These problems are due on Friday, Oct 23.

1. The piston-cylinder arrangement below has a frictionless piston free to move between a set of stops. When the piston is at the lower stops, the enclosed volume is 10 ft³, and when it reaches the upper stops, the enclosed volume is 15 ft³. The cylinder initially contains water at 14.7 lbf/in² and 20% quality. The water is now heated until it exists as saturated vapor. The mass of the piston and atmospheric pressure are such that 50 lbf/in² are required to raise the piston. Determine:
   a) the final pressure in the cylinder (lbf/in²)
   b) the work done by the water (Btu)
   c) the heat transfer required (Btu)

2. A balloon will maintain an internal pressure of $P_0 = 100$ kPa until the volume reaches $V_0 = 20$ m³, above which the pressure increases according to $P = P_0 + C(V-V_0)^2$. The balloon contains helium gas at 20°C, 100kPa with a 15m³ volume. The balloon is heated until the helium reaches 400°C, at which point the pressure is 150kPa. Determine:
   a) the work done by the helium in this process (kJ)
   b) the heat transfer required (kJ)

3. A small compressor operates on compressed air and produces 0.1 hp. The air at the inlet is 60 lbf/in², 70°F, and the exit state is 14.7 lbf/in² and –60°F. Ignore kinetic and potential energy changes. Determine the required mass flow rate of air.

4. The following data are available for the simple steam power plant at right.

   \[
   \begin{align*}
   P_1 &= 900 \text{ lbf/in}^2 \\
   P_2 &= 890 \text{ lbf/in}^2 \\
   P_3 &= 860 \text{ lbf/in}^2 \\
   P_4 &= 830 \text{ lbf/in}^2 \\
   P_5 &= 800 \text{ lbf/in}^2 \\
   P_6 &= 1.5 \text{ lbf/in}^2 \\
   P_7 &= 1.4 \text{ lbf/in}^2 \\
   \end{align*}
   \]

   \[
   \begin{align*}
   T_2 &= 115\text{F} \\
   T_3 &= 350\text{F} \\
   T_4 &= 920\text{F} \\
   T_5 &= 900\text{F} \\
   x_6 &= 92\% \\
   V_6 &= 600 \text{ ft/s} \\
   T_7 &= 110\text{F} \\
   \end{align*}
   \]

   Additionally, the mass flow rate through the system is 200,000 lbm/h. Neglect all kinetic energies except at the turbine exit. Determine:
   a) The power output of the turbine
   b) The power input for the pump
   c) Heat transfer rate in the economizer (pre-heater)
   d) Heat transfer rate in the steam generator (boiler)
   e) If the cooling water temperature rise must be limited to 20°F, determine the mass flow rate of cooling water required.