

ME 3320: Thermodynamics II Handout #1

Homework #1: Problems 3-31, 3-33E, 3-77, 3-84, 4-9, 4-29E, 4-63, 5-10, 5-16, 5-51, 5-122, 7-118E, 7-126, 7-130

3-28E Complete this table for H₂O:

$T, ^\circ\text{F}$	P, psia	$u, \text{Btu/lbm}$	Phase description
300		782	
	40		Saturated liquid
500	120		
400	400		

3-30 Complete this table for H₂O:

$T, ^\circ\text{C}$	P, kPa	$h, \text{kJ/kg}$	x	Phase description
	200		0.7	
140		1800		
	950		0.0	
80	500			
	800	3162.2		

3-31 Complete this table for refrigerant-134a:

$T, ^\circ\text{C}$	P, kPa	$\nu, \text{m}^3/\text{kg}$	Phase description
-8	320		
30		0.015	
	180		Saturated vapor
80	600		

3-33E Complete this table for refrigerant-134a:

$T, ^\circ\text{F}$	P, psia	$h, \text{Btu/lbm}$	x	Phase description
	80	78		
15			0.6	
10	70			
	180	129.46		
110			1.0	

3-75 The pressure in an automobile tire depends on the temperature of the air in the tire. When the air temperature is 25°C , the pressure gage reads 210 kPa. If the volume of the tire is 0.025 m^3 , determine the pressure rise in the tire when the air temperature in the tire rises to 50°C . Also, determine the amount of air that must be bled off to restore pressure to its original value at this temperature. Assume the atmospheric pressure is 100 kPa.

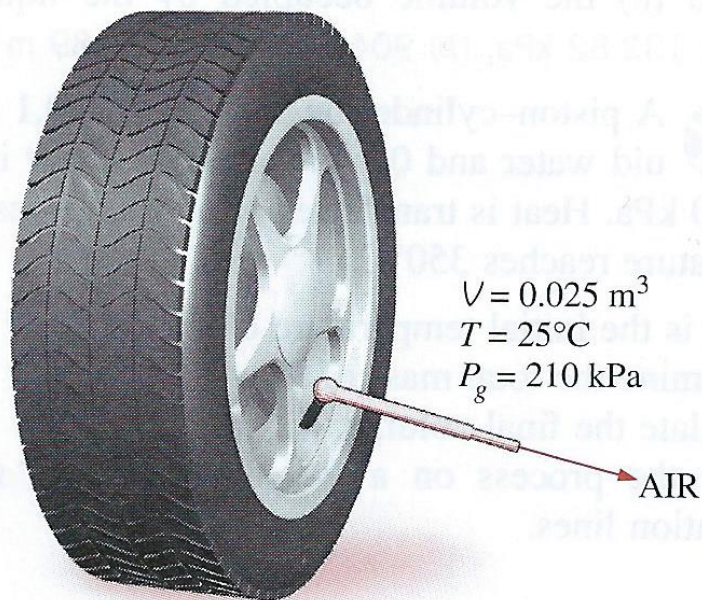


FIGURE P3-75

3-76E The air in an automobile tire with a volume of 0.53 ft^3 is at 90°F and 20 psig . Determine the amount of air that must be added to raise the pressure to the recommended value of 30 psig . Assume the atmospheric pressure to be 14.6 psia and the temperature and the volume to remain constant.

Answer: 0.0260 lbm

3-77 The pressure gage on a 2.5-m^3 oxygen tank reads 500 kPa . Determine the amount of oxygen in the tank if the temperature is 28°C and the atmospheric pressure is 97 kPa .

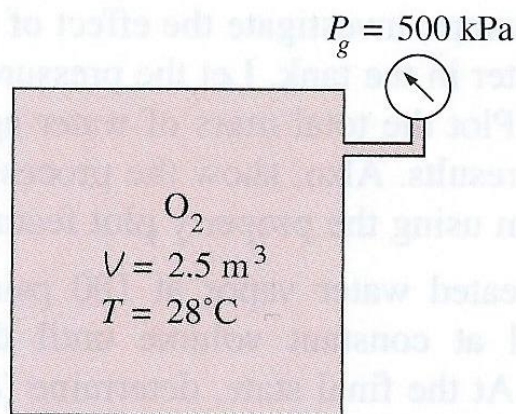


FIGURE P3-77

3-84 Determine the specific volume of superheated water vapor at 10 MPa and 400°C , using (a) the ideal-gas equation, (b) the generalized compressibility chart, and (c) the steam tables. Also determine the error involved in the first two cases.

