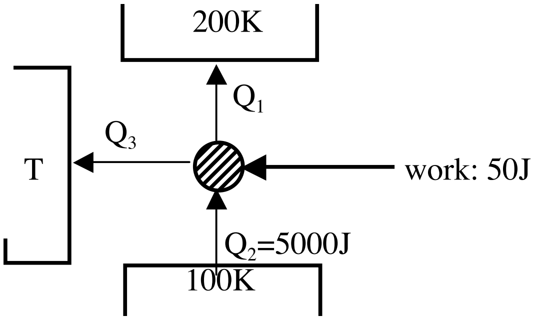
PHYSICS 4B QUIZ 5 SPRING QUARTER 2014
PROF. HIRSCH 3 Problems June 2nd

Problem 1 (10 pts)



The heat pump shown in the figure does 50J of work per cycle, extracts heat Q_2=5000 J per cycle from a heat reservoir at 100K and exhausts heat Q_1 per cycle to a heat reservoir at 200K . It also exhausts heat $Q_3>0$ per cycle to or extracts heat $Q_3<0$ per cycle from a heat reservoir at temperature T.

(a) If Q_1=5049 J, what is the range of possible values of T?

(b) If T=50K, what is the range of possible values of Q_1 and Q_3?

(c) What is the maximum possible value of T, and what values of Q_1 and Q_3 does that require? (Q_3 may be positive or negative, $Q_1 \geq 0$).

Problem 2 (10 pts)

An ideal monoatomic gas is used as a heat engine going in a reversible cycle through processes connecting states 1, 2 and 3 as follows:
State 1: initial state at temperature T_1, volume V_1.
Process 1 to 2: adiabatic expansion to volume $8V_1$.
Process 2 to 3: isothermal compression back to volume V_1.
Process 3 to 1: isovolumetric heating back to temperature T_1.

(a) Draw the cycle in a PV diagram, and indicate in it where the gas absorbs heat and where it releases heat.

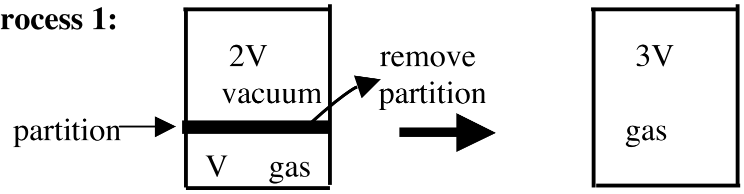
(b) Find the temperature of state 2, T_2, in terms of T_1.

(c) Find the efficiency of this heat engine, defined as $e=W/Q_1$, with W the work done in a cycle and Q_1 the heat absorbed in a cycle. Hint: calculate heats rather than work.

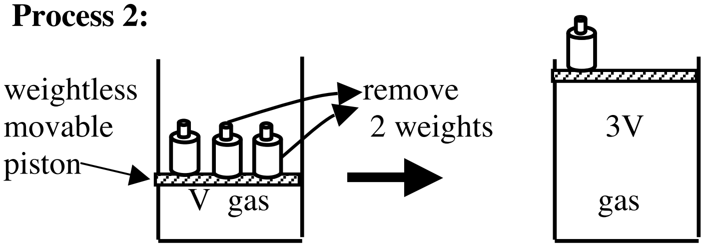
(d) Compare the efficiency found in (c) with the efficiency of a Carnot engine operating between the same temperatures T_1 and T_2. If they are not equal, explain why.

Problem 3 (10 pts)

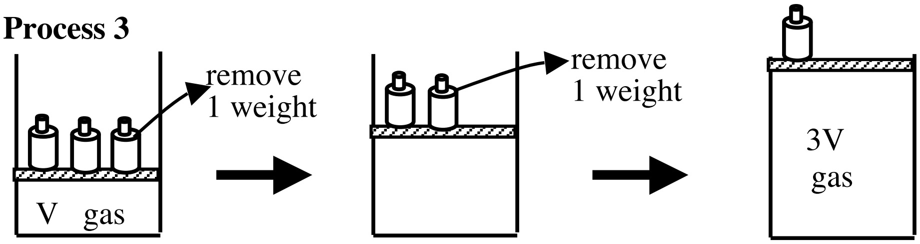
Process 1:



Process 2:



Process 3



Consider the three processes shown in the Figure undergone by n moles of an ideal gas. Assume they are all isothermal, the gas is always at the same temperature T, in some cases heat is being interchanged with a heat reservoir at the same temperature T that is not shown. In process 1, a partition is removed and the gas undergoes free expansion to three times the initial volume. In process 2, there are initially 3 equal weights on a weightless movable piston, balancing the pressure of the gas. 2 weights are removed at the same time, and the piston moves up to where the gas occupies 3 times the initial volume. In process 3, first one weight is removed, the piston moves up, later after equilibrium was reached another weight is removed and the piston moves up further.

Find the change in the entropy of the universe (final entropy minus initial entropy) as a number multiplying nR for:

(a) process 1
(b) process 2
(c) process 3
(d) for a case where instead of 3 masses there are 3000 masses each of which is 1/1000 of the ones shown in the figure, and 2000 are removed one by one so that the final state of the gas is the same as in the other processes. Your answer here may be approximate.