ME 203: Engineering Thermodynamics

Assignment 02[2025] **Submission Date: 25 July 2025**

P-1: A rigid tank contains 1 kg propane at 500 K, 1500 kPa. It is now cooled down to 300 K. Find the heat transfer and the change in entropy using ideal gas.

P-2: One kilogram of water at 500°C and 1 kg saturated water vapor, both at 200 kPa, are mixed in a constant-pressure and adiabatic process. Find the final temperature and the entropy generation for the process.

P-3: A turbine receives steam at 6 MPa, 600°C with an exit pressure of 600 kPa. Assume the turbine is adiabatic and neglect kinetic energies. Find the exit temperature and the specific work.

P-4: The exit nozzle in a jet engine receives air at 1200 K, 150 kPa with negligible kinetic energy. The exit pressure is 80 kPa, and the process is reversible and adiabatic. Use constant specific heat at 300 K to find the exit velocity.

P-5: In a heat pump that uses R-134a as the working fluid, the R-134a enters the compressor at 150 kPa, -10°C and the R-134a is compressed in an adiabatic process to 1 MPa using 4 kW of power input. Find the mass flow rate it can provide, assuming the process is reversible.

P-6: A steam turbine in a power plant receives 5 kg/s steam at 3000 kPa, 500°C. Twenty percent of the flow is extracted at 1000 kPa to a feed-water heater, and the remainder flows out at 200 kPa. Find the two exit temperatures and the turbine power output.

P-7: A small pump takes in water at 20°C, 100 kPa and pumps it to 5 MPa at a flow rate of 50 kg/min. Find the required pump power input.

P-8: A throttle process is an irreversible process. Assume that an air flow at 1000 kPa, 400 K runs through a valve out to ambient 100 kPa. Find the reversible work and irreversibility, assuming an ambient temperature of 25°C.

P-9: Find the stored exergy for water at:

(a) 150°C, 200 kPa

(b) 80°C, 500 kPa

P-10: A steam turbine inlet is at 1200 kPa, 500°C. The actual exit is at 300 kPa, with actual work of 407 kJ/kg. What is its second-law efficiency?

P-11: An air compressor is used to charge an initially empty 200-L tank with air up to 5 MPa. The air inlet to the compressor is at 100 kPa, 17°C and the compressor's isentropic efficiency is 80%. Find the total compressor work and the second law efficiency.

P-12: A steam turbine has inlet at 3 MPa, 500°C and actual exit of 100 kPa, x = 1.0. Find its first-law (isentropic) and its second-law efficiencies.

P-13: Steam at 5 MPa and 600°C enters an insulated turbine operating at steady state and exits as saturated vapour at 50 kPa. Kinetic and potential energy effects are negligible. Determine

(a) the work developed by the turbine per kg of steam flowing.

(b) the isentropic turbine efficiency.

P-14: Air is compressed in an axial-flow compressor operating at steady state from 27°C, 1 bar to a pressure of 2.1 bar. The work input required is 94.6 kJ per kg of air flowing through the compressor. Heat transfer from the compressor occurs at the rate of 14 kJ per kg at a location on the compressor's surface where the temperature is 40°C. Kinetic and potential energy changes can be ignored. Determine

(a) the temperature of the air at the exit.

(b) the rate at which entropy is produced within the compressor.

P-15: Air enters an insulated diffuser operating at steady state at 1 bar, -3°C, and 260 m/s and exits with a velocity of 130 m/s. Employing the ideal gas model and ignoring potential energy, determine

(a) the temperature of the air at the exit.

(b) the maximum attainable exit pressure.

P-16: A large condenser in a steam power plant dumps 15 MW by condensing saturated water vapour at 45°C to saturated liquid. What is the water flow rate and the entropy generation rate with an ambient at 25°C?

P-17: Steam at 0.7 MPa, 355°C enters an open feed-water heater operating at steady state. A separate stream of liquid water enters at 0.7 MPa, 35°C. A single mixed stream exits as saturated liquid at pressure p. Heat transfer with the surroundings and kinetic and potential energy effects can be ignored. Determine the ratio of the mass flow rates of the incoming streams and the rate at which entropy is produced within the feed-water heater, in kJ/K per kg of liquid exiting.

P-18: Water vapour enters an insulated nozzle operating at steady state at 0.7 MPa, 320°C, 35 m/s and expands to 0.15 MPa. If the isentropic nozzle efficiency is 94%, determine the velocity at the exit, in m/s.

P-19: Steam undergoes a throttling process as it passes through a valve operating at steady state. Steam enters the valve at 6 MPa, 360°C and exits at 3 MPa. Determine the exit temperature and the exergy rate destruction per kg of steam flowing through the valve.

P-20: At steady state, an insulated steam turbine develops work at a rate of 786 kJ/kg of steam flowing through the turbine. Steam enters at 5515 kPa and 540°C and exits at 100 kPa. Evaluate the isentropic turbine efficiency and the exergetic turbine efficiency. Ignore the effects of motion and gravity. Let $T_0 = 15°C$, $P_o = 100$ kPa.

P-21: For CO_2, $T_c = 304.13$ K & $P_c = 7.3773$ MPa. Estimate the van der Waals parameters and form the corresponding EOS. Use this EOS, estimate the density of CO_2 at:

- 310 K and 8 MPa,
- 500 K and 10 MPa.

Comment on the results.

P-22: Using Clapeyron Equation and only P-v-T data from steam table, estimate the values of h_{fg} and s_{fg} of water at 100°C, and validate the results using the data reported in the steam table data-book.