Answers: (a) $0.03106 \text{ m}^3/\text{kg}$, 17.6 percent ; (b) $0.02609 \text{ m}^3/\text{kg}$, 1.2 percent ; (c) $0.02644 \text{ m}^3/\text{kg}$

3-86 Determine the specific volume of refrigerant-134a vapor at 0.9 MPa and 70°C based on (a) the ideal-gas equation, (b) the generalized compressibility chart, and (c) data from tables. Also, determine the error involved in the first two cases.

3-87 Determine the specific volume of nitrogen gas at 10 MPa and 150 K based on (a) the ideal-gas equation and (b) the generalized compressibility chart. Compare these results with the experimental value of $0.002388 \text{ m}^3/\text{kg}$, and determine the error involved in each case. *Answers: (a) $0.004452 \text{ m}^3/\text{kg}$, 86.4 percent; (b) $0.002404 \text{ m}^3/\text{kg}$, 0.7 percent*

4-8 A mass of 5 kg of saturated water vapor at 300 kPa is heated at constant pressure until the temperature reaches 200°C . Calculate the work done by the steam during this process. *Answer: 165.9 kJ*

4-9 A frictionless piston-cylinder device initially contains 200 L of saturated liquid refrigerant-134a. The piston is free to move, and its mass is such that it maintains a pressure of 900 kPa on the refrigerant. The refrigerant is now heated until its temperature rises to 70°C . Calculate the work done during this process. *Answer: 5571 kJ*

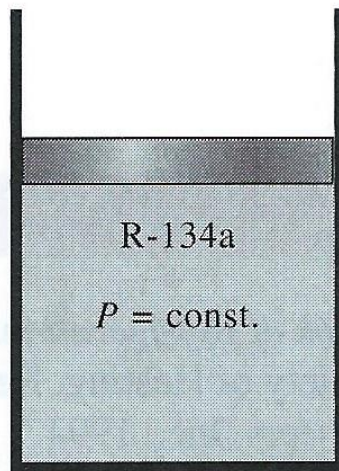


FIGURE P4-9

4-11E A frictionless piston-cylinder device contains 16 lbm of superheated water vapor at 40 psia and 600°F . Steam is now cooled at constant pressure until 70 percent of it, by mass, condenses. Determine the work done during this process.

4–28 A 0.5-m³ rigid tank contains refrigerant-134a initially at 160 kPa and 40 percent quality. Heat is now transferred to the refrigerant until the pressure reaches 700 kPa. Determine (a) the mass of the refrigerant in the tank and (b) the amount of heat transferred. Also, show the process on a P - v diagram with respect to saturation lines.

4–29E A 20-ft³ rigid tank initially contains saturated refrigerant-134a vapor at 160 psia. As a result of heat transfer from the refrigerant, the pressure drops to 50 psia. Show the process on a P - v diagram with respect to saturation lines, and determine (a) the final temperature, (b) the amount of refrigerant that has condensed, and (c) the heat transfer.

4–62 A piston–cylinder device whose piston is resting on top of a set of stops initially contains 0.5 kg of helium gas at 100 kPa and 25°C. The mass of the piston is such that 500 kPa of pressure is required to raise it. How much heat must be transferred to the helium before the piston starts rising?
Answer: 1857 kJ

4–63 An insulated piston–cylinder device contains 100 L of air at 400 kPa and 25°C. A paddle wheel within the cylinder is rotated until 15 kJ of work is done on the air while the pressure is held constant. Determine the final temperature of the air. Neglect the energy stored in the paddle wheel.

4–65 A mass of 15 kg of air in a piston–cylinder device is heated from 25 to 77°C by passing current through a resistance heater inside the cylinder. The pressure inside the cylinder is held constant at 300 kPa during the process, and a heat loss of 60 kJ occurs. Determine the electric energy supplied, in kWh.

