MS PROBLEMS

1.4 An object has a mass of 10 lb. Determine its weight, in lbf, at a location where the acceleration of gravity is 31.0 ft/s^2.

1.11 When an object of mass 5 kg is suspended from a spring, the spring is observed to stretch by 8 cm. The deflection of the spring is related linearly to the weight of the suspended mass. What is the proportionality constant, in newtons per cm, if $g = 9.81\ m/s^2$?

2.20 The drag force, F_d, imposed by the surrounding air on a vehicle moving with velocity V is given by

$$F_d = C_d A \tfrac{1}{2} \rho V^2$$

where C_d is a constant called the drag coefficient, A is the projected frontal area of the vehicle, and ρ is the air density. Determine the power, in kW, required to overcome aerodynamic drag for a truck moving at 110 km/h, if $C_d = 0.65$, $A = 10\ m^2$, and $\rho = 1.1\ kg/m^3$.

2.31 Warm air is contained in a piston–cylinder assembly oriented horizontally as shown in Fig. P2.31. The air cools slowly from an initial volume of 0.003 m^3 to a final volume of 0.002 m^3. During the process, the spring exerts a force that varies linearly from an initial value of 900 N to a final value of zero. The atmospheric pressure is 100 kPa, and the area of the piston face is 0.018 m^2. Friction between the piston and the cylinder wall can be neglected. For the air, determine the initial and final pressures, in kPa, and the work, in kJ.

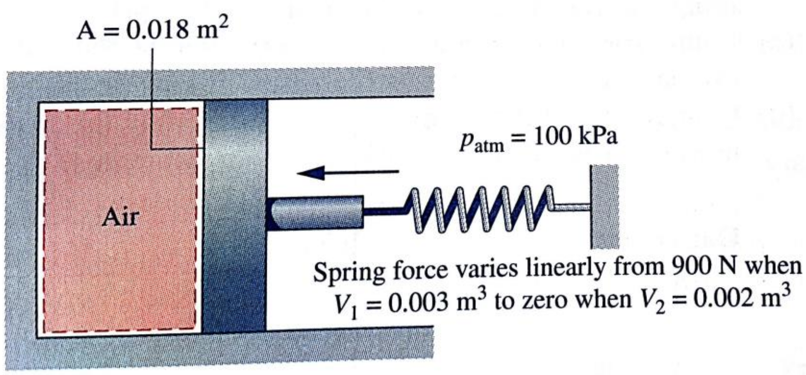


Fig. P2.31

2.56 As shown in Fig. P2.56, 5 kg of steam contained within a piston–cylinder assembly undergoes an expansion from state 1, where the specific internal energy is $u_1 = 2709.9$ kJ/kg, to state 2, where $u_2 = 2659.6$ kJ/kg. During the process, there is heat transfer *to* the steam with a magnitude of 80 kJ. Also, a paddle wheel transfers energy *to* the steam by work in the amount of 18.5 kJ. There is no significant change in the kinetic or potential energy of the steam. Determine the energy transfer by work from the steam to the piston during the process, in kJ.

