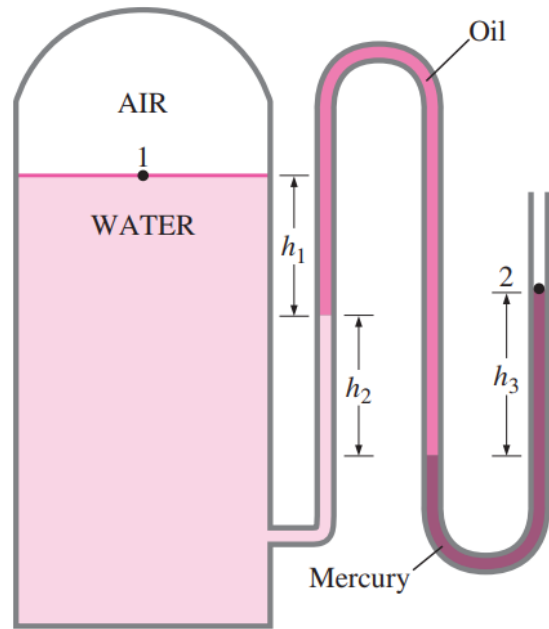
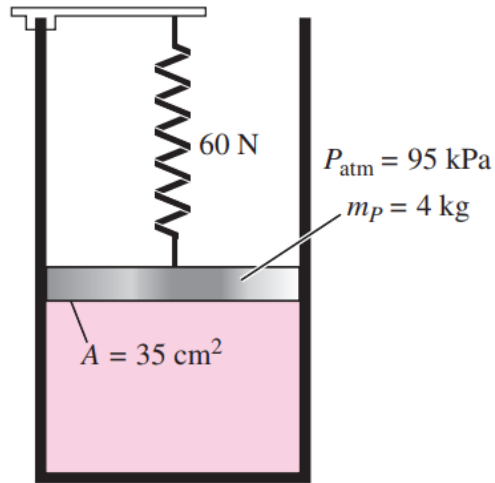


SEM0233 TERMODINÂMICA E APLICAÇÕES DE ENGENHARIA

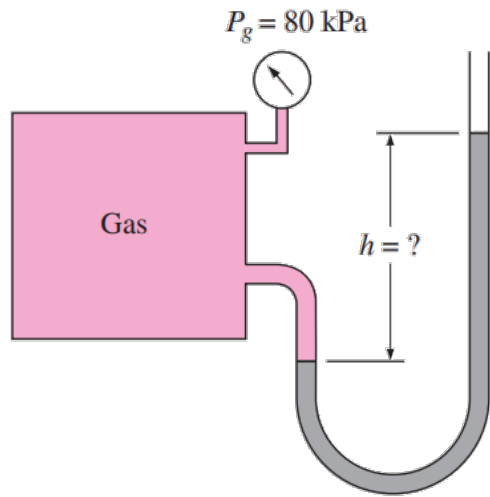
EXERCÍCIOS SELECIONADOS: AULAS 1 – 4




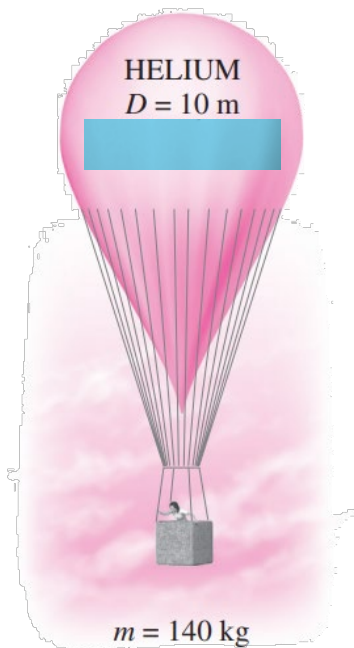
1-42 The water in a tank is pressurized by air, and the pressure is measured by a multifluid manometer as shown in Fig. P1-42. Determine the gage pressure of air in the tank if $h_1 = 0.2$ m, $h_2 = 0.3$ m, and $h_3 = 0.46$ m. Take the densities of water, oil, and mercury to be 1000 kg/m³, 850 kg/m³, and $13,600$ kg/m³, respectively.



1-57 A gas is contained in a vertical, frictionless piston-cylinder device. The piston has a mass of 4 kg and a cross-sectional area of 35 cm². A compressed spring above the piston exerts a force of 60 N on the piston. If the atmospheric pressure is 95 kPa, determine the pressure inside the cylinder. *Answer: 123.4 kPa*



1-59  Both a gage and a manometer are attached to a gas tank to measure its pressure. If the reading on the pressure gage is 80 kPa, determine the distance between the two fluid levels of the manometer if the fluid is (a) mercury ($\rho = 13,600 \text{ kg/m}^3$) or (b) water ($\rho = 1000 \text{ kg/m}^3$).



