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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)

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Name

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Exam 1

Sep 28, 2015

Problem 1	______/ 24
Problem 2	______/ 36
Problem 3	______/ 40
Total	______/ 100

Show all work for full credit.

Open property tables, **interpolate as necessary**.
Computer use for computational purposes and/or music.
One 8 ½ × 11″ equation sheet—one side, hand-written, no worked examples or homework.

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Problem 1 [24 pts]

(a) [2 pts each] For each the following properties of steam (water) identify the phase.

Properties	Phase				
	Compressed Liquid	**Saturated Liquid**○	**Saturated Mixture**○	**Saturated Vapor**○	**Superheated Vapor**
(i) T = 38°C, p = 2 bars	○	○	○	○	○
(ii) T = 38°C, h = 2600 kJ/kg	○	○	○	○	○
(iii) T = 38°C, s = 2.00 kJ/(kg·K)	○	○	○	○	○
(iv) T = 273°C, p = 35 bars	○	○	○	○	○
(v) p = 35 bars, u = 2000 kJ/kg	○	○	○	○	○
(vi) p = 35 bars, x = 0.32	○	○	○	○	○

(b) [3 pts each] For the following given properties of steam (water), find the indicated property:

(i) Given: T = 200°C, p = 5.0 bars   Find: s

(ii) Given: T = 200°C, x = 0.25   Find: h

(iii) Given: T = 38°C, p = 2 bars   Find: u

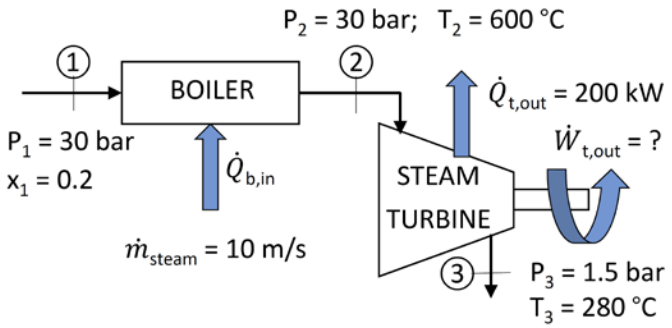
(iv) Given: p = 1.75 bars, x = 1   Find: v

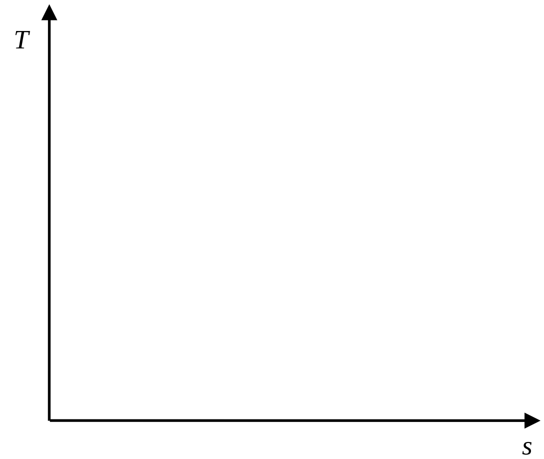
Problem 2 [36 pts]

Steam (**water**) is heated in a boiler and then passed through a steam turbine to generate power as indicated in the diagram below.

Pertinent properties are shown on the diagram.

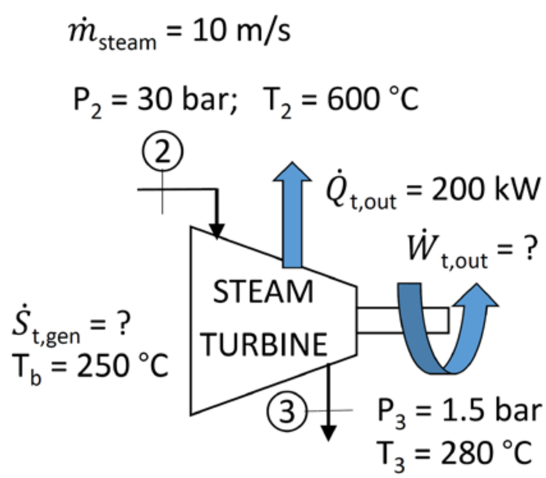
(a) [10 pts] Plot **both** processes on the *T-s* diagram at the right.
Include: a saturation curve and both isobars.





For the remaining questions consider just the turbine (redrawn at the right).

(b) [14 pts] Determine the power out of the turbine in kW.



(c) [12 pts] Determine the rate of entropy generation in the turbine in kW/K. Assume the surface temperature of the turbine is 250°C.

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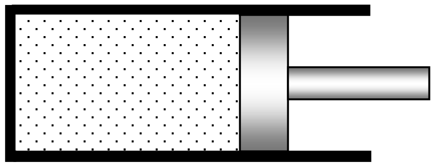
Problem 3 [40 pts]

Air (R = 0.287 kJ/kg-K) in a closed piston-cylinder assembly is originally at a temperature of 300 K, a pressure of 100 kPa, and a volume of 3 m^3 (State 1).



It undergoes a compression process from V_1 = 3 m^3 to V_2 = 1.0 m^3 (State 2) during which the product $P V^2$ is kept constant, *i.e.*

$$P V^2 = \text{constant}$$

(a) [24 pts] Determine the <u>heat</u> and <u>work transfers</u> of energy for the process from State 1 to State 2, in kJ. Your results should include the <u>magnitude</u> and <u>direction</u> of both transfers.

(b) [16 pts] Determine the <u>entropy generation</u> for the process from State 1 to State 2, in kJ/K, by assuming the average temperature of the boundary at which the heat transfer occurs to be at T_b = 600 K.

You may use the following ideal gas table for air to solve the above problem.

Ideal gas properties of air

				when $\Delta s = 0$	
T (K)	h (kJ/kg)	u (kJ/kg)	s^0 (kJ/kg-K)	p_r	v_r
300	300.19	214.07	1.70203	1.3860	621.2
400	400.98	286.16	1.99194	3.806	301.6
500	503.02	359.49	2.21952	8.411	170.6
600	607.02	434.78	2.40902	16.28	105.8
700	713.27	512.33	2.57277	28.80	69.76
800	821.95	592.30	2.71787	47.75	48.08
900	932.93	674.58	2.84856	75.29	34.31

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