Homework #2

MEMS 0051 - Introduction to Thermodynamics

Assigned: May 14$^{\text{th}}$, 2020
Due: May 21$^{\text{st}}$, 2020

Problem #1

1. Given the MATLAB script "`Phase_diagram.m`", plot each of the following points and indicate, on the graph, if the substance is existing as a solid, liquid, vapor, or super-critical fluid. Additionally, for the process, plot the initial and final state, and indicate what type of process has occurred, i.e. sublimation, deposition, vaporization, condensation, melting or freezing. An example of how to plot a point, a line, and text is included within the MATLAB script.
   (a) 350 [K] and 100 [MPa] $\rightarrow$ 300 [K] and 1,200 [MPa]
   (b) 380 [K] and 10 [kPa] $\rightarrow$ 420 [K] and 0.8 [MPa]
   (c) 240 [K] and 100 [Pa] $\rightarrow$ 240 °C and 0.1 [kPa]
   (d) 300 °C and 10 [GPa] $\rightarrow$ 220 °C and 0.5 [GPa]
   (e) 490 [K] and 50 [MPa] $\rightarrow$ 523.55 [K] and 4 [MPa]
   (f) 480 °C and 40 [MPa] $\rightarrow$ 620 [K] and 700 [kPa]
2. Pasta often includes directions for different cooking times at different elevations above sea level. How is the cooking time at an elevation of 2 [km] different from that at sea level? Why is this?
3. Imagine you are on a space flight from Earth to the International Space Station. As your ship approaches the station, you suddenly feel discomfort and realize the saliva on your tongue has started bubbling. If the flight was comfortable just moments ago, what could be happening to cause this?

Problem #2

Given the following properties, determine the remaining properties (i.e. pressure, temperature, specific volume and quality, if applicable), for water. Indicate if the water is existing as a compressed/subcooled liquid, saturated liquid water, saturated vapor or superheated steam. Additionally, using the Matlab Script titled "`Pv_and_Tv_curves`.m", plot and label each item on both a $P-\nu$ and $T-\nu$ diagram. Note: interpolation may be required multiple times.

(a) $P = 500$ [kPa], $T = 130$ °C

(b) $P = 520$ [kPa], $\nu = 0.180\ 46$ [m^3/kg]

(c) $P = 2{,}000$ [kPa], $x = 0.8$

(d) $P = 950$ [kPa], $T = 320$ °C

(e) $T = 325$ °C, $\nu = 0.001\ 528$ [m^3/kg]

(f) $T = 103$ °C, $x = 0.2$

(g) $P = 215$ [kPa], $T = 121.5$ °C

(h) $T = 270$ °C, $\nu = 0.035\ 64$ [m^3/kg]

Problem #3

A piston-cylinder initially has a volume of 0.05 [m^3] and contains saturated water at a temperature of 110 °C with a quality of 80%. It undergoes isochoric heating until the water reaches 150 °C. The piston-cylinder next experiences isobaric cooling until the water returns to 110 °C. Finally, an isothermal expansion process occurs until the water is once again a saturated mixture with a quality of 80%.

1. For each state, identify the phase(s) and determine the pressure, temperature, specific volume, and if applicable, quality.
2. Do these processes represent a cycle? Why or why not?
3. Calculate the total mass, and if applicable, the mass of the liquid and vapor at each state within the vapor dome.
4. Given the MATLAB script "`Pv_and_Tv_curves.m`", plot and label each of the states. For the process, plot lines between each state, and indicate what type of process has occurred, i.e. isobaric, isochoric or isothermal. An example of how to plot a point, a line, and text is included within the MATLAB script.

Problem #4

Create an interpolation script in MATLAB. The interpolation script should have five inputs and one output. You are to use the input command to request user data. Use your script, which is to be submitted to (use MATLAB online grader utility), to interpolate any set of inputs.

Problem #5

Create a program in MATLAB to calculate the quality of saturated water. The script should have three input: saturated liquid specific volume, saturated vapor specific volume, and specific volume.