

Homework #4

MEMS 0051 - Introduction to Thermodynamics

Assigned February 1st, 2019

Due: February 8th, 2019

Problem #1

- a) You push a lawnmower with a total force of 100 [N] at a constant velocity of 0.5 [m/s] for a total of 35 seconds. The lawnmower has a mass of 20 [kg].
 - i.) How much power (\dot{W}) are you transferring to the lawnmower [W]?
 - ii.) How much work (W) do you transfer to the lawnmower during those 35 seconds [J]?
 - iii.) How much specific work (w) do you transfer to the lawnmower [J/kg]?
- b) Now assume that heat is leaving the lawnmower at a rate of 2 [W] from the engine block throughout the 35 seconds.
 - i.) How much total heat (Q) leaves the lawnmower during those 35 seconds [J]?
 - ii.) How much specific heat (q) leaves the lawnmower during those 35 seconds [kJ/kg]?
- c) Now consider the lawnmower as a thermodynamic system with a control surface drawn all around it. Make sure you use the 1st Law sign conventions for heat and work.
 - i.) Is work positive or negative for the lawnmower system? Explain.
 - ii.) Is heat positive or negative for the lawnmower system? Explain.

Problem #2

- a) A piston cylinder is initially filled with air occupying 0.5 [m³] at a pressure of 50 [kPa]. The piston then compresses the air to a new volume of 0.2 [m³]. The compression process is governed by the polytropic equation: $P_1 \forall_1^n = P_2 \forall_2^n$. Determine how much work is done by the gas for the following polytropic indices:
 - i.) $n = \infty$
 - ii.) $n = 0$
 - iii.) $n = 1$
 - iv.) $n = 1.2$
- b) Now assume that we don't know the polytropic index, but we do know that the final pressure is 235 [kPa]. Solve for the polytropic index, n

Problem #3

- a) Determine the change in internal energy, ($U_2 - U_1$), for each of the following ideal gas cases. (Hint: refer to Table A.5 to look up C_v for each of these gases.)
 - i.) 1 [kg] of Neon gas going from 300 K to 500 K
 - ii.) 2.5 [kg] of R-12 refrigerant going from 500 K to 300 K
 - iii.) 2 [kg] of Acetylene going from 400 K to 300 K

Problem #4

- a) A piston-cylinder device contains nitrogen at 100 [kPa], 25 °C and 0.2 [m³]. The air then undergoes an isobaric, polytropic expansion to a volume of 0.5 [m³].
 - i.) What is the mass of air contained in the piston-cylinder?
 - ii.) What is the final temperature after expansion?
 - iii.) How much work is done by the gas during this expansion?
 - iv.) What is the change in internal energy, ($U_2 - U_1$), during this expansion?
 - v.) How much heat is transferred into the gas during this expansion?

Problem #5

- a) Water contained in a piston-cylinder assembly has an initial temperature of 200 °C, a quality of 50% and an initial volume of 0.05 m³. The pressure of the process is given as $P(v)=100 + Cv^{0.5}$ [kPa], where C is a constant. Heat is transferred to the piston-cylinder until the final pressure reaches 600 kPa.
- i.) Determine the heat input. (Hint, you need to determine C.)