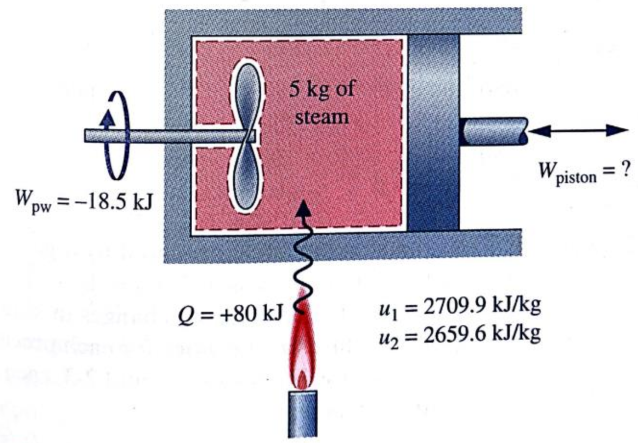


Fig. P2.56

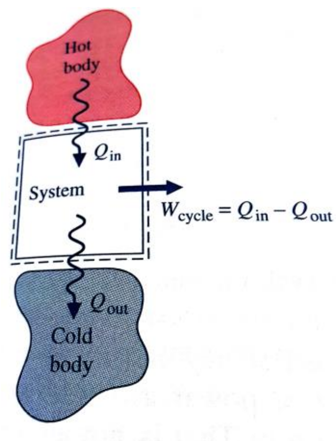
2.58 An electric generator coupled to a windmill produces an average electric power output of 15 kW. The power is used to charge a storage battery. Heat transfer from the battery to the surroundings occurs at a constant rate of 1.8 kW. For 8 h of operation, determine the total amount of energy stored in the battery, in kJ.

2.62 An electric generator supplies electricity to a storage battery at a rate of 15 kW for a period of 12 hours. During this 12-h period there also is heat transfer from the battery to the surroundings at a rate of 1.5 kW. Then, during the next 12-hour period the battery discharges electricity to an external load at a rate of 5 kW while heat transfer from the battery to the surroundings occurs at a rate of 0.5 kW.

(a) For the first 12-h period, determine, in kW, the time rate of change of energy stored within the battery.
(b) For the second 12-h period, determine, in kW, the time rate of change of energy stored in the battery.
(c) For the *full* 24-h period, determine, in kJ, the *overall* change in energy stored in the battery.

2.68 Air is contained in a vertical piston–cylinder assembly by a piston of mass 50 kg and having a face area of 0.01 m^2. The mass of the air is 5 g, and initially the air occupies a volume of 5 liters. The atmosphere exerts a pressure of 100 kPa on the top of the piston. The volume of the air slowly decreases to 0.002 m^3 as the specific internal energy of the air decreases by 260 kJ/kg. Neglecting friction between the piston and the cylinder wall, determine the heat transfer to the air, in kJ.

2.78 For a power cycle operating as in Fig. 2.17*a*, the heat transfers are Q_{in} = 50 kJ and Q_{out} = 35 kJ. Determine the net work, in kJ, and the thermal efficiency.



(a)

2.89 A household refrigerator operating steadily and with a coefficient of performance of 2.4 removes energy from a refrigerated space at a rate of 600 Btu/h. Evaluating electricity at $0.08 per kW · h, determine the cost of electricity in a month when the refrigerator operates for 360 hours.

3.22 A closed system consists of a two-phase liquid–vapor mixture of H_2O in equilibrium at 300°F. The quality of the mixture is 0.8 (80%) and the mass of saturated vapor present is 2 lb. Determine the mass of saturated liquid present, in lb, and the total volume of the system, in ft^3.

3.34 Ammonia in a piston-cylinder assembly undergoes a constant-pressure process at 2.5 bar from T_1 = 30°C to saturated vapor. Determine the work for the process, in kJ per kg of refrigerant.

3.45 Evaluate the specific volume, in ft^3/lb, and the specific enthalpy, in Btu/lb, of water at 400°F and a pressure of 3000 $lbf/in.^2$

3.70 A two-phase, liquid–vapor mixture of H_2O, initially at $x = 30\%$ and a pressure of 100 kPa, is contained in a piston-cylinder assembly, as shown in Fig P3.70. The mass of the piston is 10 kg, and its diameter is 15 cm. The pressure of the surroundings is 100 kPa. As the water is heated, the pressure inside the cylinder remains constant until the piston hits the stops. Heat transfer to the water continues at constant volume until the pressure is 150 kPa. Friction between the piston and the cylinder wall and kinetic and potential energy effects are negligible. For the overall process of the water, determine the work and heat transfer, each in kJ.