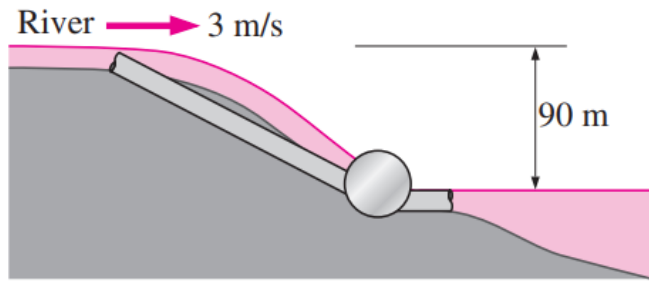
1-101 Balloons are often filled with helium gas because it weighs only about one-seventh of what air weighs under identical conditions. The buoyancy force, which can be expressed as $F_b = \rho_{\text{air}} g V_{\text{balloon}}$, will push the balloon upward. If the balloon has a diameter of 10 m and carries two people, 70 kg each, determine the acceleration of the balloon when it is first released. Assume the density of air is $\rho = 1.16 \text{ kg/m}^3$, and neglect the weight of the ropes and the cage. **Answer:**

16.5 m/s²

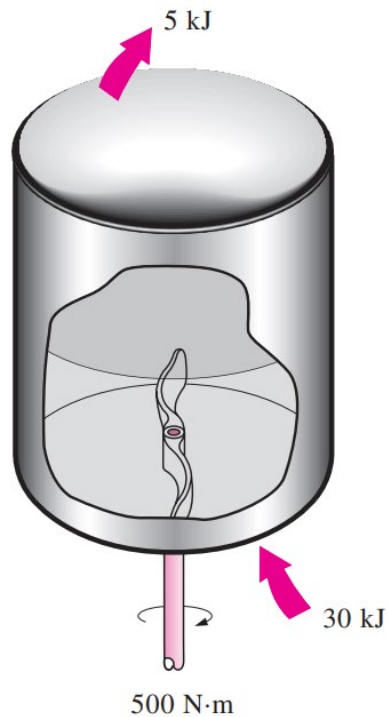
Sugestão: calcule a altitude máxima alcançada pelo balão; determine a densidade do hélio usando a lei dos gases perfeitos



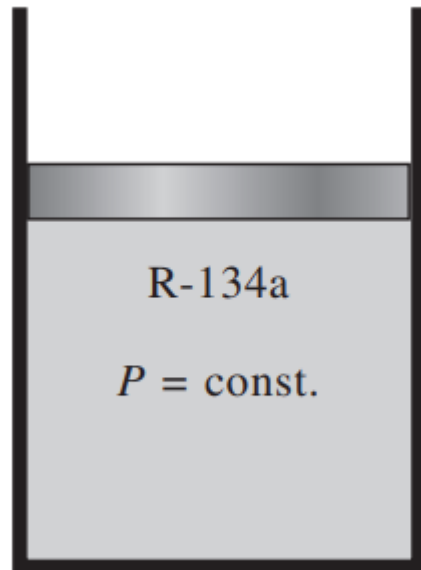
1-108 A pressure cooker cooks a lot faster than an ordinary pan by maintaining a higher pressure and temperature inside. The lid of a pressure cooker is well sealed, and steam can escape only through an opening in the middle of the lid. A separate metal piece, the petcock, sits on top of this opening and prevents steam from escaping until the pressure force overcomes the weight of the petcock. The periodic escape of the steam in this manner prevents any potentially dangerous pressure buildup and keeps the pressure inside at a constant value. Determine the mass of the petcock of a pressure cooker whose operation pressure is 100 kPa gage and has an opening cross-sectional area of 4 mm². Assume an atmospheric pressure of 101 kPa, and draw the free-body diagram of the petcock. *Answer: 40.8 g*



2-8 Consider a river flowing toward a lake at an average velocity of 3 m/s at a rate of $500 \text{ m}^3/\text{s}$ at a location 90 m above the lake surface. Determine the total mechanical energy of the river water per unit mass and the power generation potential of the entire river at that location.




