

# Homework #3

MEMS 0051 - Introduction to Thermodynamics

Assigned June 5<sup>th</sup>, 2018

Due: June 11<sup>th</sup>, 2018

## Problem #1

A piston-cylinder device contains He gas initially at 150 [kPa], 20 °C and 0.5 [m<sup>3</sup>]. The He gas is compressed in a polytropic process to 400 [kPa] and 140 °C. Assume the He gas satisfies the ideal gas law. For He,  $R=2.0771$  [kJ/kg-K],  $C_P=5.2$  [kJ/kg-K],  $C_V=3.116$  [kJ/kg-K]. Determine:

- The work into or out of the system during this process.
- The heat loss or gain during this process.
- Hint: Determine  $n$ .

## 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.

- Sketch both processes on T-v and P-v diagrams in using the Matlab script previously developed.
- For the overall process determine the work, in [kJ/kg].
- 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.

- 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 ( $R=0.287$  [kJ/kg-K],  $C_P=1.004$  [kJ/kg-K],  $C_V=0.717$  [kJ/kg-K]).

- 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.

- Determine the final volume and work required for this two step process.