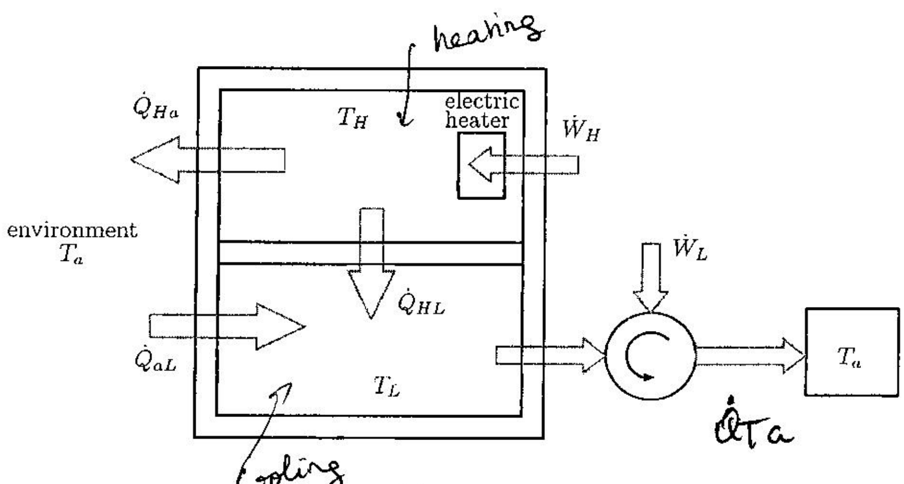
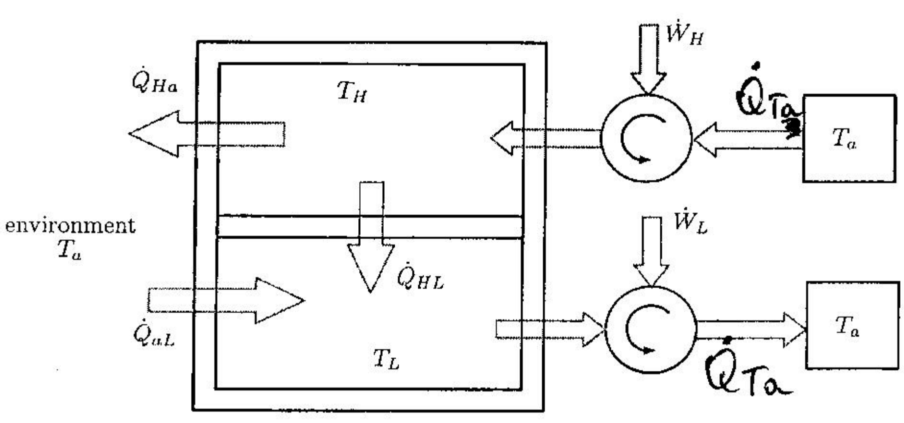
MECH 310 Thermodynamics I — January 15, 2011
American University of Beirut, Fall 2010 — Handout # Quiz 2

Quiz 2

Problem 1 (40 points)
Consider a two story storage building. The first floor is maintained at low temperature T_L such that $T_L < T_a$ and the second floor is maintained at a high temperature T_H such that $T_H > T_a$, where T_a is the ambient temperature. The upper floor loses heat steadily to the both the environment and the lower floor. In addition, the lower floor also gain heat steadily from the environment and the upper floor.
Evaluate each of the following two scenarios for heating the upper floor and cooling the lower floor in terms of the minimum possible cost (rate of work consumed):
(a) The heat rate lost by the upper floor is compensated by electric heating and that gained by the lower floor is removed using a refrigeration cyclic engine operating between the lower floor and the environment.
(b) Same as in (a) except that instead of electrically heating the upper floor, we employ a heat pump operating between the upper floor and the environment.
(c) Can you do better than (a) and (b) to achieve lower rate of work consumption. Sketch your solution including all the heat engines, heat pumps and refrigeration cycles you employ.



scenario (a)



scenario (b)

Specific heat of water
4.18 KJ/kg K

Problem 2 (30 points)
A simple steam power plant operates at steady state with water circulating through components with a mass flow rate of 60 kg/s. Figure 2 shows additional data at key points in the cycle. Stray heat transfer and kinetic and potential effects are negligible. Determine
(a) the thermal efficiency
(b) the mass flow rate of cooling water through the condenser, in kg/s.

