Assignment Problems

ME 203: Engineering Thermodynamics

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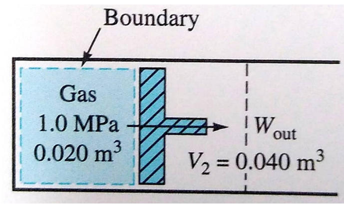
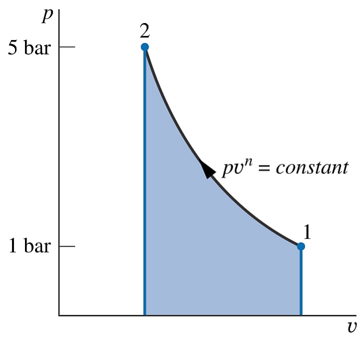
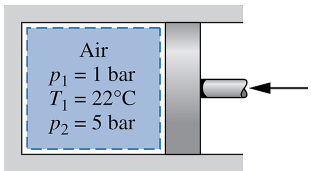
1. A gas contained within a piston-cylinder device is initially at 0.1 MPa and 0.020 m^3. It expands to a final volume of 0.040 m^3 under the consideration that (a) Pressure remains constant, and (b) PV remains constant. Determine the work outputs.



2. Air undergoes a polytropic compression in a piston-cylinder assembly from $P_1 = 1$ bar, $T_1 = 22°C$ to $P_2 = 5$ bars. Employing the ideal gas model with constant specific heat ratio k, determine the work and heat transfer per unit mass, in kJ/kg, if (a) $n = 1.3$, (b) $n = k = 1.4$.

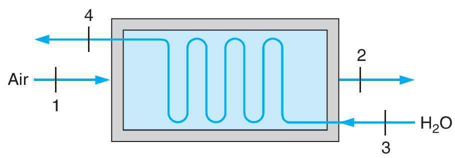




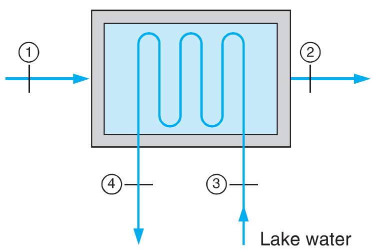
3. A boiler receives a constant flow of 5000 kg/h liquid water at 5 MPa and 20°C, and it heats the flow such that the exit state is 450°C with a pressure of 4.5 MPa. Determine the necessary minimum pipe flow area in both the inlet and exit pipe(s) if there should be no velocities larger than 20 m/s.

4. In a steam generator, compressed liquid water at 10 MPa, 30°C enters a 30-mm-diameter tube at a rate of 3 L/s. Steam at 9 MPa, 400°C exits the tube. Find the rate of heat transfer to the water.

5. A heat exchanger is used to cool an air flow from 800 to 360 K, with both states at 1 MPa. The coolant is a water flow at 15°C, 0.1 MPa. If the water leaves as saturated vapour, find the ratio of the flow rates $\dot{m}_{water}/\dot{m}_{air}$.



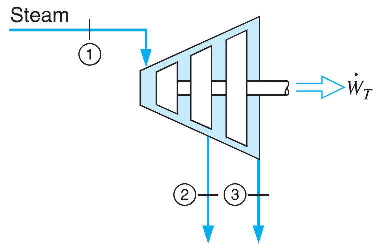
6. A condenser (heat exchanger) brings 1 kg/s water flow at 10 kPa quality 95% to saturated liquid at 10kPa. The cooling is done by lake water at 20°C that returns to the lake at 30°C. For an insulated condenser, find the flow rate of cooling water.



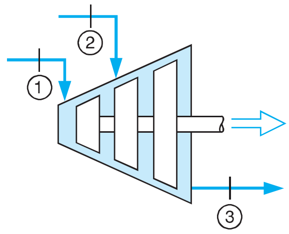
7. Superheated vapour ammonia enters an insulated nozzle at 30°C, 1000 kPa, with a low velocity and at a rate of 0.01 kg/s. The ammonia exits at 300 kPa with a velocity of 450 m/s. Determine the temperature (or quality, if saturated) and the exit area of the nozzle.

8. A diffuser has air entering at 100 kPa and 300 K with a velocity of 200 m/s. The inlet cross-sectional area of the diffuser is 100 mm^2. At the exit the area is 860 mm^2, and the exit velocity is 20 m/s. Determine the exit pressure and temperature of the air.

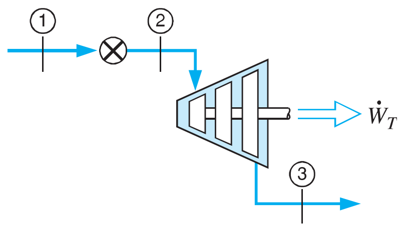
9. A steam turbine in a power plant receives 100 kg/s steam at 15 MPa, 600°C. Twenty percent of the flow is extracted at 2 MPa, 350°C to a feed-water heater, and the rest exists the turbine at 75 kPa, 95% quality. Find the turbine power output.



10. A steam turbine receives steam from two boilers. One flow is 5 kg/s at 3 MPa, 700°C and the other flow is 10 kg/s at 800 kPa, 500°C. The exit state is 10 kPa, with a quality of 96%. Find the total power out of the adiabatic turbine.



