Homework #3

MEMS 0051 - Introduction to Thermodynamics

Assigned January 25th, 2020
Due: January 31st, 2020

Problem #1

A piston-cylinder device contains nitrogen gas initially at 150 [kPa], 20 °C and 0.5 [m^3]. The gas is compressed in a polytropic process to 400 [kPa] and 140 °C. Assume the nitrogen gas satisfies the ideal gas law. For N, R=0.2968 [kJ/kg-K]. Determine:

(a) The work into or out of the system during this process.
(b) The heat loss or gain during this process.

Problem #2

Water contained in a piston-cylinder assembly undergoes two processes in series from an initial state where the pressure is 1.0 [MPa] and the temperature is 400 °C. Process 1-2: The water is cooled as it is compressed at constant pressure to the saturated vapor state at 1.0 [MPa]. Process 2-3: The water is cooled at constant volume to 150 °C.

(a) Sketch both processes on $T - \nu$ and $P - \nu$ diagrams in using the Matlab script previously developed.
(b) For the overall process determine the work, in [kJ/kg].
(c) For the overall process determine the heat transfer, in [kJ/kg].

Problem #3

A piston-cylinder device contains a 1.5 [kg] of water at a pressure of 200 [kPa] and a temperature of 150 °C. It is heated in such a fashion that the pressure is linearly related to the volume, and reaches a final state where the pressure is 600 [kPa] and the temperature is 350 °C.

(a) Find the final volume of the system and the work required for this process.

Problem #4

A piston-cylinder device with a set of stops in the middle initially contains 3 kg of air at 200 [kPa] and 500 K. The air is compressed by lowering the frictionless piston in an isobaric process (n=0). When the piston hits the stops, the gas volume is 50% of the initial volume. Assume air behaves as an ideal gas and R=0.287 [kJ/kg-K].

(a) If the final temperature is 300 K, determine the total work done on the system.

Problem #5

A piston-cylinder device contains 1.5 [kg] of air at a temperature of 300 K and a pressure of 150 [kPa]. It is heated in a two-step process. The first step is a constant volume process where the final temperature is 1,000 K. The second step is a constant pressure process where the final temperature is 1,500 K.

(a) Determine the final volume and work required for this two step process.