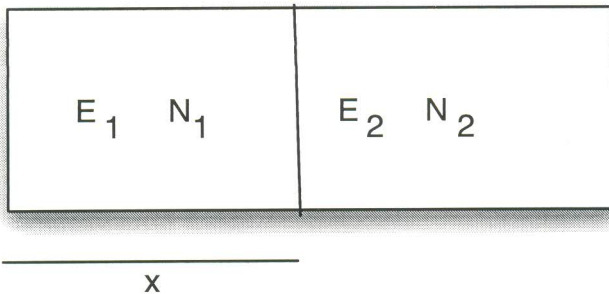


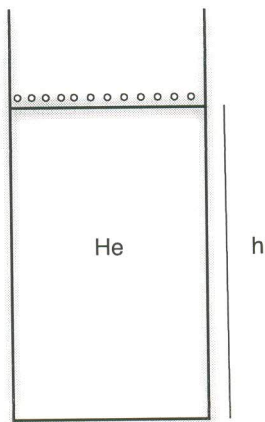
1. Consider a horizontal cylinder of length a , and cross section A , divided into two parts by a piston P of mass m . The piston can slide back and forth inside the cylinder without any friction. The walls of the cylinder as well as the piston are perfect heat insulators. The left side of the piston is filled with N_1 molecules of helium gas, and the right side is filled with N_2 molecules of Helium gas. The total energy of the system is fixed and is given by E . We assume that the piston is heavy and moves slowly so that at any instant of time we can regard the gas on each side to be in equilibrium, obeying ideal gas equation of state.



- a) Take the distance x of the piston from the left wall, the velocity v of the piston and the energy E_1 of the gas on the left side of the piston as independent variables and write down the equations of motion in the standard form with first order time derivatives only.
- b) Express the total entropy of the system in terms of the independent variables E_1 , x and v and show, using the equations of motion, that the total entropy does not change with time.
- c) Now assume that the system is not in complete thermal equilibrium during the motion of the piston so that the pressure on the piston due to the gas on left compartment differs from the one calculated using the ideal gas equation of state by c_1v and similarly pressure on the piston due to the gas on right compartment differs from the one calculated using the ideal gas equation of state by c_2v for some constants c_1 , c_2 . Find the equations of motion to first order in c_1 , c_2 .

d) Calculate the rate of change of entropy of the system. Show that for physical choice of the sign of c_1, c_2 the entropy increases with time.

2. Consider a vertical cylinder of cross section A containing helium gas, closed from the top by a piston P of zero mass. The piston can slide up and down without any friction. The walls of the cylinder as well as the piston are perfect heat insulators. The piston is held in place by putting $2n$ equal weights, each of mass m , on top of it. The piston is at a height h above the base of the cylinder.



*Considering these
n wts. to be
non-dynamical
particles*

a) Now suppose we suddenly remove n of the weights and wait till the system comes to rest. You can assume that the system is in equilibrium at the beginning and the end of the process but not in the intermediate stage. What will be the final height of the piston? What is the difference between the initial and the final entropy?

b) Next consider the case where we remove n of the weights one by one, and after each removal wait for the system to come to rest before the next one is removed. What will be the height of the system at the end of the process? What is the difference between the initial and the final entropy?