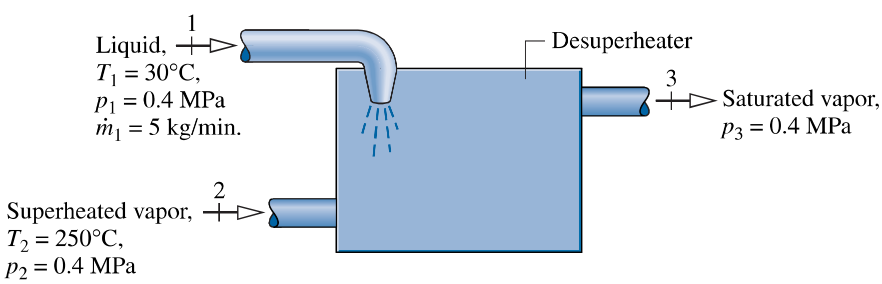
11. A small turbine, is operated at part load by throttling a 0.25-kg/s steam supply at 1.4 MPa and 250°C down to 1.1 MPa before it enters the turbine, and the exhaust is at 10 kPa. If the turbine produces 110 kW, find the exhaust temperature (and quality if saturated).



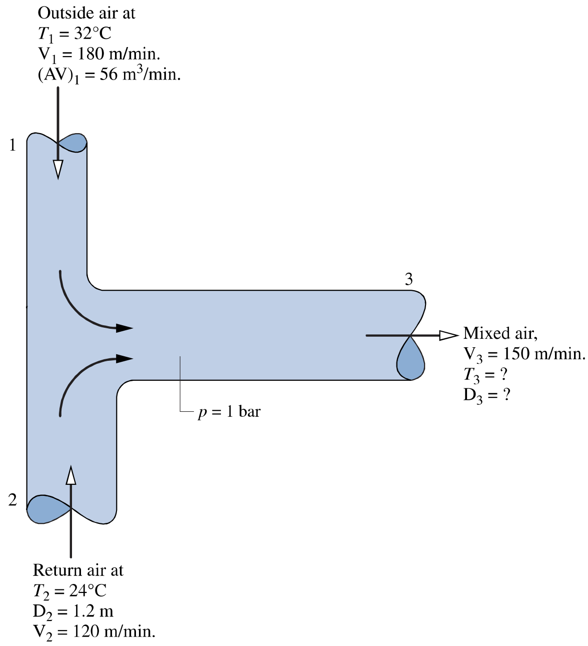
12. A small water pump is used in an irrigation system. The pump takes water in from a river at 10°C, 100 kPa at a rate of 5 kg/s. The exit line enters a pipe that goes up to an elevation 20 m above the pump and river, where the water runs into an open channel. Assume that the process is adiabatic and that the water stays at 10°C. Find the required pump work.

13. The compressor of a large gas turbine receives air from the ambient surroundings at 95 kPa,20°C with low velocity. At the compressor discharge, air exits at 1.52 MPa, 430°C with a velocity of 90 m/s. The power input to the compressor is 5000 kW. Determine the mass flow rate of air through the unit.

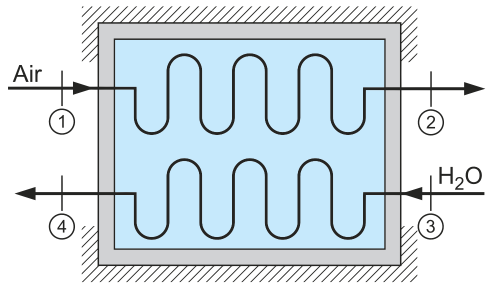
14. For the desuperheater, liquid water at state 1 is injected into a stream of superheated vapour entering at state 2. As a result, saturated vapour exits at state 3. Ignoring stray heat transfer and kinetic and potential energy effects, determine the mass flow rate of the incoming superheated vapour, in kg/min.



15. Steady-state data for the ducting ahead of the chiller coils in an air-conditioning system is given. Outside air at 32°C is mixed with return air at 24°C. Stray heat transfer is negligible, kinetic and potential energy effects can be ignored, and the pressure throughout is 1 bar. Modelling the air as an ideal gas, determine (a) the mixed-air temperature, in °C, and (b) the diameter of the mixed-air duct, in m.

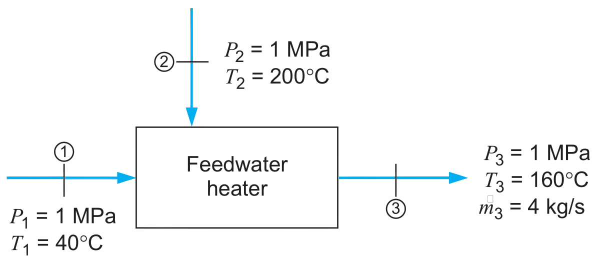


16. A counterflowing heat exchanger has one line with 2 kg/s air at 125 kPa, 1000 K entering, and the air is leaving at 100 kPa, 400 K. The other line has 0.5 kg/s water coming in at 200 kPa, 20°Cand leaving at 200 kPa. What is the exit temperature of the water and the total rate of entropy generation?



17. Two flowstreams of water, one of saturated vapor at 0.6 MPa and the other at 0.6 MPa, and 600°C, mix adiabatically in a steady flow to produce a single flow out at 0.6 MPa, 400°C. Find the total entropy generation for this process.

18. One type of feedwater heater for preheating the water before entering a boiler operates on the principle of mixing the water with steam that has been bled from the turbine. For the states as shown in Fig. , calculate the rate of net entropy increase for the process, assuming the process to be steady flow and adiabatic.



19. Saturated R-134a at -10°Cis pumped/compressed to a pressure of 1.0 MPa at the rate of 0.5 kg/s in a reversible adiabatic process. Calculate the power required and the exit temperature for the two cases of inlet state of the R-134a: a. Quality of 100%, b. Quality of 0%.

20. Air enters an insulated compressor at ambient conditions, 100 kPa and 20°C, at the rate of 0.1 kg/s and exits at 200°C. The isentropic efficiency of the compressor is 70%. Assume that the ideal and actual compressor have the same exit pressure. What is the exit pressure? How much power is required to drive the unit?