Name:_____ **Thermo no.**_____

ME 200

Summer 2011

Exam 3

Friday 29 July

READ THESE INSTRUCTIONS

1. This is a closed book examination. All needed property tables, equation sheets and units conversions are provided as attachments to this exam.
2. Do not hesitate to ask questions if you do not understand a problem statement.
3. Start each problem on the same page as the problem statement. Write on only one side (the front) of each page. Material on the back side of any page **will not** be graded. Additional paper will be provided upon request.
4. Put only one problem on each page. A second problem on the same page **will not** be graded.
5. Follow the Problem Solution Format given in class in order to be eligible for full credit.
6. If you provide multiple solutions, you will receive only partial credit even if one of the solutions is correct. Delete the solution(s) you do not want.
7. For your own benefit, please write clearly and legibly.
8. After you have completed the exam, **at your seat**, put your papers in order. This may mean that you have to remove the staple and then re-staple at the front of the room. Regardless, **do not turn in loose pages**.
9. Once time is called you must stop writing **immediately**. Points will be subtracted from those writing after this time (**not kidding** on this one—it's a pet peeve of mine).

Problem	Possible score	Your score
1	45	
2	55	
Total	**100**	

[45 points] A vapor compression heat pump consists of a compressor, condenser, throttling valve and evaporator. The relevant states are listed in the table below.

State	p, kPa	T, C	h, kJ/kg	s, kJ/kg-K
1	300.0	5.0	255	0.945
2	1500	70.0	295	0.963
3	1500	50.0	123	0.441
4a	300	0.653	123	0.466
4s	300	0.653	117	0.441

None of the devices are adiabatic. The compressor loses energy by (specific) heat transfer to the surroundings at the rate of 5.0 kJ/kg while the throttle loses energy by (specific) heat transfer to the surroundings at the rate of 1.0 kJ/kg. The surroundings is at 25 C.

What is the entropy generation for the compressor? Report your answer in kJ/kg-K.
What is the entropy generation for the throttling valve? Report your answer in kJ/kg-K.
Calculate the compressor work. Report your answer in kJ/kg.
Calculate the work that could be provided if the throttling valve were replaced by an isentropic turbine. Report your answer in kJ/kg.

Use your computed values of entropy generation and work to quantitatively explain why substituting a turbine for the throttle is of less importance than improving the compressor efficiency.

[55 points] Vapor power cycles can also be used as part of "co-generation, or co-gen" systems. A typical co-gen system is shown in the figure below. Note that the only difference between it and a Rankine vapor power cycle is the addition of the heating load, positioned in the middle of the figure.

The heating load is a *desired energy output* that comes from turbine bleed steam used to heat buildings. Purdue uses such a system to heat campus buildings and produce electricity for lighting.

Use the data shown in the figure to compute the following:

i) **The mass flow rates through the heating load and condenser legs of the cycle**. Report your answers in kg/sec.

ii) **The specific enthalpy at State 1**. Report your answer in kJ/kg.

iii) **The rate of heat addition to the boiler/superheater**. Report your answer in MW.

iv) **The thermal efficiency of the entire cycle**. Note that this includes both the turbine and the heating load. Report your answer in %.

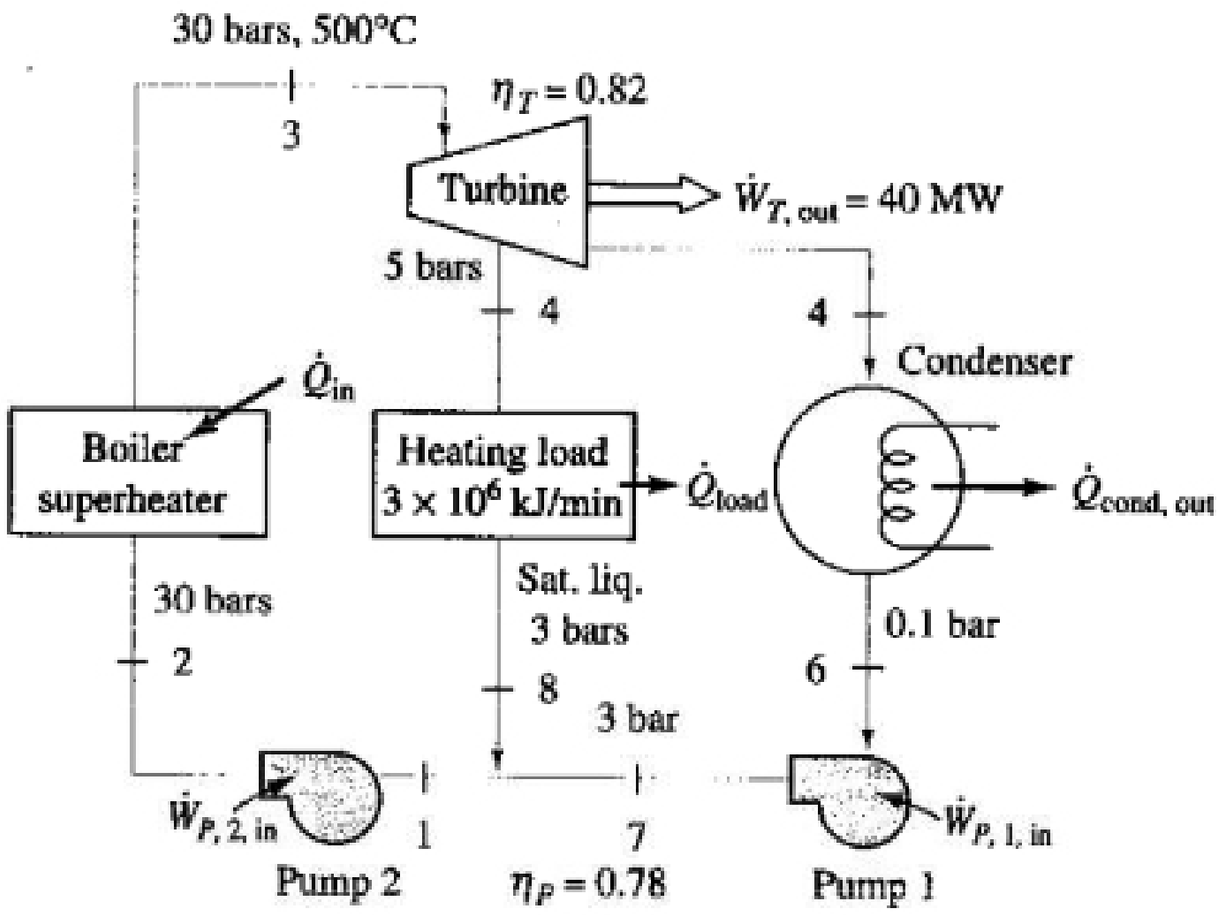

Figure 16-19 Equipment schematic and data for Example 16-10.

State 2:
h2=337 kJ/kg

State 3:
h3=3460 kJ/kg

State 4:
h4s=2940 kJ/kg
h4a=3030 kJ/kg

State 5:
h5s=2290 kJ/kg
h5a=2500 kJ/kg

State 6:
h6=192 kJ/kg

State 7:
h7=193 kJ/kg

State 8:
h8=562 kJ/kg