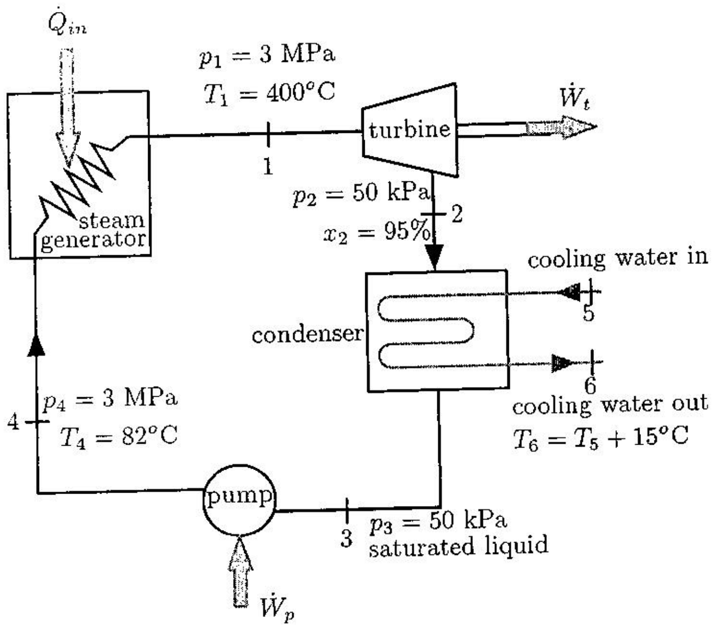


Figure 2

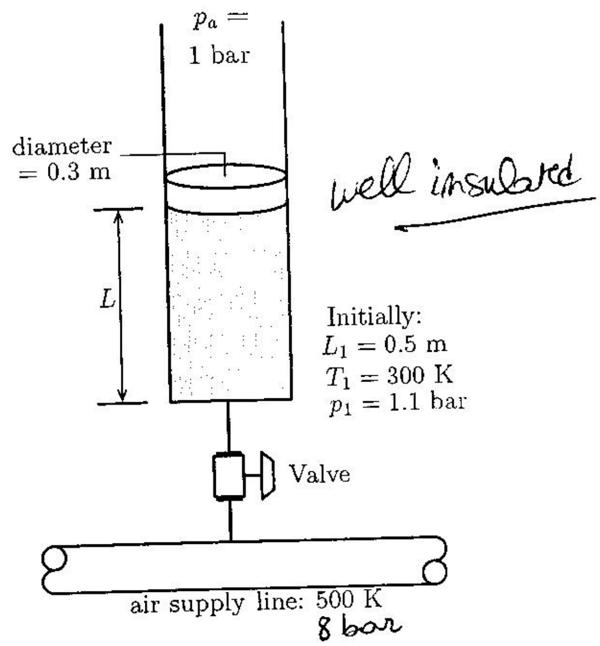


Figure 3

Problem 3 (30 points)
A well insulated piston-cylinder assembly is connected by a valve to an air supply line at 500 K and 8 bar, as shown in Figure 3. Initially the air inside the cylinder is at 1.1 bar, 300 K, and the piston is located 0.5 m above the bottom of the cylinder. The atmospheric pressure is 1 bar, and the diameter of the piston face is 0.3 m. The valve is opened and air is admitted slowly until the volume of air inside the cylinder has doubled. The friction between the piston and the cylinder wall can be ignored.
(a) Find the final temperature in °K.
(b) Find the final mass in kg.
(c) What are the final temperature and mass if the air supply line is at 6 bar.

by Erik.V.Z
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$pv = RT$

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