Answer: 0.235 kWh

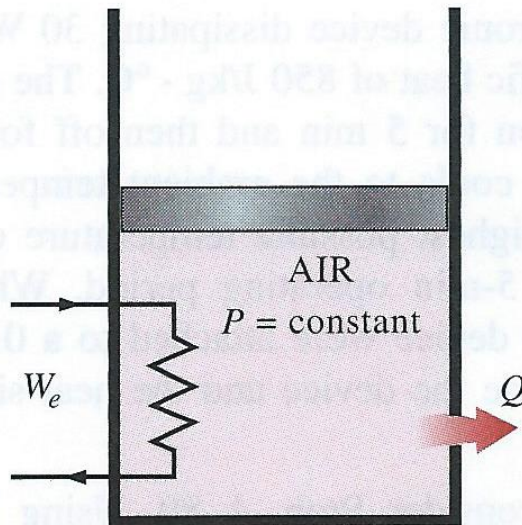


FIGURE P4–65

5–10 A 1-m³ rigid tank initially contains air whose density is 1.18 kg/m³. The tank is connected to a high-pressure supply line through a valve. The valve is opened, and air is allowed to enter the tank until the density in the tank rises to 7.20 kg/m³. Determine the mass of air that has entered the tank.

Answer: 6.02 kg

5–11 The ventilating fan of the bathroom of a building has a volume flow rate of 30 L/s and runs continuously. If the density of air inside is 1.20 kg/m³, determine the mass of air vented out in one day.

5–15 Air enters a 28-cm diameter pipe steadily at 200 kPa and 20°C with a velocity of 5 m/s. Air is heated as it flows, and leaves the pipe at 180 kPa and 40°C. Determine (a) the volume flow rate of air at the inlet, (b) the mass flow rate of air, and (c) the velocity and volume flow rate at the exit.

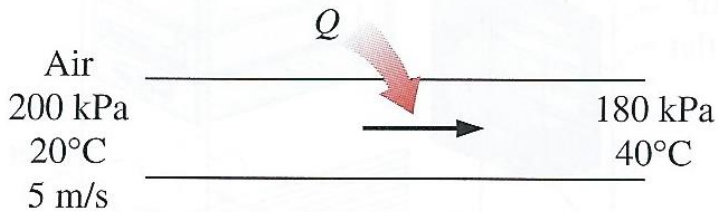


FIGURE P5–15

5–16 Refrigerant-134a enters a 28-cm diameter pipe steadily at 200 kPa and 20°C with a velocity of 5 m/s. The refrigerant gains heat as it flows and leaves the pipe at 180 kPa and 40°C. Determine (a) the volume flow rate of the refrigerant at the inlet, (b) the mass flow rate of the refrigerant, and (c) the velocity and volume flow rate at the exit.

5-17 Consider a 300-L storage tank of a solar water heating system initially filled with warm water at 45°C . Warm water is withdrawn from the tank through a 2-cm diameter hose at an average velocity of 0.5 m/s while cold water enters the tank at 20°C at a rate of 5 L/min. Determine the amount of water in the tank after a 20-minute period. Assume the pressure in the tank remains constant at 1 atm.
Answer: 212 kg

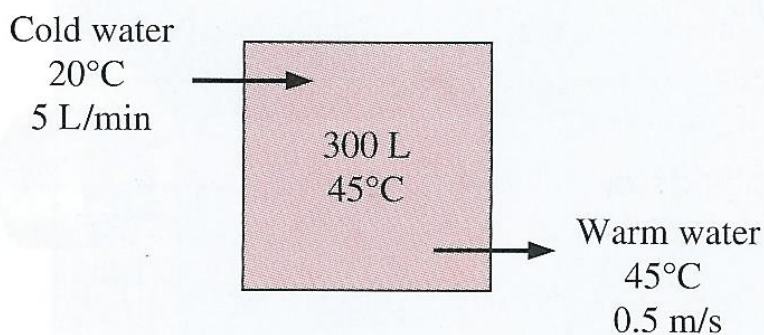


FIGURE P5-17

5-49 Steam flows steadily through an adiabatic turbine. The inlet conditions of the steam are 10 MPa, 450°C , and 80 m/s, and the exit conditions are 10 kPa, 92 percent quality, and 50 m/s. The mass flow rate of the steam is 12 kg/s. Determine (a) the change in kinetic energy, (b) the power output, and (c) the turbine inlet area. *Answers:* (a) -1.95 kJ/kg, (b) 10.2 MW, (c) 0.00447 m²

5-51 Steam enters an adiabatic turbine at 10 MPa and 500°C and leaves at 10 kPa with a quality of 90 percent. Neglecting the changes in kinetic and potential energies, determine the mass flow rate required for a power output of 5 MW. *Answer:* 4.852 kg/s

5-56 Refrigerant-134a enters an adiabatic compressor as saturated vapor at -24°C and leaves at 0.8 MPa and 60°C . The mass flow rate of the refrigerant is 1.2 kg/s. Determine (a) the power input to the compressor and (b) the volume flow rate of the refrigerant at the compressor inlet.