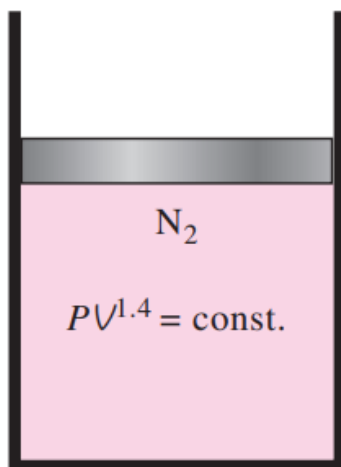
2-37 Water is being heated in a closed pan on top of a range while being stirred by a paddle wheel. During the process, 30 kJ of heat is transferred to the water, and 5 kJ of heat is lost to the surrounding air. The paddle-wheel work amounts to $500 \text{ N} \cdot \text{m}$. Determine the final energy of the system if its initial energy is 10 kJ. *Answer: 35.5 kJ*





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*

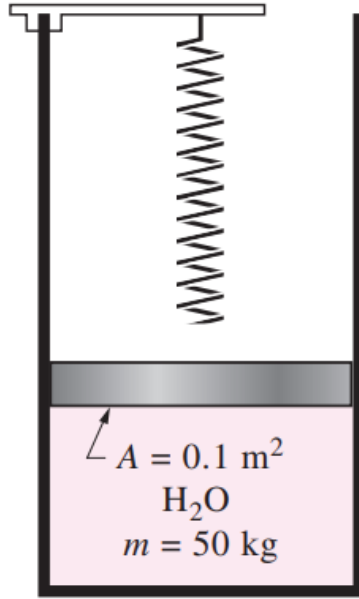
4–10  Reconsider Prob. 4–9. Using EES (or other) software, investigate the effect of pressure on the work done. Let the pressure vary from 400 kPa to 1200 kPa. Plot the work done versus the pressure, and discuss the results. Explain why the plot is not linear. Also plot the process described in Prob. 4–9 on the P - v diagram.



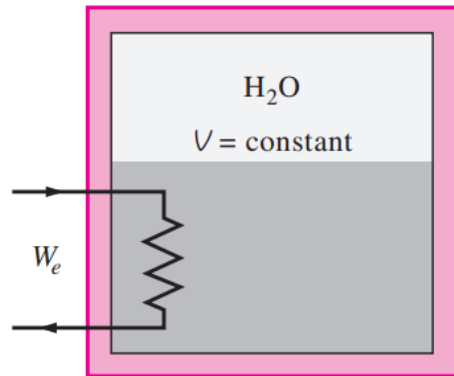
4-16  During some actual expansion and compression processes in piston–cylinder devices, the gases have been observed to satisfy the relationship $PV^n = C$, where n and C are constants. Calculate the work done when a gas expands from 150 kPa and 0.03 m^3 to a final volume of 0.2 m^3 for the case of $n = 1.3$.

4-17  Reconsider Prob. 4–16. Using the EES (or other) software, plot the process described in the problem on a P - V diagram, and investigate the effect of the polytropic exponent n on the boundary work. Let the polytropic exponent vary from 1.1 to 1.6. Plot the boundary work versus the polytropic exponent, and discuss the results.

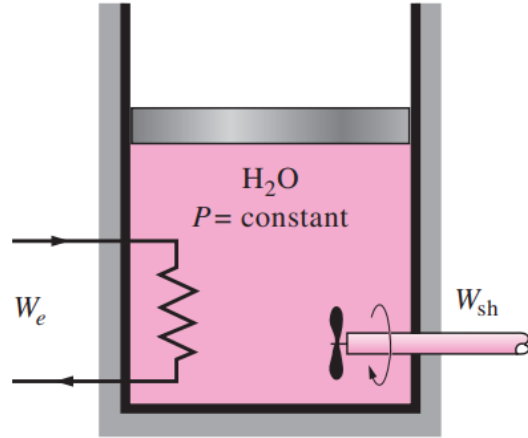
4-18 A frictionless piston–cylinder device contains 2 kg of nitrogen at 100 kPa and 300 K. Nitrogen is now compressed slowly according to the relation $PV^{1.4} = \text{constant}$ until it reaches a final temperature of 360 K. Calculate the work input during this process. *Answer: 89 kJ*



4–23 A piston–cylinder device contains 50 kg of water at 250 kPa and 25°C. The cross-sectional area of the piston is 0.1 m². Heat is now transferred to the water, causing part of it to evaporate and expand. When the volume reaches 0.2 m³, the piston reaches a linear spring whose spring constant is 100 kN/m. More heat is transferred to the water until the piston rises 20 cm more. Determine (a) the final pressure and temperature and (b) the work done during this process. Also, show the process on a P - V diagram. *Answers: (a) 450 kPa, 147.9°C, (b) 44.5 kJ*

