Homework #1

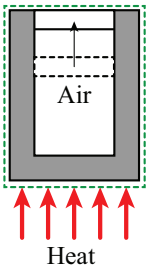
MEMS 0051 - Introduction to Thermodynamics

Assigned January 11th, 2019
Due: January 18th, 2019

Problem #1

Consider a piston cylinder shown to the right. The green dashed line is the control surface (C.S.) Answer the following questions.

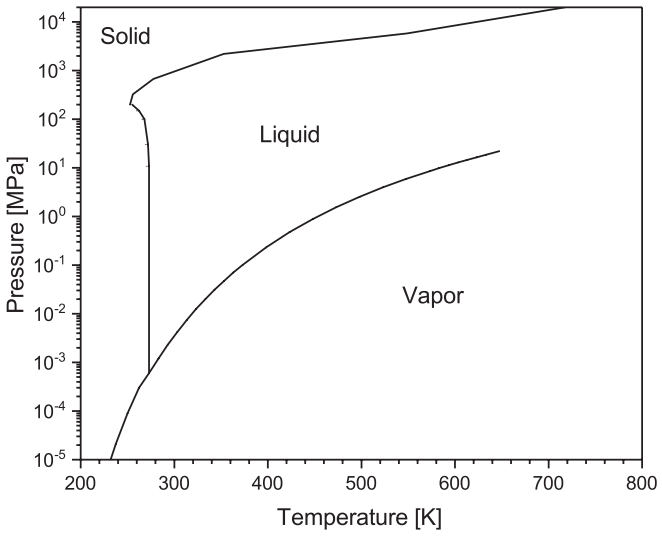
(a) Is the control volume (C.∀.) an open or closed system?
(b) Is the C.∀. that of an isolated system?
(c) Are the contents of the C.∀. undergoing a process or cycle?



Problem #2

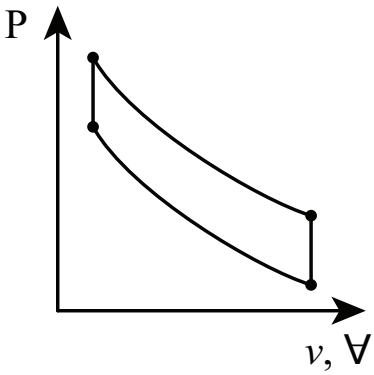
Given the phase diagram of water below, determine the phase based upon the following properties:

(a) 200 [K] and 1 [MPa]
(b) 220 [K] and 0.1 [kPa]
(c) 400 [K] and 10,000 [MPa]
(d) 326.85 [C] and 0.01 [MPa]
(e) 126.85 [C] and 0.1 [kPa]
(f) 400 [K] and 100 [MPa]
(g) 700 [K] and 100 [MPa]



Problem #3

Given the $P - \nu$ diagram for the Otto cycle below, identify the two processes that comprise this cycle.



Problem #4

Given the following list of properties, determine if they are intensive or extensive (i.e. write "intensive" or "extensive" next the corresponding number on the homework submission sheet). You may have to research what a given property is.

(a) Temperature
(b) Thermal conductivity
(c) Density
(d) Thermal diffusivity
(e) Total energy
(f) Kinematic viscosity
(g) Volume
(h) Specific Heat Capacity
(i) Magnetic permeability
(j) Coefficient of thermal expansion

Problem #5

Water vapor at 350 [kPa], which has a specific volume of 0.52425 [m^3/kg], is contained in a piston-cylinder device. At this initial state, the piston is 0.2 [m] from the bottom of the cylinder. The water vapor is then cooled in a constant pressure process such that final volume occupies half the initial. Determine:

(a) the final specific volume;
(b) the final mass;
(c) specify if this system is a open or closed, a control mass and/or isolated.

Problem #6

There exists a container with a volume of 10 [m^3]. This container is filled with 7 [m^3] of coarse stone, which has a density of 1,575 [kg/m^3], 1 [m^3] of sand, which has a density of 1,482 [kg/m^3], and the rest is filled with water, which has a density of 998 [kg/m^3]. Determine:

(a) the average specific volume;
(b) the average density.

Problem #5

A pipe feeds water 20 [m] from the ground to a local reservoir. The water flows with a velocity of approximately 5 [m/s]. It also has a specific internal energy of 100 [kJ/kg]. What is the total specific energy of the system with respect to the ground?

Problem #6

Consider the piston-cylinder assembly shown below. Assume that the fluid has been given sufficient time to expand, and that the piston has been stationary for awhile. Weights are then placed on the piston. Given that the total mass of the piston and the attached weights is 10 [kg] and the piston has a diameter of 5 [cm], answer the following:

(a) Determine the internal pressure of the fluid to reach static equilibrium;
(b) What happens if the diameter of the piston-cylinder assembly is halved?
(c) If air has a density 1.225 [kg/m^3] and water has a density of 998 [kg/m^3], which fluid will experience greater internal pressure if used in the piston-cylinder assembly?
(d) Can you assume quasi-static equilibrium throughout the fluid during compression? Explain.
(e) Did the fluid undergo a process or a cycle? Explain.
(f) Is the fluid an isolated system during this compression? Explain.