ME 354 THERMODYNAMICS - 2

13 June 1998

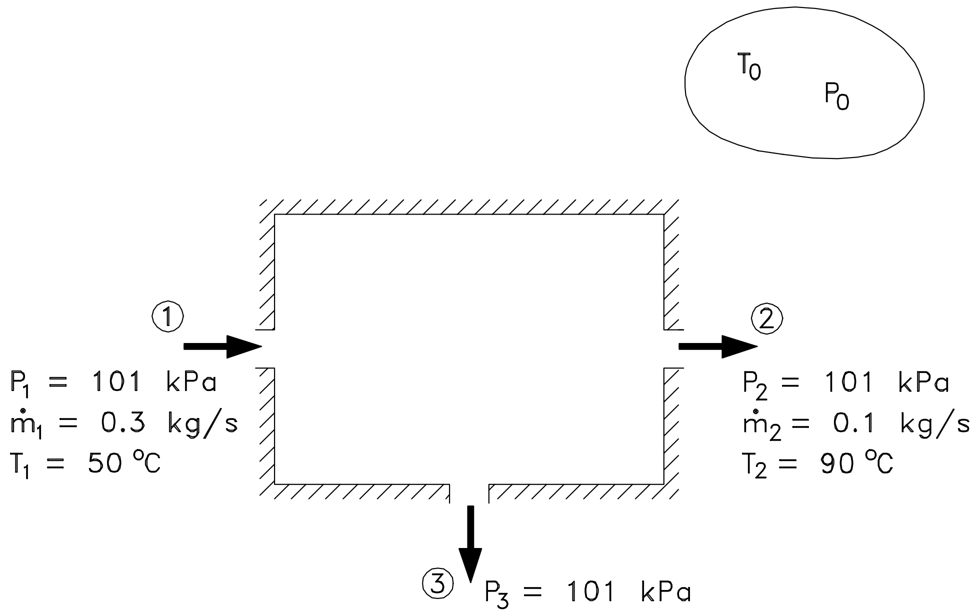
Midterm Examination R. Culham

- This is a two-hour, closed-book examination.
- You are permitted to use one 8.5 in.$\times$ 11 in. crib sheet. (one side only)
- There are 3 questions to be answered. Read the questions very carefully.
- Clearly state all assumptions.
- It is your responsibility to write clearly and legibly.
- Hand in this question sheet with your exam booklet.

Question 1 (20 marks)

Air enters a black box at 50 $°C$, 101 kPa at 0.3 kg/s. The air flows steadily through the box and leaves through two different exits. At one exit the air leaves at 90 $°C$, 101 kPa at a rate of 0.1 kg/s. The air pressure is 101 kPa at the other exit. There is no work or heat transfer entering or leaving the box. Assume that the specific heat of the air is constant, with a value $c_p = 1004\ J/(kg \cdot K)$.

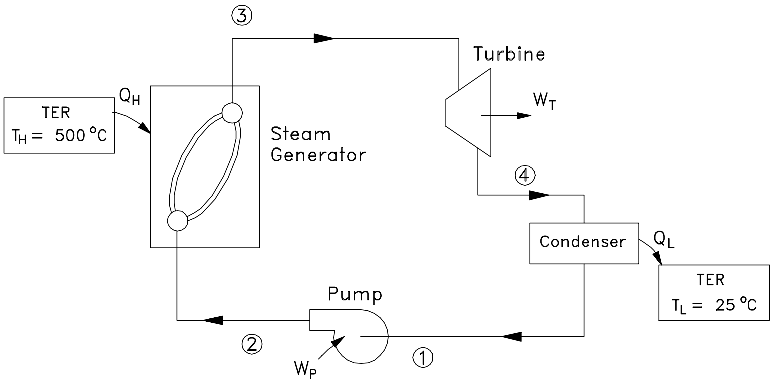
a) Determine the unknown exit temperature.
b) Determine the rate of availability destruction within the black box if $T_0 = 25\ °C$ and $P_0 = 101\ kPa$.
c) In this particular example, is it possible for the destruction term to be negative? Why or why not?



Question 2 (20 marks)

A Rankine-cycle, steam power plant operates between a source temperature at 500 °C and the reference atmosphere at 25 °C. For safety reasons the boiler pressure cannot be more than 10 MPa. The mass-flow rate of steam is 50 kg/s. The pumping process is in the liquid region. Assume that both the pump and the turbine are isentropic.

a) Determine the maximum first-law efficiency.
b) Determine the maximum second-law efficiency.
c) Determine the electrical generating capacity $[MW]$.



Question 3 (20 marks)

A vapour-compression refrigerator using R-12 has a maximum pressure of 800 kPa and a minimum pressure of 120 kPa. The R-12 is saturated liquid leaving the condenser and saturated vapour leaving the evaporator. The compressor is reversible and adiabatic.

a) Determine the maximum room temperature and the minimum food compartment temperature.
b) Determine the coefficient of performance.
c) Is the expansion valve isentropic? If not, what is the change in entropy?
d) Determine the availability destroyed in the condenser $[kJ/kg]$ if $T_0 = T_{room}$, where T_{room} is from part a)