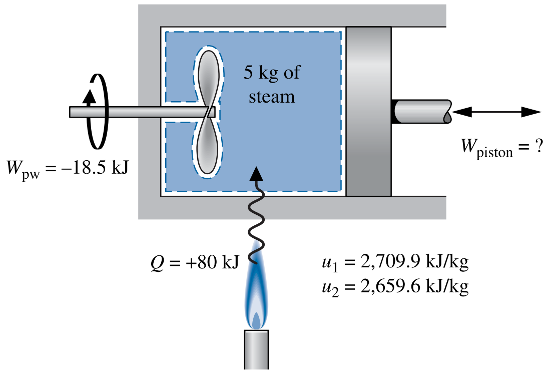
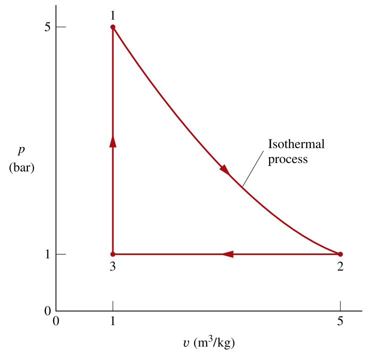
ME 203: Engineering Thermodynamics

Assignment 01[2025] **Submission Date: 20 June 2025**

P-1: Estimate the work transfer to the piston.



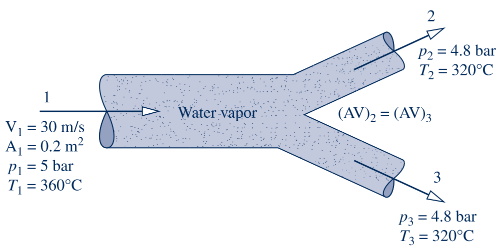
P-2: Air contained in a piston-cylinder assembly undergoes the power cycle. Evaluate the thermal efficiency of the cycle.



P-3: A gas in a piston-cylinder equipment undergoes a polytropic process such that PV^n = constant. The initial pressure is 0.1 MPa, the initial volume is 0.01 m^3, and the final volume is 0.03 m^3. Calculate the work and heat transfer for the process, in kJ, if (a) n = 2.0, (b) n = 0.0, and (c) n = 1.0.

P-4: A vessel having a volume of 5 m^3 contains 0.05 m^3 of saturated liquid water and 4.95 m^3 of saturated water vapour at 0.1 MPa. Heat is transferred until the vessel is filled with saturated vapour. Determine the heat transfer for this process.

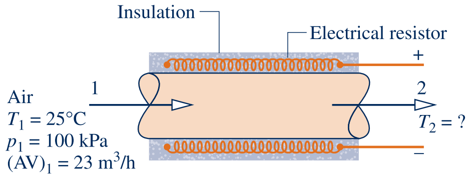
P-5: Determine the mass flow rate at the inlet and exits, each in kg/s.



P-6: A feed-water heater operates at steady state with liquid water entering at inlet 1 at 7 bar, 42°C, and a mass flow rate of 70 kg/s. A separate stream of water enters at inlet 2 as a two-phase liquid-vapour mixture at 7 bar with a quality of 98%. Saturated liquid at 7 bar exits the feed-water heater at 3. Ignoring heat transfer with the surroundings and neglecting kinetic and potential energy effects, determine the mass flow rate, in kg/s, at inlet 2.

P-7: Refrigerant 134a enters a horizontal pipe operating at steady state at 40°C, 300 kPa, and a velocity of 40 m/s. At the exit, the temperature is 50°C and the pressure is 240 kPa. The pipe diameter is 0.04 m. Determine (a) the mass flow rate of the refrigerant, in kg/s, (b) the velocity at the exit, in m/s, and (c) the rate of heat transfer between the pipe and its surroundings, in kW.

P-8: With a voltage of 120 V, the resistor draws a current of 4 amps. Determine (a) the mass flow rate of the air, in kg/h, and (b) the temperature of the air at the exit, in °C.



P-9: At steady state, air at 200 kPa, 52°C, and mass flow rate of 0.5 kg/s enters an insulated duct having differing inlet and exit cross-sectional areas. The inlet cross-sectional area is 2×10^{-3} m^2 . At the duct exit, the pressure of the air is 100 kPa and the velocity is 255 m/s. Determine

(a) the temperature of the air at the exit, in °C.