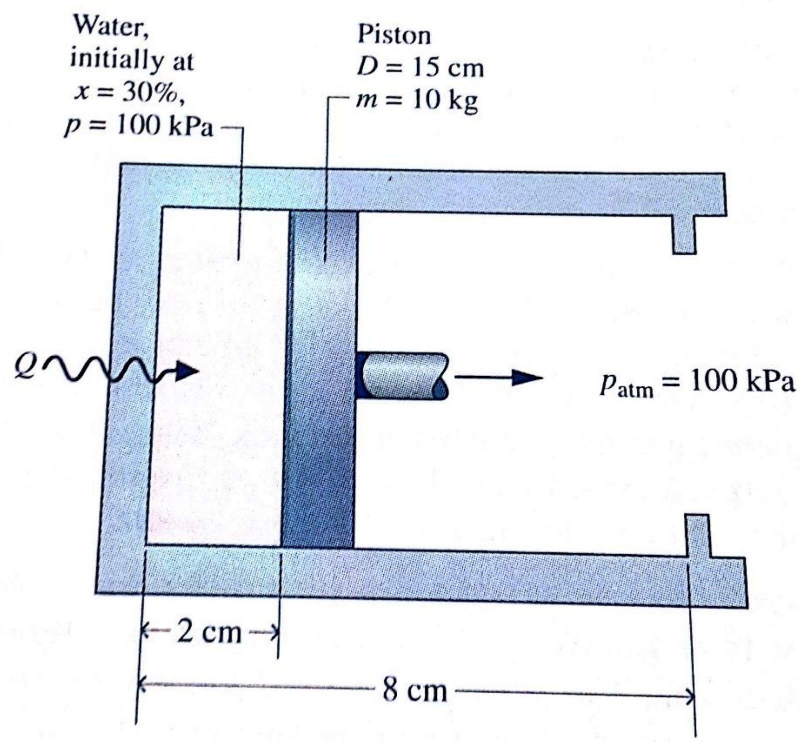
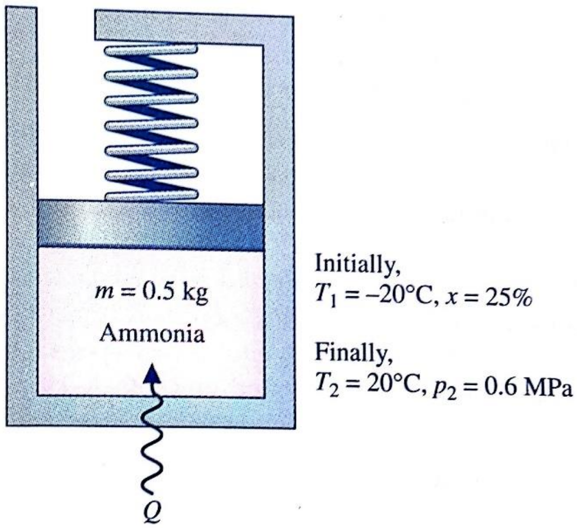


Fig. P3.70

3.84 As shown in Fig. P3.84, 0.5 kg of ammonia is contained in a piston-cylinder assembly, initially at $T_1 = -20°C$ and a quality of 25%. As the ammonia is slowly heated to a final state, where $T_2 = 20°C$, $p_2 = 0.6$ MPa, its pressure varies linearly with specific volume. There are no significant kinetic and potential energy effects. For the ammonia, (a) show the process on a sketch of the p–v diagram and (b) evaluate the work and heat transfer, each in kJ.



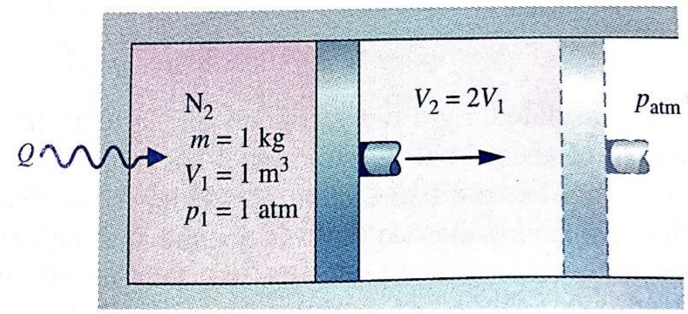
Using Generalized Compressibility Data

3.91 Determine the compressibility factor for water vapor at 200 bar and 470°C, using

(a) data from the compressibility chart.
(b) data from the steam tables.

