

Homework #1 Solutions

Thermodynamics

1-2C On a downhill road the potential energy of the bicyclist is being converted to kinetic energy, and thus the bicyclist picks up speed. There is no creation of energy, and thus no violation of the conservation of energy principle.

1-10 The variation of gravitational acceleration above the sea level is given as a function of altitude. The height at which the weight of a body will decrease by 1% is to be determined.

Analysis The weight of a body at the elevation z can be expressed as

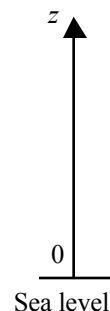
$$W = mg = m(9.807 - 3.32 \times 10^{-6} z)$$

In our case,

$$W = 0.99W_s = 0.99mg_s = 0.99(m)(9.807)$$

Substituting,

$$0.99(9.81) = (9.81 - 3.32 \times 10^{-6} z) \quad z = \mathbf{29,539 \text{ m}}$$



1-20C Intensive properties do not depend on the size (extent) of the system but extensive properties do.

1-22C The number of moles of a substance in a system is directly proportional to the number of atomic particles contained in the system. If we divide a system into smaller portions, each portion will contain fewer atomic particles than the original system. The number of moles is therefore an *extensive property*.

1-34E A temperature is given in °C. It is to be expressed in °F, K, and R.

Analysis Using the conversion relations between the various temperature scales,

$$T(\text{K}) = T(^{\circ}\text{C}) + 273 = 18^{\circ}\text{C} + 273 = \mathbf{291 \text{ K}}$$

$$T(^{\circ}\text{F}) = 1.8T(^{\circ}\text{C}) + 32 = (1.8)(18) + 32 = \mathbf{64.4^{\circ}\text{F}}$$

$$T(\text{R}) = T(^{\circ}\text{F}) + 460 = 64.4 + 460 = \mathbf{524.4 \text{ R}}$$

1-45E The maximum pressure of a tire is given in English units. It is to be converted to SI units.

Assumptions The listed pressure is gage pressure.

Analysis Noting that 1 atm = 101.3 kPa = 14.7 psi, the listed maximum pressure can be expressed in SI units as

$$P_{\max} = 35 \text{ psi} = (35 \text{ psi}) \left(\frac{101.3 \text{ kPa}}{14.7 \text{ psi}} \right) = \mathbf{241 \text{ kPa}}$$

Discussion We could also solve this problem by using the conversion factor 1 psi = 6.895 kPa.

1-58 The mass of a woman is given. The minimum imprint area per shoe needed to enable her to walk on the snow without sinking is to be determined.

Assumptions 1 The weight of the person is distributed uniformly on the imprint area of the shoes. 2 One foot carries the entire weight of a person during walking, and the shoe is sized for walking conditions (rather than standing). 3 The weight of the shoes is negligible.

Analysis The mass of the woman is given to be 70 kg. For a pressure of 0.5 kPa on the snow, the imprint area of one shoe must be

$$A = \frac{W}{P} = \frac{mg}{P}$$

$$= \frac{(70 \text{ kg})(9.81 \text{ m/s}^2)}{0.5 \text{ kPa}} \left[\frac{1 \text{ N}}{1 \text{ kg} \cdot \text{m/s}^2} \right] \left[\frac{1 \text{ kPa}}{1000 \text{ N/m}^2} \right] = 1.37 \text{ m}^2$$



Discussion This is a very large area for a shoe, and such shoes would be impractical to use. Therefore, some sinking of the snow should be allowed to have shoes of reasonable size.

1-59 The vacuum pressure reading of a tank is given. The absolute pressure in the tank is to be determined.

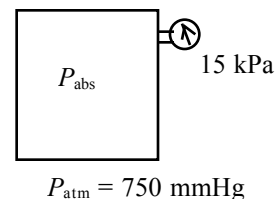
Properties The density of mercury is given to be $\rho = 13,590 \text{ kg/m}^3$.

Analysis The atmospheric (or barometric) pressure can be expressed as

$$P_{\text{atm}} = \rho gh$$

$$= (13,590 \text{ kg/m}^3)(9.807 \text{ m/s}^2)(0.750 \text{ m}) \left[\frac{1 \text{ N}}{1 \text{ kg} \cdot \text{m/s}^2} \right] \left[\frac{1 \text{ kPa}}{1000 \text{ N/m}^2} \right]$$

$$= 100.0 \text{ kPa}$$



Then the absolute pressure in the tank becomes

$$P_{\text{abs}} = P_{\text{atm}} - P_{\text{vac}} = 100.0 - 15 = 85.0 \text{ kPa}$$

(a) For mercury,

$$h = \frac{P_{\text{gage}}}{\rho_{\text{Hg}} g}$$

$$= \frac{80 \text{ kPa}}{(13,600 \text{ kg/m}^3)(9.81 \text{ m/s}^2)} \left[\frac{1 \text{ kN/m}^2}{1 \text{ kPa}} \right] \left[\frac{1000 \text{ kg/m} \cdot \text{s}^2}{1 \text{ kN}} \right] = 0.60 \text{ m}$$

(b) For water,

$$h = \frac{P_{\text{gage}}}{\rho_{\text{H}_2\text{O}} g} = \frac{80 \text{ kPa}}{(1000 \text{ kg/m}^3)(9.81 \text{ m/s}^2)} \left[\frac{1 \text{ kN/m}^2}{1 \text{ kPa}} \right] \left[\frac{1000 \text{ kg/m} \cdot \text{s}^2}{1 \text{ kN}} \right] = 8.16 \text{ m}$$