FINAL EXAMINATION FROM 2000

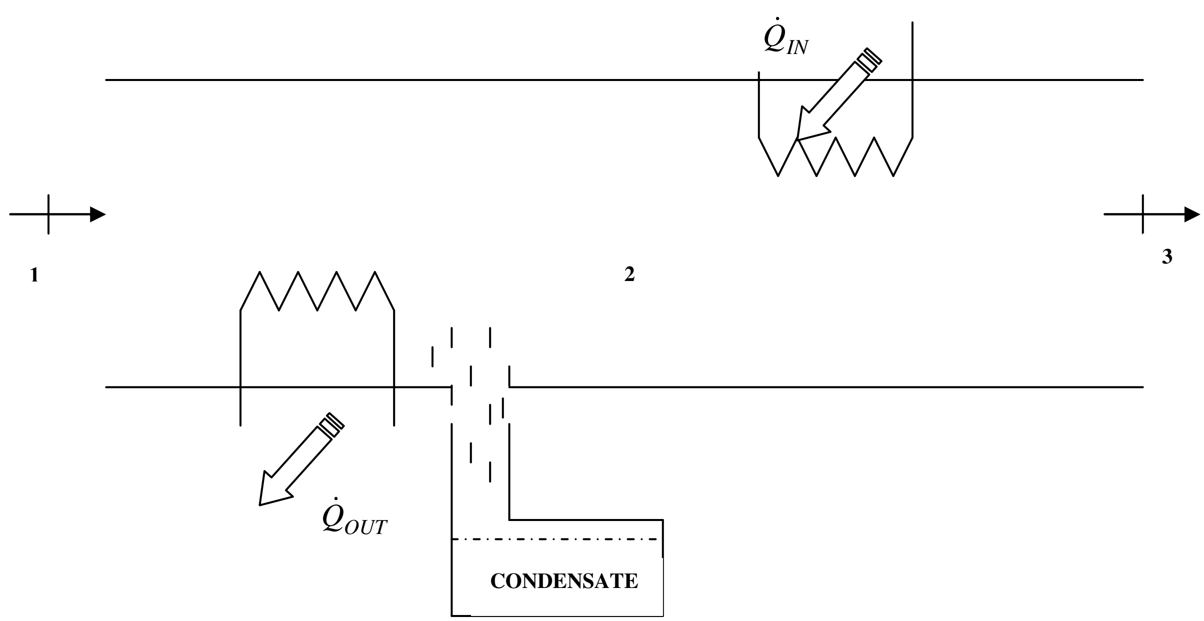
ME 40 FALL 2009 PRACTICE FINAL: REMEMBER, THIS EXAM IS MORE DIFFICULT THAN YOUR FINAL WILL BE. DON'T PANIC.

NAME______________________

This examination is open book and open notes. The test consists of four problems equally graded. Please write your name in the space provided above.

1. A combination air cooler and dehumidification unit receives outside ambient air at 1atm, 35°C and a relativity humidity of 70%. The moist air is first cooled to a low temperature to condense the proper amount of water. The moist air is then heated and leaves the unit at 1 atm, 20°C, and 30% relative humidity. The volume flow rate of the moist air at the exit is 0.01 m^3/sec.

a) Find the temperature to which the mixture must be cooled and the mass of water vapor condensed out per kilogram of dry air.
b) Assuming all the liquid condensed out leaves at the minimum temperature, calculate the **overall** heat transfer rate.
c) Draw the process on a rough psychrometric chart, labeling the state points.



2. Water at 20°C and 0.101MPa is pumped to 2MPa. The pump has an isentropic efficiency of 75%, and the total flowrate through the pump is $0.01\, m^3/\text{sec}$.

(a) Find the power required to drive the pump.

(b) Find the temperature rise across the pump (**be careful with significant digits**).

