Homework #4

MEMS 0051 - Introduction to Thermodynamics

Assigned: May 28th, 2020
Due: June 4th, 2020

Problem #1

Calculate the change in specific internal energy, u_2-u_1, for the following items. Assume the change occurs at constant pressure.

a) Aluminum at 100 [kPa] cooled from 200 °C to 80 °C;
b) Ammonia at 100 [kPa] cooled from -35 °C to -50 °C;
c) Carbon monoxide at 100 [kPa] heated from -15 °C to 45 °C;
d) R-12 at 100 [kPa] heated from 0 °C to 105 °C;
e) R-134a at 101.3 [kPa] cooled from a quality of 0.6 to a saturated liquid;

Calculate the change in specific enthalpy, h_2-h_1, for the following items. Assume the change occurs at constant pressure.

a) Aluminum at 100 [kPa] cooled from 200 °C to 80 °C;
b) Water at 100 [kPa] heated from 10 °C to 95 °C;
c) Carbon monoxide at 100 [kPa] heated from -15 °C to 45 °C;
d) R-22 at 100 [kPa] cooled from 30 °C to -41.03 °C;
e) Nitrogen (N_2) at 101.3 [kPa] heated from a quality of 0.4 to a saturated vapor;

Problem #2

Consider a piston-cylinder device where the piston is putting pressure on water due to a linear spring, i.e. a spring that follows Hooke's Law, attached to the other side of the piston. The saturated water is at a pressure of 400 [kPa] and a quality of 0.8. Heat is now added such that the spring is further compressed and the height of the piston increases by 0.5 [m]. If the area of the piston is 0.1 [m^2] and the spring constant, k, is 80 [kN/m], determine the following:

a) The height of the piston at state 1;
b) The work done by the system;
c) The heat transferred into the system;

Problem #3

A piston-cylinder device contains Helium (He) at 100 [kPa] and -40 °C. The helium now undergoes isobaric heating until it reaches a temperature of 90 °C. If the change in internal energy is $U_2 - U_1 = 202.54$ [kJ] and the helium can be treated as an ideal gas, determine the following:

a) The work performed;
b) The heat transferred using internal energy, U;
c) The heat transferred using enthalpy, H;

Problem #4

A piston-cylinder device contains air at 100 [kPa] and 25 °C. At this state, the specific enthalpy, h_1, is also known, and is given as 298.62 [kJ/kg]. From this state, the air is first heated at constant volume to a temperature of 400 °C. The air next undergoes a polytropic process where the polytropic index is unknown to a volume of 0.1 [m^3]. The air then undergoes isothermal expansion until its specific enthalpy is $h_4 = 399.02$ [kJ/kg]. The air is now finally cooled at constant pressure until it has returned to its initial state, experiencing a reduction in internal energy of 16.763 [kJ]. Treating the air as an ideal gas, determine the following:

a) The pressure, P, temperature, T, and volume, $\forall$ for each state (*Hint:* there are four states);
b) The unknown polytropic index;