

# Homework #1

MEMS 0051 - Introduction to Thermodynamics

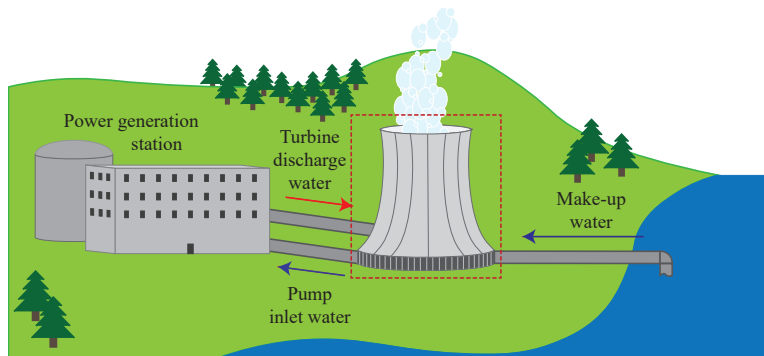
Assigned January 10<sup>th</sup>, 2020

Due: January 17<sup>th</sup>, 2020

## Problem #1

Consider a power plant shown below. The red dashed line is the control surface (C.S.) around the cooling tower. Answer the following questions.

- (a) Is the control volume (C.V.) an open or closed system?
- (b) Is the C.V. that of an isolated system?
- (c) Is the C.S. stationary or moving?



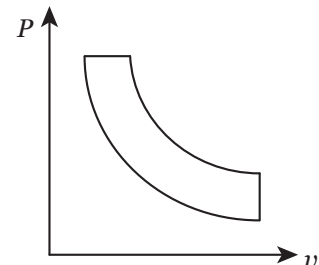
## Problem #2

Given the Matlab script for the phase diagram of water, determine the phase(s) based upon the following properties. Plot the phase diagram and label each state (i.e. (a), (b), (c), etc.).

- (a) 250 [K] and  $4 \cdot 10^4$  [MPa]
- (b) 700 [K] and  $1.1 \cdot 10^4$  [kPa]
- (c) 273 [K] and 100 [kPa]
- (d) 274 [K] and 100 [kPa]
- (e) 400 [K] and 2,000 [kPa]
- (f) 273.16 [K] and 600 [Pa]
- (g) 373.15 [K] and 101.325 [kPa]
- (h) 600 [K] and 10,000 [Pa]
- (i) 750 [K] and 250 [MPa]

## Problem #3

Given the  $P - v$  diagram for the diesel cycle to the right, and based upon the processes learned in Lecture 1, identify and label the three types of 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 a given property.

- |                             |                         |
|-----------------------------|-------------------------|
| (a) Electrical conductivity | (f) Dielectric strength |
| (b) Dynamic viscosity       | (g) Permeability        |
| (c) Thermal conductivity    | (h) Emissivity          |
| (d) Modulus of elasticity   | (i) Boiling point       |
| (e) Modulus of rigidity     | (j) Yield strength      |

## Problem #5

1 [kg] of compressed water at 500 [kPa] and 20 °C has a specific volume of 0.001002 [m<sup>3</sup>/kg], is contained in a piston-cylinder device. The water is then heated in a constant pressure process such that final volume is ten times that of the initial volume. Determine:

- (a) the final specific volume;
- (b) 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 18.9 [L]. This container is filled with 68 [kg] of steel ( $\rho_S=7,750$  [kg/m<sup>3</sup>]) shot, with 5 [L] of sand, which has a density of 1,482 [kg/m<sup>3</sup>], and the rest is filled with water, which has a density of 998 [kg/m<sup>3</sup>]. Determine:

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

## Problem #7

Water flows through a pipe from a high-elevation reservoir to a low-elevation reservoir purely via gravity-driven flow. If the change of elevation between the high- and low-elevation reservoirs is 15 [m], the average velocity of the water is 3 [m/s], and the water is at standard-temperature standard-pressure (i.e. has a specific internal energy of 104.86 [kJ/kg]), what is the total specific energy of the system at the exit of the pipe with respect to the high-elevation reservoir?

## Problem #8

Consider the piston-cylinder assembly shown to the right (neglecting the heads, and intake and exhaust vales). Both intake and exhaust valves are closed. The piston starts at bottom dead center (BDC) and compresses to top dead center (TDC). The displacement of the piston is 0.5 [L], and the compression ratio is 10.5:1. The bore diameter is 83 [mm] and the stroke length is 92 [mm]. Assume that the fluid, which is air, has been given sufficient time to compress. If it takes 5.5 [kJ] to compress the air, i.e. move the piston from BDC to TDC, answer the following:

- (a) Determine the internal pressure of the fluid after compression, assuming the initial pressure was 101.325 [kPa];
- (b) What happens if the diameter of the piston-cylinder assembly is halved?
- (c) Can you assume quasi-static equilibrium throughout the fluid during compression? Explain.
- (d) Did the fluid undergo a process or a cycle? Explain.
- (e) Is the fluid an isolated system during this compression? Explain.

