# Homework #3

MEMS 0051 - Introduction to Thermodynamics

Assigned January 25$^{th}$, 2019
Due: February 1$^{st}$, 2019

## Problem #1

Please refer to the Saturated Water tables.

a) Determine the quality of water at the following states:
   i.) $T$=150 °C, $\nu$=0.285 [m$^3$/kg]
   ii.) $P$=500 [kPa], $\nu$=0.285 [m$^3$/kg]
   iii.) $P$=800 [kPa], $\nu$=0.61813 [m$^3$/kg]
   iv.) $T$=100 °C, $\nu$=0.001020 [m$^3$/kg]

b) Determine the specific volume and specific internal energy of water at the following states:
   i.) $P$=200 [kPa], $x$=0.5
   ii.) $T$=300 °C, $x$=0.5
   iii.) $P$=523 [kPa], $x$=0.5
   iv.) $T$=72 °C, $x$=0.5

c) Determine the specific internal energy of water for the states listed in part a.

## Problem #2

a) 100 [kg] of $C_2H_4$ is contained in a 3 [m$^3$] vessel at 300 °K.
   i.) Calculate the gas constant, $R$, for $C_2H_4$ based on its molecular mass listed in Table A.5.
   ii.) Determine how many moles, $n$, of $C_2H_4$ are in the vessel.
   iii.) What is the pressure of $C_2H_4$ in the vessel?

b) Heat is now added to the vessel until it reaches a temperature of 500 °K.
   i.) Is the specific volume of $C_2H_4$ constant during this process? Why or why not?
   ii.) What is the final pressure in the vessel?
   iii.) Calculate the reduced pressure, $P_r$, of $C_2H_4$ <u>after</u> being heated.
   iv.) Calculate the reduced temperature, $C_2H_4$ $T_r$, of <u>before</u> being heated.
   v.) Can we assume that $C_2H_4$ behaved like an ideal gas throughout this process? Why or why not?

## Problem #3

a) Consider 2 [kg] of saturated R-134a vapor contained in a piston-cylinder apparatus. The vapor temperature is -52 °C.
   i.) What is the total internal energy, $U$, of the R-134a vapor at this state?
   ii.) What is the pressure of R-134a vapor at this state?
   iii.) What volume is occupied by the R-134a vapor? (*Hint: look up the specific volume*)

b) An external force now pushes down on the piston, compressing the vapor isobarically until it reaches a final volume of 1.0 [m$^3$].
   i.) What is the specific volume of the saturated R-134a mixture now?
   ii.) What is the quality of the saturated R-134a mixture?
   iii.) What is the total internal energy of both phases ($U_f$+$U_g$) in this final state?
   iv.) How much work was **<u>done by</u>** the piston in this process? (Note: $W$=$P$($\forall_2$-$\forall_1$) for constant pressure processes).
   v.) How much heat was **<u>transferred into</u>** the saturated R-134a during this process?