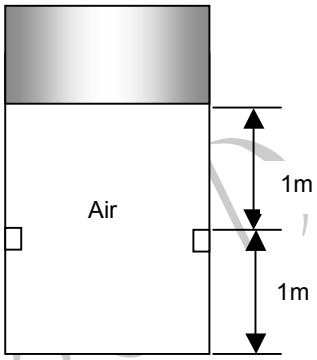
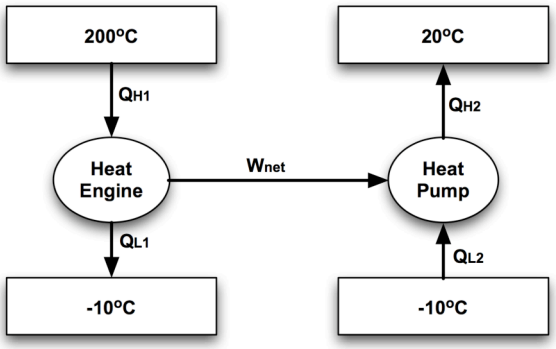
Final Exam
8:00-10:30am (12/14/2006)

1. Air is contained in a frictionless piston-cylinder assembly with a set of stops as shown. The cross-sectional area of the piston is $0.1m^2$, and the air is initially at 200kPa, 500°C. The air is then cooled as a result of heat transfer to the surroundings. (a) What is the temperature of the air inside when the piston reaches the stops? (b) If the cooling is continued until the temperature reaches 20°C, what is the pressure inside the cylinder at this state? (c) Draw the pressure-volume diagram of this process. Assume the air in the cylinder as an ideal gas.



2. A piston-cylinder device contains helium gas initially at 150kPa, 30°C and $0.5m^3$. The helium is now compressed via a polytropic process ($PV^{1.6}$=constant) to 400kPa and 140°C. The ideal gas constant of helium is 2.0769 kJ/kgK, and the specific heat at constant volume is 3.1156 kJ/kgK. Determine the heat loss or gain during this process.

3. Heating is provided to a house at 20°C using combined heat engine and heat pump as shown. The heat engine operates between 200°C and the ambient at -10°C, and generates work. This work drives the heat pump which pumps heat from the -10°C ambient to the house. If the heating requirement of the house is 100,000 kJ/hour, determine the amount of heat supplied to the heat engine (i.e. Q_{H1}). The both cycles can be considered as Carnot cycles.



4. Air expands in a gas turbine from a pressure of 450kPa and a temperature of 400K to an exhaust pressure of 150kPa. Assume the process to be reversible and adiabatic with negligible kinetic and potential energy. Calculate the work per kg of air flowing through the turbine assuming constant specific heat, i.e. Cp = 1.00kJ/kgK and Cv = 0.718kJ/kgK. **(Note: Do not use variable specific heat relations. No credit will be given)**

5. A steam turbine receives steam at 1MPa and 350°C. The steam leaves the turbine at a pressure of 15kPa. The work output of the turbine is 600kJ/kg of steam flowing through the turbine. Determine the isentropic efficiency of the turbine.