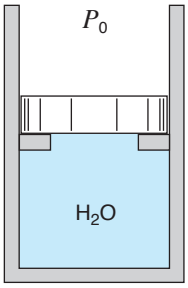
CHE 260F – Thermodynamics and Heat Transfer

Mid-Term Exam – 2017

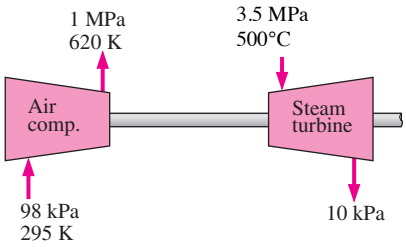
You have 110 minutes to do the following five problems. You may use any type of non-communicating calculator. All questions are worth equal marks.

1) Ten kilograms of water in a piston/cylinder arrangement, as shown in the figure, exists as a saturated liquid-vapour mixture at 100 kPa, with a quality of 50%. The system is now heated so that the volume triples. The mass of the piston is such that a cylinder pressure of 200 kPa will float it. Find the final temperature of the steam and the heat transferred to it in the process.



2) A mass of 2 kg of ethane gas at 500 kPa, 100°C undergoes a reversible polytropic expansion with exponent $n = 1.3$ to a final ambient air temperature of 20°C. Calculate the total entropy generation for the process if the heat is exchanged with the ambient surroundings. For ethane $c_p = 1.766$ kJ/kg and $R = 0.2765$ kJ/kg.

3) An adiabatic air compressor is to be powered by an adiabatic steam turbine. Steam enters the turbine at 3.5 MPa and 500°C at a rate of 25 kg/s and exits at 10 kPa and a quality of 0.92. Air enters the compressor at 98 kPa and 295 K at a rate of 10 kg/s and exits at 1 MPa and 620 K. What percentage of the power produced by the turbine is used by the compressor? For air $c_p = 1.020$ kJ/kg.



4) Steam enters a long pipe with an inlet diameter of D_1=12 cm at 1 MPa and 300°C with a velocity of 2 m/s. At the exit of the pipe the conditions are 800 kPa and 250°C, and the diameter is D_2=10 cm. Determine (*a*) the mass flow rate of the steam and (*b*) the rate of heat transfer from the pipe to the surroundings.

5) Steam enters an adiabatic turbine at 3 MPa, 600°C, and 80 m/s and leaves at 50 kPa, 150°C, and 140 m/s. If the power output of the turbine is 6 MW determine (*a*) the mass flow rate of the steam flowing through the turbine and (*b*) the isentropic efficiency of the turbine.