Phys 119A HW#3

Due: Friday, Oct. 15 at the beginning of class.

READING: CARTER: CHAPTER 3, CHAPTER 4, 5.1 – 5.2
SCHROEDER, PAGES 32-37, CHAPTER 2

BOOK PROBLEMS: CARTER 3.9, 4.3, 4.4, 4.7, 4.9, 4.13
SCHROEDER 1.41 AND 1.43

ADDITIONAL PROBLEM:

Consider a box filled with one mole of an ideal gas. The box has cross sectional area A and the top of the box is a movable piston. Initially, the piston is held in place by a pin, setting the height of the piston h(0) (and hence the volume of the box V=Ah(0)) constant. The piston has mass M and is subject to gravity (ignore the effect of gravity on the gas in the box). At time t=0 the pin is removed. The piston is heavy enough that it starts to drop (i.e. h(t) starts to decrease).

Assume that the gas is able to equilibrate quickly enough that the motion following removal of the pin may be regarded as quasi-static as far as the gas is concerned, and further assume that the process is isothermal (i.e. the gas is in equilibrium with a heat bath at temperature T).

A) At what height will the piston eventually come to rest in the distant future? Call this height h_f.

B) Write down an equation of motion for the height of the piston h(t) in terms the variables introduced above. Assume there are no dissipative/friction effects.

C) What is the kinetic energy of the piston at the point when $h(t) = h_f$, (assume the e.o.m from part B is valid)?

D) The frictionless equation of motion you wrote down in part B predicts oscillations indefinitely into the future and is not realistic. Furthermore, the idea of V(t) changing with finite speed is technically in violation of our quasi-static assumption. Assume that a more realistic treatment would involve dissipation of the piston's kinetic energy into the gas. In other words, the K.E. you calculated in part C should be regarded as a dissipative contribution to the work done on the gas, had the process actually been carried out quasi-statically. What is the sum of the dissipative and "configuration" contributions to the work performed on the system for the quasi-static compression from h(0) to h_f? Explain your result.