ROSE-HULMAN Institute of Technology
Department of Mechanical Engineering

Applications of Thermodynamics — Fall 2015-2016

Section: □ 01 (Lui, 9th hour) □ 04 (Mech, 10th hour)
□ 02 (Lui , 10th hour) □ 05 (Adams, 9th hour)
□ 03 (Mech, 9th hour) □ 06 (Adams, 10th hour)

____
Name

____
CM

Exam 1

Oct 26, 2015

Problem 1	______/ 15
Problem 2	______/ 40
Problem 3	______/ 45
Total	______/ 100

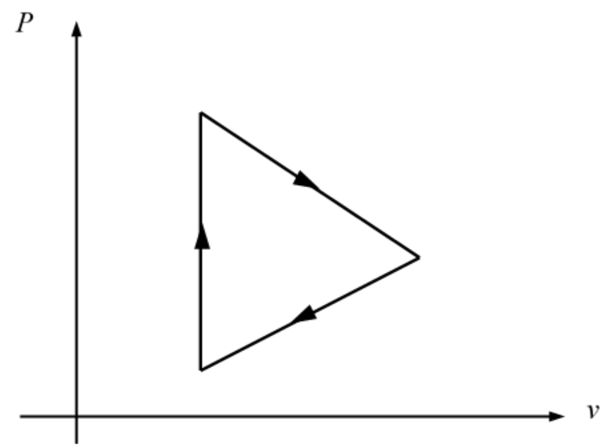
Show all work for full credit.

Open property tables. **Do not interpolate;** use closest values.
Computer use for computational purposes and/or music.
Two 8 ½ × 11″ equation sheets—one side, hand-written, no worked examples or homework.

CM: ________

Problem 1 [15 pts]

(a) [6 pts] Consider a thermodynamic cycle of a closed system as represented by the following *P-v* diagram. Does it describe a power cycle or a refrigeration cycle? Briefly explain your answer.



(b) [9 pts] Circle the correct answer(s) in the following questions:

a. [3 pts] The thermal efficiency of a power cycle is a second-law efficiency.

True | False

b. [2 pts] Inter-cooling between successive stages of compression has the following effect on the net power output:

Increase | Decrease | No change

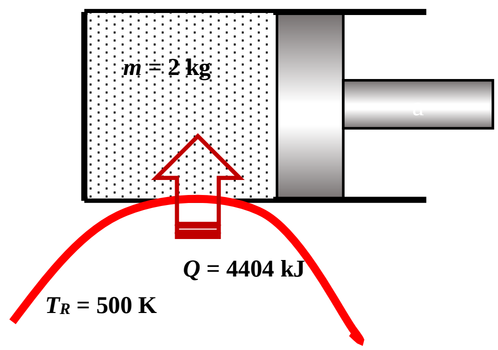
c. [2 pts] An increase in the compression ratio of a reciprocating internal combustion engine has the following effect on the overall thermal efficiency of the cycle

Increase | Decrease | No change

d. [2 pts] Under steady-state operation, a fluid at a given location experiences no change in the following thermodynamic variable(s). Circle all correct answer(s).

Pressure | Enthalpy | Entropy

Problem 2 [40 pts]



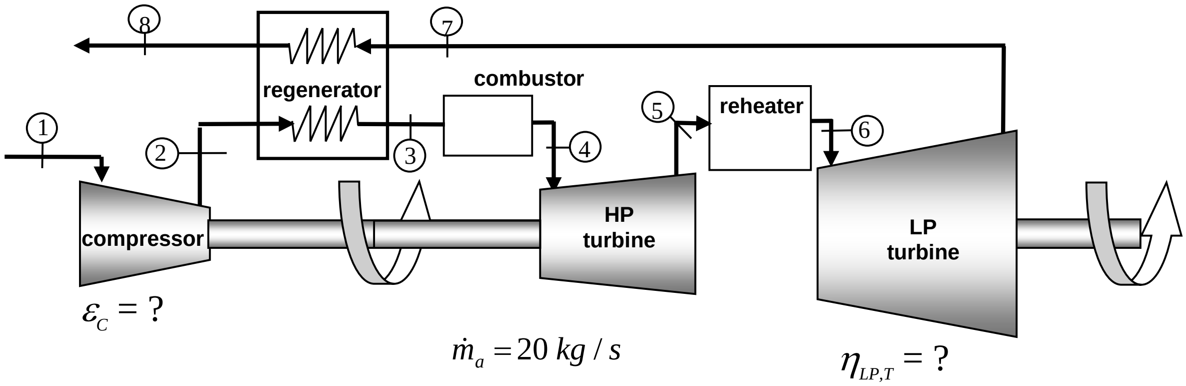
A piston cylinder contains a mass m = 2 kg of saturated liquid steam at a pressure of P_1 = 2 bar. Heat transfer in the amount of Q = 4404 kJ is added to the steam and it expands at constant pressure until it is a saturated vapor. The heat transfer comes from a reservoir at temperature T_R = 500 K. The surroundings are at T_0 = 300 K and P_0 = 100 kPa.

(a) [15 pts] Find the useful work into or out of the steam indicate its direction.
(b) [10 pts] Find the change in exergy of the steam during the process.
(c) [15 pts] **Using an accounting of exergy approach** (i.e., not entropy accounting), find the total exergy destroyed in this process.

CM: ________

Problem 3 [45 pts]

A modified Brayton cycle operates as shown in the figure below. **All of the power output of the high-pressure (HP) turbine is used to power the compressor, which has no other power input**. The cycle is well-modeled using the air standard assumptions. Partial property data are noted in the table. **Don't interpolate when using property tables for other values**; choose closest data.



(a) [12 pts] Compute the exergetic efficiency of the compressor, ε_C.

(b) [13 pts] Compute the isentropic efficiency of the low-pressure (LP) turbine, $\eta_{LP\ T}$.

(c) [8 pts] Compute the regenerator effectiveness.

(d) [1 pts] Compute the thermal efficiency of the cycle.

	Air Flow data: $\dot{m}$ = 20 kg/s				
	***T* [K]**	***P* [kPa]**	***h* [kJ/kg]**	**$s°$ [kJ/(kg-K)]**	**p_r**
0	300	100	300.2	1.702	1.39
1	290	100	290.2	1.668	1.23
2	600	900	607.0	2.409	16.3
3	840	900	866.1	2.772	57.6
4	1200	900	1278.0	3.179	238.0
5		410			
6	1200	410	1278.0	3.179	238.0
7	900	100	932.9	2.849	75.3
8		100			