ME 24-221
Thermodynamics I

Second Mid-Term Examination
6 November 2000
Fall 2000
Instructor: J. Murthy
Open book, open notes
50 minutes
Total: 25 points
Problem 1: 5 points; Problem 2: 10 points; Problem 3: 10 points

1. A refrigerator salesman claims that his refrigerator maintains an interior temperature of -5∘C when operating in a room at 27°C. He claims that the coefficient of performance (COP) under these conditions is 10.
   (a) Can his claim be true?
   (b) If the rate of heat removal from the cold space is 2 kW, compute the minimum possible power that must be provided to the refrigerator in kW.
2. An adiabatic steam turbine receives steam from two different sources, as shown in Figure 1. The pressure and temperature at state 1 are 5 Mpa and 800°C and the mass flow rate is 10 kg/s. At state 2, the pressure and temperature are 1 MPa and 500°C, and the mass flow rate is 5 kg/s. The exit state is given by 30 kPa and 90% quality. You may ignore potential and kinetic energy changes through the device.
   (a) What is the exit volumetric flow rate in m^3/s ?
   (b) What is the work done by the turbine in kW?
3. Consider the control volume shown in Figure 2 operating in steady state. Two steady flows of air enter the control volume as shown, are mixed together in it, and exit at state 3. The temperature and pressure in state 1 are 200°C and 500 kPa and the mass flow rate is 2 kg/s. The temperature and pressure at state 2 are 100°C and 500 kPa and the mass flow rate is 5 kg/s. The exit pressure is 100 kPa. The velocities in states 1 and 2 are neglible. The exit velocity is not negligible, and is measured at 50 m/s. Potential energy changes can be ignored. Assume specific heats to be constant.
   (a) If the heat rejected by the control volume is 20 kW and it produces 40 kW of power, determine the exit temperature of the device.
   (b) If the exit is a circular pipe, find the exit diameter in m^2.
   (c) Find the net rate of outflow of internal energy $\dot{m}_3 u_3 - \dot{m}_1 u_1 - \dot{m}_2 u_2$ in kW.

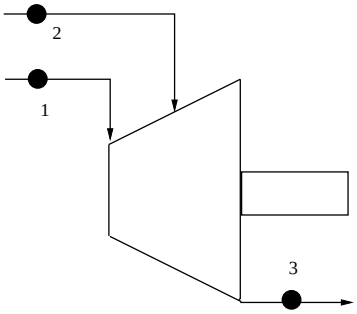

Figure 1: Schematic for Problem 2

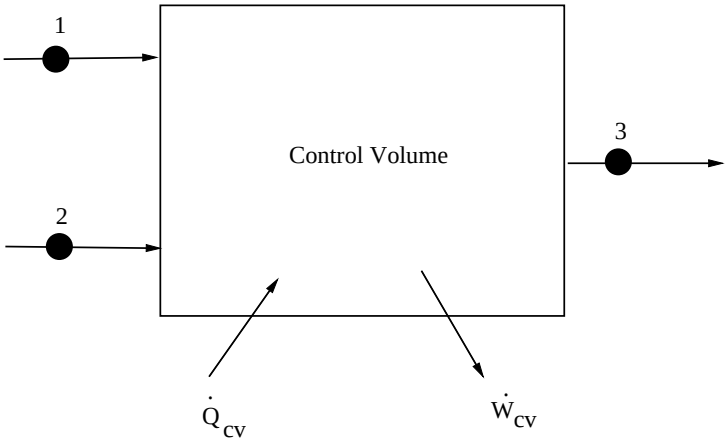

Figure 2: Schematic for Problem 3