5-57 Air enters the compressor of a gas-turbine plant at ambient conditions of 100 kPa and 25°C with a low velocity and exits at 1 MPa and 347°C with a velocity of 90 m/s. The compressor is cooled at a rate of 1500 kJ/min, and the power input to the compressor is 250 kW. Determine the mass flow rate of air through the compressor.

5-122 A rigid, insulated tank that is initially evacuated is connected through a valve to a supply line that carries steam at 4 MPa. Now the valve is opened, and steam is allowed to flow into the tank until the pressure reaches 4 MPa, at which point the valve is closed. If the final temperature of the steam in the tank is 550°C , determine the temperature of the steam in the supply line and the flow work per unit mass of the steam.

5-127 A 2-m³ rigid tank initially contains air at 100 kPa and 22°C. The tank is connected to a supply line through a valve. Air is flowing in the supply line at 600 kPa and 22°C. The valve is opened, and air is allowed to enter the tank until the pressure in the tank reaches the line pressure, at which point the valve is closed. A thermometer placed in the tank indicates that the air temperature at the final state is 77°C. Determine (a) the mass of air that has entered the tank and (b) the amount of heat transfer. *Answers: (a) 9.58 kg, (b) $Q_{\text{out}} = 339$ kJ*

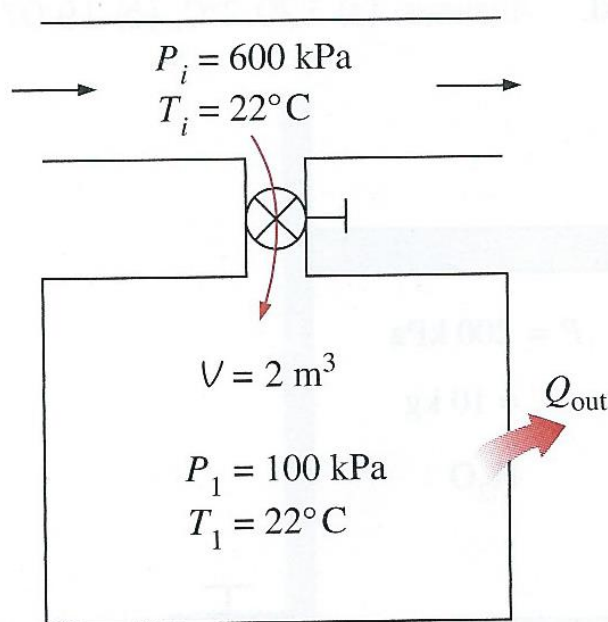


FIGURE P5-127

7-117 Steam enters an adiabatic turbine at 5 MPa, 650°C, and 80 m/s and leaves at 50 kPa, 150°C, and 140 m/s. If the power output of the turbine is 8 MW, determine (a) the mass flow rate of the steam flowing through the turbine and (b) the isentropic efficiency of the turbine. *Answers: (a) 8.03 kg/s, (b) 82.8 percent*

7-118E Combustion gases enter an adiabatic gas turbine at 1540°F and 120 psia and leave at 60 psia with a low velocity. Treating the combustion gases as air and assuming an isentropic efficiency of 82 percent, determine the work output of the turbine. *Answer: 71.7 Btu/lbm*

7-123 A refrigeration unit compresses saturated R-134a vapor at 10°C to 1000 kPa . How much power is required to compress 0.9 kg/s of R-134a with a compressor efficiency of 85 percent? *Answer: 19.3 kW*

7-126 Air is compressed by an adiabatic compressor from 95 kPa and 27°C to 600 kPa and 277°C . Assuming variable specific heats and neglecting the changes in kinetic and potential energies, determine (a) the isentropic efficiency of the compressor and (b) the exit temperature of air if the process were reversible. *Answers: (a) 81.9 percent, (b) 506 K*

7-128E Air enters an adiabatic nozzle at 45 psia and 940°F with low velocity and exits at 650 ft/s . If the isentropic efficiency of the nozzle is 85 percent, determine the exit temperature and pressure of the air.

7-130 The exhaust nozzle of a jet engine expands air at 300 kPa and 180°C adiabatically to 100 kPa . Determine the air velocity at the exit when the inlet velocity is low and the nozzle isentropic efficiency is 96 percent.