(b) the velocity of the air at the inlet, in m/s.

(c) the exit cross-sectional area, in m^2.

P-10: Steam enters a nozzle operating at steady state at 30 bar, 320°C, with a velocity of 100 m/s. The exit pressure and temperature are 10 bar and 200°C, respectively. The mass flow rate is 2.0 kg/s. Neglecting heat transfer and potential energy, determine

(a) the exit velocity, in m/s.

(b) the inlet and exit flow areas, in cm^2.

P-11: Air with a mass flow rate of 2 kg/s enters a horizontal nozzle operating at steady state at 445 K, 345 kPa, and velocity of 3 m/s. At the exit, the temperature is 317 K and the velocity is 460 m/s. Determine

(a) the area at the inlet, in m^2.

(b) the heat transfer between the nozzle at its surroundings, in kW.

P-12: Steam enters a turbine operating at steady state at 2 MPa, 360°C with a velocity of 100 m/s. Saturated vapor exits at 0.1 MPa and a velocity of 50 m/s. The elevation of the inlet is 3 m higher than at the exit. The mass flow rate of the steam is 15 kg/s, and the power developed is 7 MW. Determine

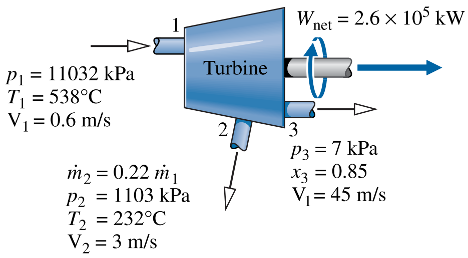
(a) the area at the inlet, in m^2, and

(b) the rate of heat transfer between the turbine and its surroundings, in kW.

P-13: Determine

(a) the mass flow rate of the steam entering the turbine, in kg/h.

(b) the diameter of the extraction duct, in m.



P-14: Air enters a compressor operating at steady state at 1.05 bar, 300 K, with a volumetric flow rate of 12 m^3/min and exits at 12 bar, 400 K. Heat transfer occurs at a rate of 2 kW from the compressor to its surroundings. Assuming the ideal gas model for air and neglecting kinetic and potential energy effects, determine the power input, in kW.

P-15: Refrigerant 134a enters an air conditioner compressor at 3.2 bar, 10°C, and is compressed at steady state to 10 bar, 70°C. The volumetric flow rate of the refrigerant entering is 3.0 m^3/min. The work input to the compressor is 55.2 kJ per kg of refrigerant flowing. Neglecting kinetic and potential energy effects, determine the heat transfer rate, in kW.

P-16: A pump steadily draws water through a pipe from a reservoir at a volumetric flow rate of 1.3 L/s. At the pipe inlet, the pressure is 101.4 kPa, the temperature is 18°C, and the velocity is 3 m/s. At the pump exit, the pressure is 240 kPa, the temperature is 18°C, and the velocity is 12 m/s. The pump exit is located 12 m above the pipe inlet. Ignoring heat transfer, determine the power required by the pump, in kJ/s and kW.

P-17: Air expands through a turbine from 10 bar, 900 K to 1 bar, 500 K. The inlet velocity is small compared to the exit velocity of 100 m/s. The turbine operates at steady state and develops a power output of 3200 kW. Heat transfer between the turbine and its surroundings and potential energy effects are negligible. Calculate the mass flow rate of air, in kg/s, and the exit area, in m^2.

P-18: Refrigerant 134a enters the expansion valve of an air-conditioning unit at 965 kPa, 27°C, and exits at 345 kPa. If the refrigerant undergoes a throttling process, what are the temperature, in °C, and the quality at the exit of the valve?

P-19: A condenser is a heat exchanger designed to condense a vapour into a liquid. Determine the flow rate of cooling water taken from a local river required to condense 12.0 kg/min of water vapour at 1.00 MPa and 500°C into a saturated liquid at 1.00 MPa. The river water can be considered to be an incompressible fluid with an inlet temperature of 15.0°C. The cooling water must be returned to the river and is restricted by environmental code requirements not to exceed 20.0°C.

P-20: A supply line carries a two-phase liquid-vapour mixture of steam at 20 bar. A small fraction of the flow in the line is diverted through a throttling calorimeter and exhausted to the atmosphere at 1 bar. The temperature of the exhaust steam is measured as 120°C. Determine the quality of the steam in the supply line.