3.107 Assuming the ideal gas model, determine the volume, in ft^3, occupied by 1 lbmol of argon (Ar) gas at 100 $lbf/in.^2$ and 550°R.

3.115 One kilogram of nitrogen fills the cylinder of a piston-cylinder assembly, as shown in Fig. P3.115. There is no friction between the piston and the cylinder walls, and the surroundings are at 1 atm. The initial volume and pressure in the cylinder are 1 m^3 and 1 atm, respectively. Heat transfer to the nitrogen occurs until the volume is doubled. Determine the heat transfer for the process, in kJ, assuming the specific heat ratio is constant, $k = 1.4$.



4.6 Figure P4.6 shows a mixing tank initially containing 3000 lb of liquid water. The tank is fitted with two inlet pipes, one delivering hot water at a mass flow rate of 0.8 lb/s and the other delivering cold water at a mass flow rate of 1.3 lb/s. Water exits through a single exit pipe at a mass flow rate of 2.6 lb/s. Determine the amount of water, in lb, in the tank after one hour.

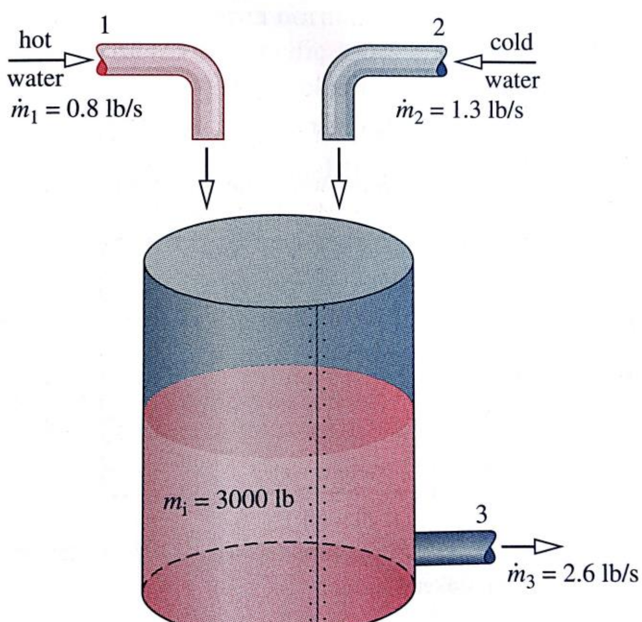


Fig. P4.6

4.9 Air enters a one-inlet, one-exit control volume at 8 bar, 600 K, and 40 m/s through a flow area of 20 cm^2. At the exit, the pressure is 2 bar, the temperature is 400 K, and the velocity is 350 m/s. The air behaves as an ideal gas. For steady-state operation, determine

(a) the mass flow rate, in kg/s.
(b) the exit flow area, in cm^2.

4.22 Figure P4.22 shows a cylindrical tank being drained through a duct whose cross-sectional area is 3×10^{-4} m^2. The velocity of the water at the exit varies according to $(2gz)^{1/2}$, where z is the water level, in m, and g is the acceleration of gravity, 9.81 m/s^2. The tank initially contains 2500 kg of liquid water. Taking the density of the water as 10^3 kg/m^3, determine the time, in minutes, when the tank contains 900 kg of water.