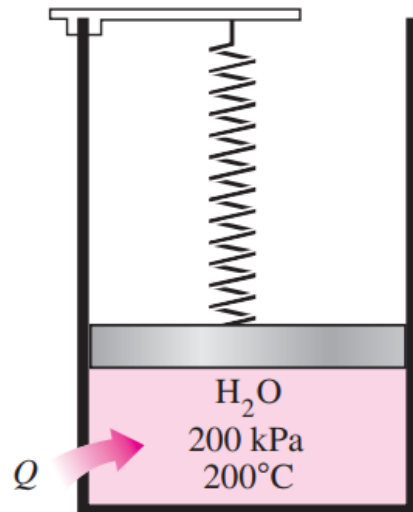



4–30 A well-insulated rigid tank contains 5 kg of a saturated liquid–vapor mixture of water at 100 kPa. Initially, three-quarters of the mass is in the liquid phase. An electric resistor placed in the tank is connected to a 110-V source, and a current of 8 A flows through the resistor when the switch is turned on. Determine how long it will take to vaporize all the liquid in the tank. Also, show the process on a T - v diagram with respect to saturation lines.

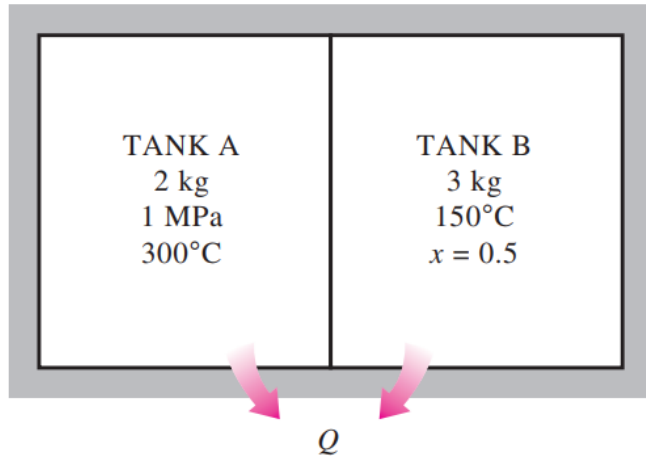


4–36 An insulated piston–cylinder device contains 5 L of saturated liquid water at a constant pressure of 175 kPa. Water is stirred by a paddle wheel while a current of 8 A flows for 45 min through a resistor placed in the water. If one-half of the liquid is evaporated during this constant-pressure process and the paddle-wheel work amounts to 400 kJ, determine the voltage of the source. Also, show the process on a P - v diagram with respect to saturation lines.

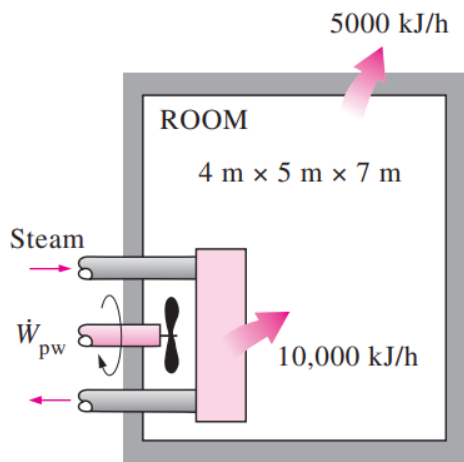
Answer: 224 V



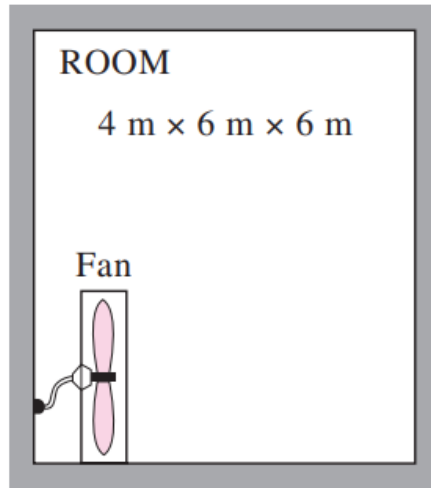
4–38  A piston–cylinder device initially contains steam at 200 kPa, 200°C , and 0.5 m^3 . At this state, a linear spring ($F \propto x$) is touching the piston but exerts no force on it. Heat is now slowly transferred to the steam, causing the pressure and the volume to rise to 500 kPa and 0.6 m^3 , respectively. Show the process on a P - v diagram with respect to saturation lines and determine (a) the final temperature, (b) the work done by the steam, and (c) the total heat transferred. *Answers: (a) 1132°C , (b) 35 kJ, (c) 808 kJ*



