
1 slug = 32.174 lbm

Temperature Values

$(T/K) = (T/{}^\circ R) / 1.8$
$(T/K) = (T/{}^\circ C) + 273.15$
$(T/{}^\circ C) = [\,(T/{}^\circ F) - 32\,]/1.8$
$(T/{}^\circ R) = 1.8(T/K)$
$(T/{}^\circ R) = (T/{}^\circ F) + 459.67$
$(T/{}^\circ F) = 1.8(T/{}^\circ C) + 32$

Temperature Differences

$(\Delta T/{}^\circ R) = 1.8(\Delta T/K)$
$(\Delta T/{}^\circ R) = (\Delta T/{}^\circ F)$
$(\Delta T/K) = (\Delta T/{}^\circ C)$

Volume

1 m^3 = 1000 L = 10^6 cm^3 = 10^6 mL = 35.315 ft^3
= 264.17 gal
1 ft^3 = 1728 in^3 = 7.4805 gal = 0.028317 m^3
1 gal = 0.13368 ft^3 = 0.0037854 m^3

Volumetric Flow Rate

1 m^3/s = 35.315 ft^3/s = 264.17 gal/s
1 ft^3/s = 1.6990 m^3/min = 7.4805 gal/s
= 448.83 gal/min

Force

1 N = 1 kg·m/s^2 = 0.22481 lbf
1 lbf = 1 slug·ft/s^2 = 32.174 lbm·ft/s^2
= 4.4482 N

Pressure

1 atm = 101.325 kPa = 1.01325 bar
= 14.696 lbf/in^2
1 bar = 100 kPa = 10^5 Pa
1 Pa = 1 N/m^2 = 10^{-3} kPa
1 lbf/in^2 = 6.8947 kPa = 6894.7 N/m^2 ;
[lbf/in^2 = “psi”]

Energy

1 J = 1 N·m = 1 Pa·m^3
1 kJ = 1000 J = 737.56 ft·lbf = 0.94782 Btu
1 Btu = 1.0551 kJ = 778.17 ft·lbf
1 ft·lbf = 1.3558 J

Energy Transfer Rate

1 kW = 1 kJ/s = 737.56 ft·lbf/s = 1.3410 hp = 0.94782 Btu/s
1 Btu/s = 1.0551 kW = 1.4149 hp
= 778.17 ft·lbf/s
1 hp = 550 ft·lbf/s = 0.74571 kW
= 0.70679 Btu/s

Specific Energy

1 kJ/kg = 1000 m^2/s^2
1 Btu/lbm = 25037 ft^2/s^2
1 ft·lbf /lbm = 32.174 ft^2/s^2