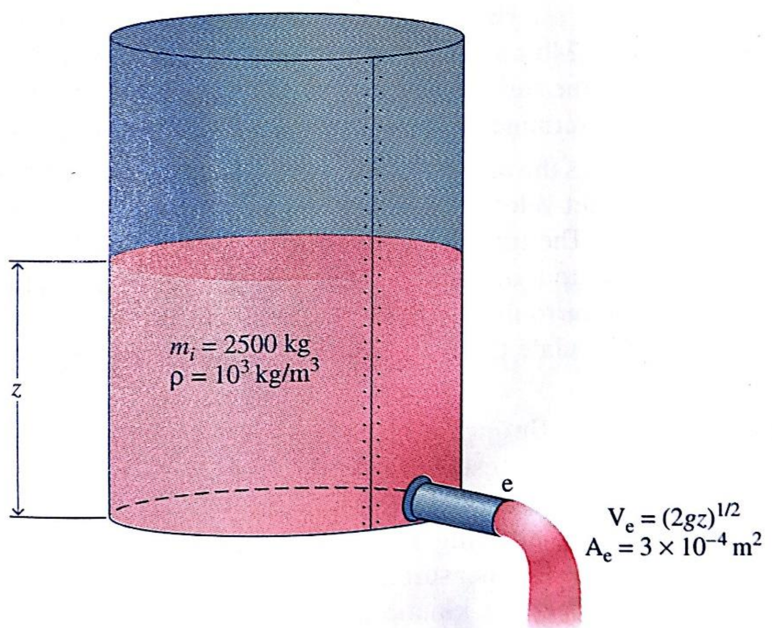


Fig. P4.22

4.45 Steam enters a turbine operating at steady state at 800°F and 500 lbf/in.^{2} and leaves at 0.8 lbf/in.^{2} with a quality of 93%. The turbine develops 15,000 hp, and heat transfer from the turbine to the surroundings occurs at a rate of 2.5×10^6 Btu/h. Neglecting kinetic and potential energy changes from inlet to exit, determine the volumetric flow rate of the steam at the inlet, in ft^3/h.

4.59 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 refrigerant entering is 3.0 m^3/min. The power *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.

4.89 Ammonia enters the expansion valve of a refrigeration system at a pressure of 1.4 MPa and a temperature of 32°C and exits at 0.08 MPa. If the refrigerant undergoes a throttling process, what is the quality of the refrigerant exiting the expansion valve?

4.102 A simple steam power plant operates at steady state with water circulating through the components with a mass flow rate of 60 kg/s. Figure P4.102 shows additional data at key points in the cycle. Stray heat transfer and kinetic and potential effects are negligible. Determine (a) the thermal efficiency and (b) the mass flow rate of cooling water through the condenser, in kg/s.