4-41 Two tanks (Tank A and Tank B) are separated by a partition. Initially Tank A contains 2-kg steam at 1 MPa and 300°C while Tank B contains 3-kg saturated liquid–vapor mixture with a vapor mass fraction of 50 percent. Now the partition is removed and the two sides are allowed to mix until the mechanical and thermal equilibrium are established. If the pressure at the final state is 300 kPa, determine (a) the temperature and quality of the steam (if mixture) at the final state and (b) the amount of heat lost from the tanks.



4-58 A 4-m × 5-m × 7-m room is heated by the radiator of a steam-heating system. The steam radiator transfers heat at a rate of 10,000 kJ/h, and a 100-W fan is used to distribute the warm air in the room. The rate of heat loss from the room is estimated to be about 5000 kJ/h. If the initial temperature of the room air is 10°C, determine how long it will take for the air temperature to rise to 20°C. Assume constant specific heats at room temperature.



4–59 A student living in a 4-m × 6-m × 6-m dormitory room turns on her 150-W fan before she leaves the room on a summer day, hoping that the room will be cooler when she comes back in the evening. Assuming all the doors and windows are tightly closed and disregarding any heat transfer through the walls and the windows, determine the temperature in the room when she comes back 10 h later. Use specific heat values at room temperature, and assume the room to be at 100 kPa and 15°C in the morning when she leaves.

Answer: 58.2°C

4-61 An insulated rigid tank is divided into two equal parts by a partition. Initially, one part contains 4 kg of an ideal gas at 800 kPa and 50°C, and the other part is evacuated. The partition is now removed, and the gas expands into the entire tank. Determine the final temperature and pressure in the tank.

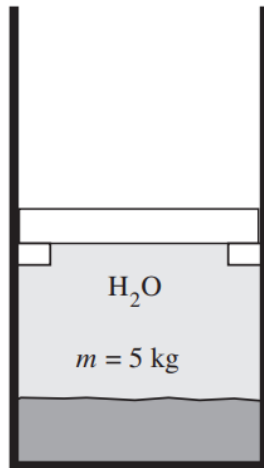
4-66 An insulated piston–cylinder device initially contains 0.3 m³ of carbon dioxide at 200 kPa and 27°C. An electric switch is turned on, and a 110-V source supplies current to a resistance heater inside the cylinder for a period of 10 min. The pressure is held constant during the process, while the volume is doubled. Determine the current that passes through the resistance heater.

4-67 A piston–cylinder device contains 0.8 kg of nitrogen initially at 100 kPa and 27°C. The nitrogen is now compressed slowly in a polytropic process during which $PV^{1.3} = \text{constant}$ until the volume is reduced by one-half. Determine the work done and the heat transfer for this process.

4-73



A piston–cylinder device, with a set of stops on the top, initially contains 3 kg of air at 200 kPa and 27°C. Heat is now transferred to the air, and the piston rises until it hits the stops, at which point the volume is twice the initial volume. More heat is transferred until the pressure inside the cylinder also doubles. Determine the work done and the amount of heat transfer for this process. Also, show the process on a P - v diagram.



4-115 A mass of 5 kg of saturated liquid–vapor mixture of water is contained in a piston–cylinder device at 125 kPa. Initially, 2 kg of the water is in the liquid phase and the rest is in the vapor phase. Heat is now transferred to the water, and the piston, which is resting on a set of stops, starts moving when the pressure inside reaches 300 kPa. Heat transfer continues until the total volume increases by 20 percent. Determine (a) the initial and final temperatures, (b) the mass of liquid water when the piston first starts moving, and (c) the work done during this process. Also, show the process on a P - v diagram.

4-119 A mass of 0.2 kg of saturated refrigerant-134a is contained in a piston–cylinder device at 200 kPa. Initially, 75 percent of the mass is in the liquid phase. Now heat is transferred to the refrigerant at constant pressure until the cylinder contains vapor only. Show the process on a P - v diagram with respect to saturation lines. Determine (a) the volume occupied by the refrigerant initially, (b) the work done, and (c) the total heat transfer.

4-120 A piston–cylinder device contains helium gas initially at 150 kPa, 20°C, and 0.5 m³. The helium is now compressed in a polytropic process ($PV^n = \text{constant}$) to 400 kPa and 140°C. Determine the heat loss or gain during this process. *Answer: 11.2 kJ loss*