These problems are due on Friday, Sept 18.

1. A sealed, rigid tank contains 2 kg of water at 80°C with a quality of 0.6. Heat is added to the water until it exists as saturated vapor. Determine the amount of heat that must be added, in kJ. Neglect potential and kinetic energy changes. **1752.6 kJ**

2. A piston-cylinder arrangement contains 2 lbm of water at 300°F. The water undergoes two processes in series:
   1 – 2 constant volume heating until \( P_2 = 100 \text{lbf/in}^2 \) and \( x_2 = 80\% \)
   2 – 3 constant pressure until \( T_3 = 400\text{F} \)

   a) Show the processes on a T-v and P-v diagram in relation to the two-phase region
   b) Determine the work for each process, in Btu. **0 Btu, 51.2 Btu**
   c) Determine the heat transfer for each process, in Btu. **440.2 Btu, 435.0 Btu**

3. A piston-cylinder assembly contains 0.1 kg of water at 1 MPa and 500°C. The water undergoes two processes:
   1 – 2 constant pressure cooling until the volume is reduced by half
   2 – 3 constant volume cooling until the final temperature is 25°C.

   a) Sketch the two processes on a P-v diagram in relation to the two-phase region
   b) Determine the work for each process, in Btu. **-17.71 kJ (16.79 Btu), 0 kJ (0 Btu)**
   c) Determine the heat transfer for each process, in Btu. **-88.19 kJ (83.6 Btu), -230.53 kJ (218.5 Btu)**

4. A gallon of milk at 68°F is placed in a refrigerator and is cooled at a constant rate of 0.08 Btu/s. How long will it take, in minutes, for the milk to cool to 40°F? The specific heat of the milk is 0.94 Btu/lbm-R and the density is 64 lbm/ft³. **47 minutes**

5. One kilogram of nitrogen gas is contained in a frictionless piston-cylinder arrangement at 100 kPa with a total volume of 1 m³. Heat is transferred to the gas until the volume is doubled. Find the work and the heat transfer for this process if
   a) the process occurs at constant pressure. **100 kJ, 350 kJ**
   b) the process occurs with \( PV^{1.1} = \text{constant} \)