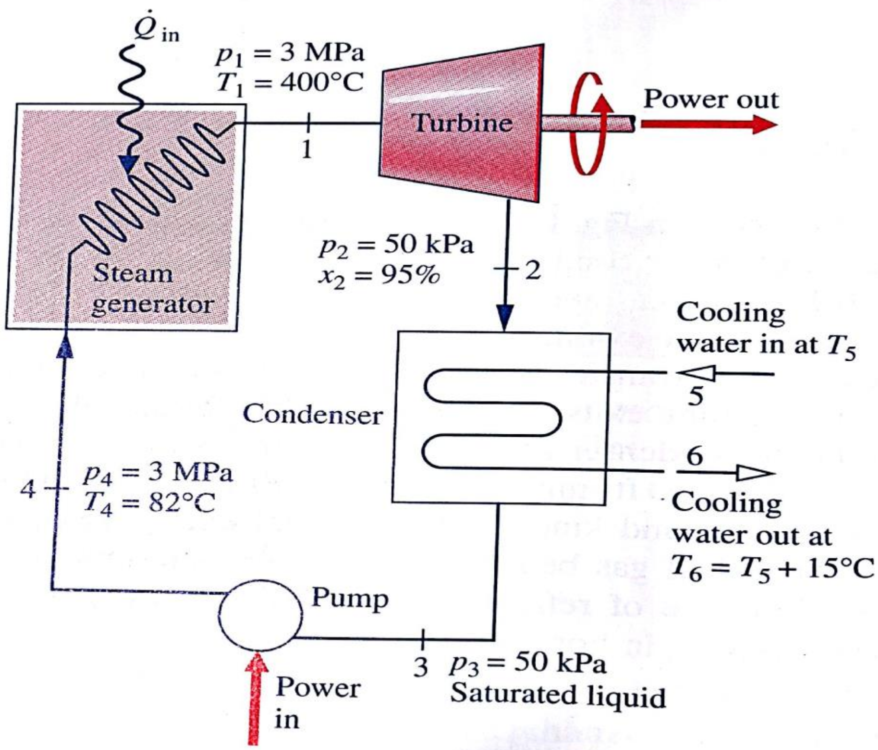


Fig. P4.102

4.107 A rigid tank of volume 0.75 m^3 is initially evacuated. A hole develops in the wall, and air from the surroundings at 1 bar, 25°C flows in until the pressure in the tank reaches 1 bar. Heat transfer between the contents of the tank and the surroundings is negligible. Determine the final temperature in the tank, in °C.

4.113 A two-phase liquid–vapor mixture of Refrigerant 134a is contained in a 2-ft^3, cylindrical storage tank at 100 lbf/in.^{2} Initially, saturated liquid occupies 1.6 ft^3. The valve at the top of the tank develops a leak, allowing saturated vapor to escape slowly. Eventually, the volume of the liquid drops to 0.8 ft^3. If the pressure in the tank remains constant, determine the mass of refrigerant that has escaped, in lb, and the heat transfer, in Btu.

4.117 A 1 m^3 tank initially contains air at 300 kPa, 300 K. Air slowly escapes from the tank until the pressure drops to 100 kPa. The air that remains in the tank undergoes a process described by $pv^{1.2} = constant$. For a control volume enclosing the tank, determine the heat transfer, in kJ. Assume ideal gas behavior with constant specific heats.

4.118 A well-insulated tank contains 25 kg of Refrigerant 134a, initially at 300 kPa with a quality of 0.8 (80%). The pressure is maintained by nitrogen gas acting against a flexible bladder, as shown in Fig. P4.118. The valve is opened between the tank and a supply line carrying Refrigerant 134a at 1.0 MPa, 120°C. The pressure regulator allows the pressure in the tank to remain at 300 kPa as the bladder expands. The valve between the line and the tank is closed at the instant when all the liquid has vaporized. Determine the amount of refrigerant admitted to the tank, in kg.

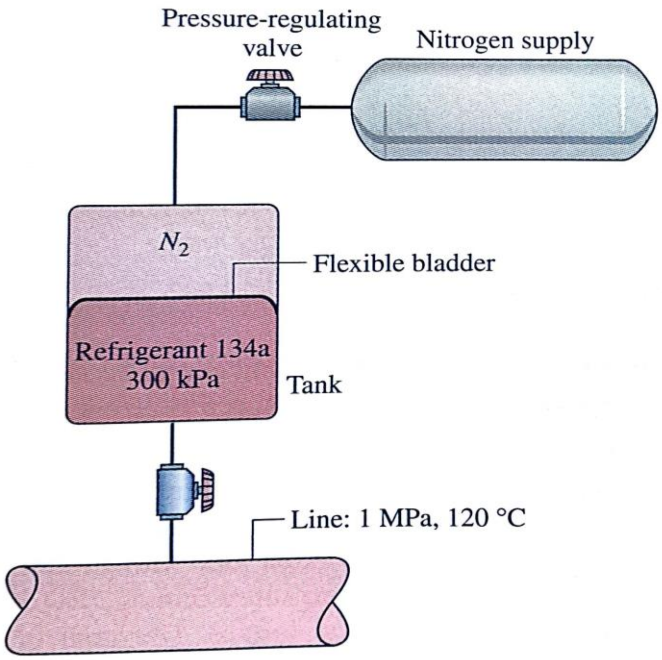


Fig. P4.118