University of Waterloo

ME 354

THERMODYNAMICS 2
MIDTERM EXAMINATION

February 13, 2012 11:30 am - 1:30 pm

Instructor: R. Culham

Name: _____

Student ID Number: _____

Instructions

1. This is a 2 hour, closed-book examination.
2. Answer all questions in the space provided. If additional space is required, use the back of the pages or the blank pages included.
3. Permitted aids include:
   - Property Tables Booklet (Fundamentals of Thermodynamics, Borgnakke and Sonntag, 7th ed) or a photocopy of this booklet
   - one 8.5 in.$\times$ 11 in. crib sheet. (one side only)
   - calculator
4. It is your responsibility to write clearly and legibly. Clearly state all assumptions. Part marks will be given for part answers, provided that your methodology is clear.

Question	**Marks**	**Grade**
1	10	
2	20	
3	20	
TOTAL	50	

Question 1 (10 marks)

Determine the maximum useful work in $\boldsymbol{kJ}$ that could be obtained from $\mathbf{0.6}\ \boldsymbol{m^3}$ of compressed air at $\mathbf{250}\ ^\circ\boldsymbol{C}$ and $\mathbf{700}\ \boldsymbol{kPa}$. Assume the dead state conditions to be $\boldsymbol{T_0 = 25\ ^\circ C}$ and $\boldsymbol{P_0 = 1\ atm\ = 101.325\ kPa}$.

Question 2 (20 marks)

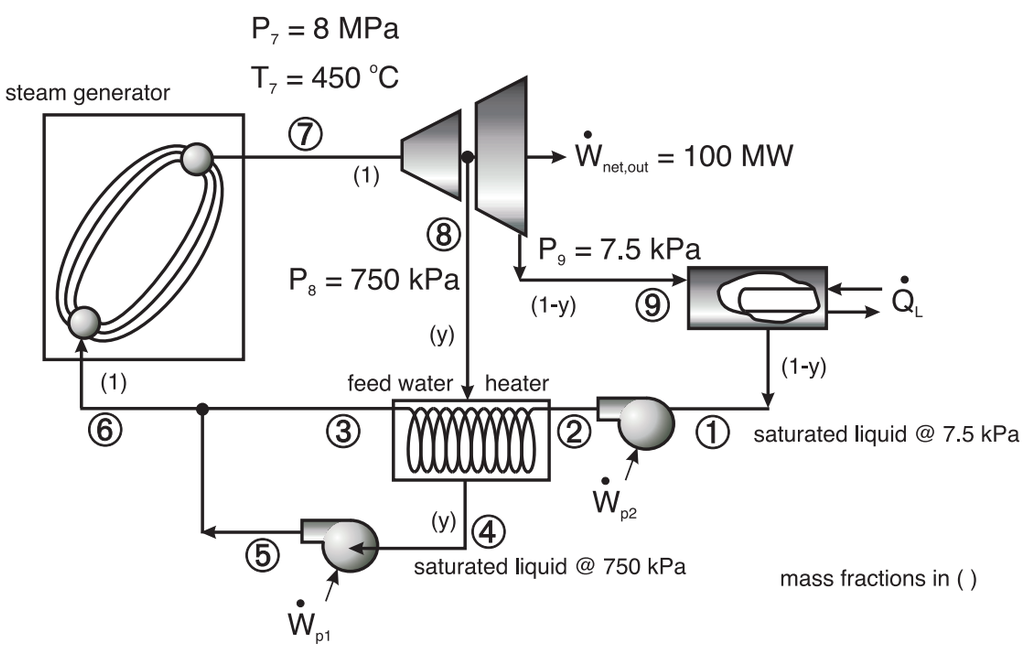
Water is used as the working fluid in a regenerative Rankine cycle where the circulation pumps and all stages of the turbine are considered to be isentropic. Superheated vapor enters the turbine at **8 MPa** and **450 °C**. After isentropic expansion in the first stage of the turbine, steam is extracted at an intermediate pressure of **0.75 MPa** and passed to a closed feedwater heater. The feedwater leaves the heater at **8 MPa** and a temperature equal to the saturation temperature at **0.75 MPa**. The saturated liquid condensate from the feedwater heater leaves at **0.75 MPa** and is pumped into the feedwater line as shown below. The condenser pressure is **7.5 kPa**. For a net power output from the cycle of **100 MW**:

a) draw the process diagram for this system and clearly label all relevant state points

b) determine the enthalpy at each state point in the process.

c) find the rate of heat transfer [MW] to the working fluid passing through the steam generator.

d) determine the thermal efficiency of the cycle.



Question 3 (20 marks)

A vapour-compression, heat pump, using R-134a, is designed to provide **10 kW** of heat between the reference atmosphere (T_0) at **-20 °C** and a building at **20 °C**. The inlet state to the compressor is a saturated vapour at **-30 °C**. The compressor exit state is at **50 °C, 800 kPa** while the inlet state to the valve is at **25 °C**.

a) determine the coefficient of performance of the heat pump
b) determine the availability destruction across each component in the system [kJ/kg]
c) determine the second law efficiency
d) determine the mass flow rate [kg/s]