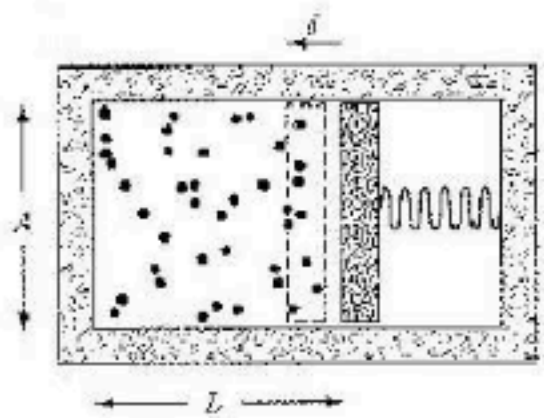
Except for an additive constant that does not depend upon energy or volume, the entropy of an ideal gas is

$$S(E,V) = \mathrm{k_B} N \ln(E^{3/2}) + \mathrm{k_B} N \ln(V)$$

where E is the internal energy, V is the volume, N is the number of particles, and $\mathrm{k_B}$ is the Boltzmann constant. The figure below shows a thermally isolated system consisting of an ideal gas with number of particles N, volume V, internal energy E, and a spring-loaded piston with cross sectional area A. At first, the piston is clamped at position L. The piston



is then unclamped and allowed to move an infinitesimally small distance δ to the left, where the piston is clamped again. During the motion, the spring pushes with a force f on the piston.

a. Give an expression for the change of potential energy stored by the spring. Where does the energy go?

b. Using the expression for entropy above, derive an expression for the change in entropy of the system, ΔS.

c. Use the result of part b to find the piston's equilibrium position L_{eq}, *i.e.*, the position at which the piston would come to rest if unclamped.

d. Show that your result for part c is in agreement with the ideal gas law.