ME 354 Thermodynamics 2
Final Exam April 1996

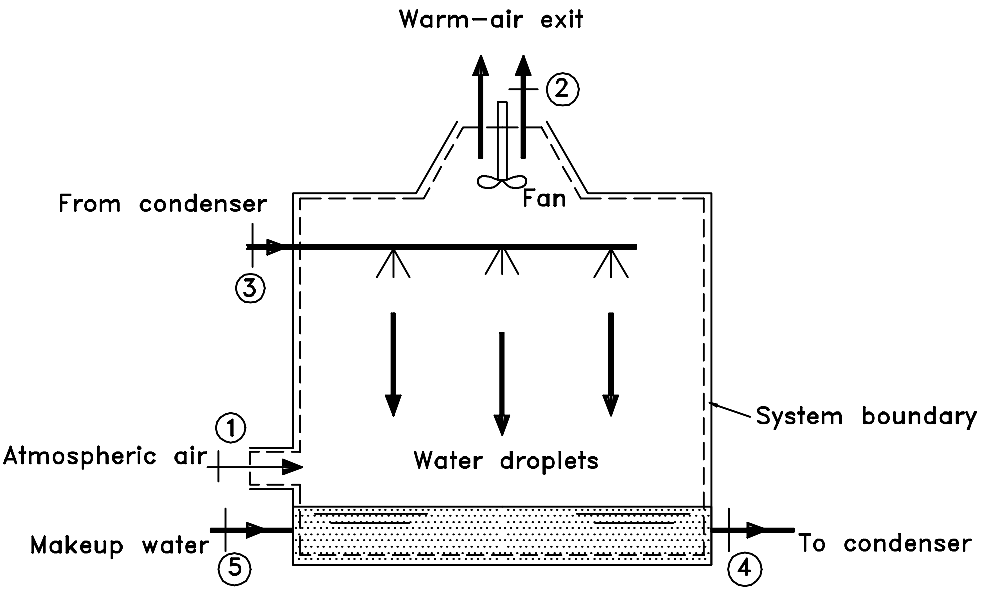
Time Limit: 3 Hours H.F. Sullivan
Aids allowed: text, calculator
1 page formula sheet

Problem #1 (10 marks)

A steady-flow industrial furnace is designed to operate in gaseous methane at a constant pressure of 1 atm. Methane gas enters the furnace at 77 $°F$ and mixes with 40 percent excess air at 700 R. The products of combustion leave the furnace at 1300 R. The furnace is designed to have a steady heat-transfer rate of 680,000 BTU/hr. Assuming complete combustion (and no dissociation) and that the water in the products is in the vapour phase, calculate (a) the mass flow rate of methane and (b) the mass flow rate of air required to provide the required heat-transfer rate from the furnace.

Problem #2 (10 marks)

Water from a power plant condenser enters a forced-draft, wet-cooling tower at 45 $°C$ at a rate of 130 kg/s and is cooled at 30 $°C$. Atmospheric air at 101.3 kPa with a dry bulb temperature of 25 $°C$ and a dew point temperature 14 $°C$ enters the tower, and the air leaves in a saturated state at 32 $°C$. The makeup water enters at 30 $°C$. Determine (a) the volumetric flow rate of air entering the cooling tower and (b) the mass flow rate of makeup water. Neglecting the power input to the fan.



Problem #3 (10 marks)

Ethane (C_2H_6) is burned with 150% theoretical air in a gas turbine combustor. The products exiting consist of a mixture of CO_2, H_2, O_2, N_2, and NO in chemical equilibrium at 2000 K, 1 MPa. (a) Determine the mole fraction of NO in the products. (b) Is it reasonable to ignore CO in the products? Justify your answer.

Problem #4 (10 marks)

One means of improving the performance of a refrigeration system that operates over a wide temperature range is to use a two-stage compressor. Consider an ideal refrigeration system of this type that uses freon-12 as the working fluid, as shown in the figure below. Saturated liquid leaves the condenser at 110 $°F$ and is throttled to 0 $°F$. The liquid and vapour at this temperature are separated, and the liquid is throttled to the evaporator temperature, -90 $°F$. Vapour leaving the evaporator is compressed to the saturation pressure corresponding to 0 $°F$, after which it is mixed with the vapour leaving the flash chamber. It may be assumed that both the flash chamber and the mixing chamber are well insulated to prevent heat transfer from the ambient. Vapour leaving the mixing chamber is compressed in the second stage of the compressor to the saturation pressure corresponding to the condenser temperature, 110 $°F$.
(a) Draw a P-h process schematic clearly labelling all state points (b) Determine the coefficient of performance (COP) of the system