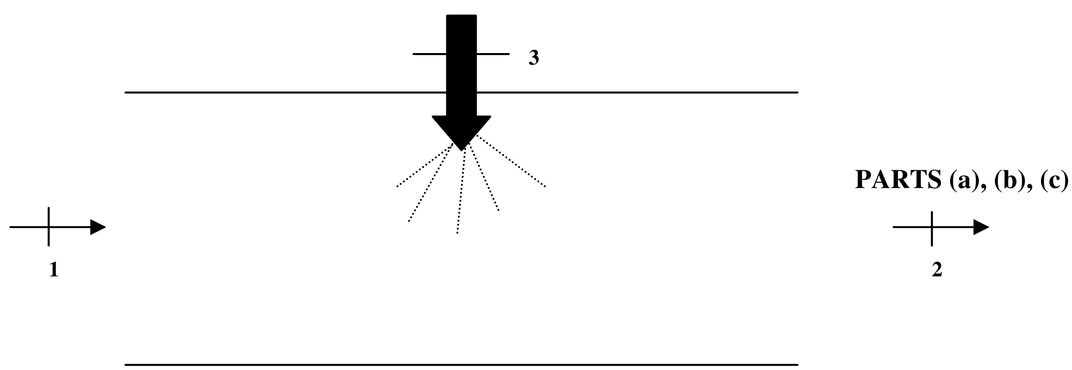
3. Consider the following air conditioning system with an air inlet, at which $\omega_1 = 0.0045\, kgH_2O/kg\ dryair$, and an outlet at which $T_2 = 10°C$ and $\phi_2 = 80\%$, both at 1atm. Saturated water vapor at $T_3 = 100°C$ is sprayed in, at a rate of $0.15\, kg/sec$.

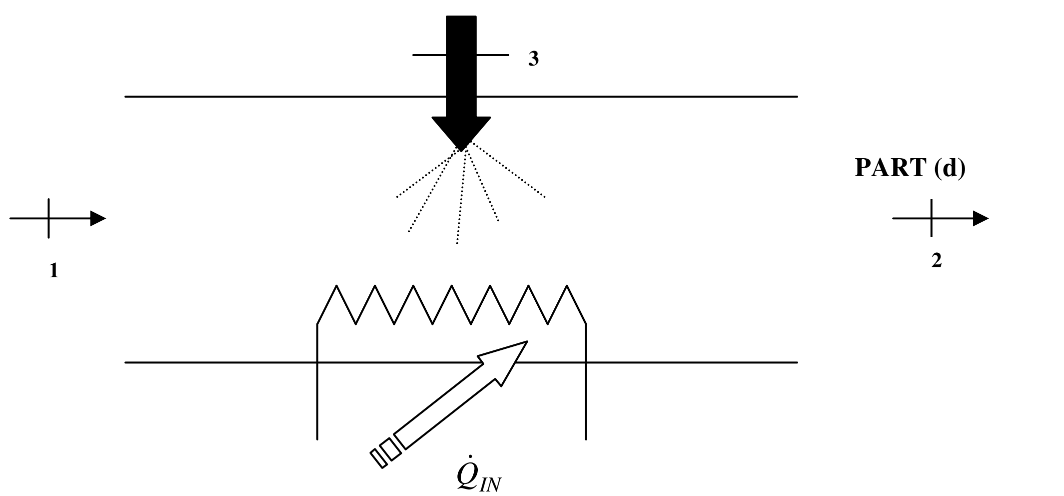
a) Determine the outlet absolute humidity

b) **Using a mass balance for water**, calculate the mass flow rate of air needed for this system to operate in steady-state

c) **Using a first law analysis**, determine the inlet air temperature

d) It is decided that the outlet of the air conditioner is too cold, so a heater is turned on adding 1330kW of heat to the system. The inlet air and water spraying conditions remain the same, and the outlet temperature increases to $T_2 = 20°C$. What is the relative humidity of the outlet? (If you were unable to determine the inlet temperature in part (c) assume it is 8°C)





4. 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 cycle of this type that uses R-134a as the working fluid at a flow rate of 0.05kg/sec. Saturated liquid leaves the condenser at 40°C and is throttled to -20°C. The liquid and vapor at this temperature are separated by use of a flash chamber, **whose only function is to separate the liquid and vapor**. The liquid is then throttled to -40°C - the inlet temperature of the evaporator. Vapor leaving the evaporator is compressed to 0.10MPa, after which it is mixed with the vapor leaving the flash chamber. Vapor leaving the mixing chamber then enters the second compressor, where it is compressed to the condenser pressure, and a final temperature of 41.3°C. Consider the mixing chamber to be perfectly insulated, and having no work interactions. All devices are ideal.

Find the coefficient of performance of this two stage refrigeration cycle.