Solutions Manual for

Thermodynamics: An Engineering Approach
9th Edition
Yunus A. Çengel, Michael A. Boles, Mehmet Kanoğlu
McGraw-Hill Education, 2019

Chapter 1
INTRODUCTION AND BASIC CONCEPTS

PROPRIETARY AND CONFIDENTIAL

This Manual is the proprietary property of McGraw-Hill Education and protected by copyright and other state and federal laws. By opening and using this Manual the user agrees to the following restrictions, and if the recipient does not agree to these restrictions, the Manual should be promptly returned unopened to McGraw-Hill Education: This Manual is being provided only to authorized professors and instructors for use in preparing for the classes using the affiliated textbook. No other use or distribution of this Manual is permitted. This Manual may not be sold and may not be distributed to or used by any student or other third party. No part of this Manual may be reproduced, displayed or distributed in any form or by any means, electronic or otherwise, without the prior written permission of McGraw-Hill Education.

PROPRIETARY MATERIAL © 2019 McGraw-Hill Education. Limited distribution permitted only to teachers and educators for course preparation. If you are a student using this Manual, you are using it without permission.

Thermodynamics

1-1C 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.

1-2C A car going uphill without the engine running would increase the energy of the car, and thus it would be a violation of the first law of thermodynamics. Therefore, this cannot happen. Using a level meter (a device with an air bubble between two marks of a horizontal water tube) it can shown that the road that looks uphill to the eye is actually downhill.

1-3C There is no truth to his claim. It violates the second law of thermodynamics.

1-4C Classical thermodynamics is based on experimental observations whereas statistical thermodynamics is based on the average behavior of large groups of particles.

PROPRIETARY MATERIAL © 2019 McGraw-Hill Education. Limited distribution permitted only to teachers and educators for course preparation. If you are a student using this Manual, you are using it without permission.

Mass, Force, and Units

1-5C In this unit, the word *light* refers to the speed of light. The light-year unit is then the product of a velocity and time. Hence, this product forms a distance dimension and unit.

1-6C Pound-mass lbm is the mass unit in English system whereas pound-force lbf is the force unit. One pound-force is the force required to accelerate a mass of 32.174 lbm by 1 ft/s^2. In other words, the weight of a 1-lbm mass at sea level is 1 lbf.

1-7C There is no acceleration, thus the net force is zero in both cases.

1-8 The mass of an object is given. Its weight is to be determined.

Analysis Applying Newton's second law, the weight is determined to be

$$W = mg = (200\ \text{kg})(9.6\ \text{m/s}^2) = \mathbf{1920\ N}$$

1-9E The mass of an object is given. Its weight is to be determined.

Analysis Applying Newton's second law, the weight is determined to be

$$W = mg = (10\ \text{lbm})(32.0\ \text{ft/s}^2)\left(\frac{1\ \text{lbf}}{32.174\ \text{lbm}\cdot\text{ft/s}^2}\right) = \mathbf{9.95\ lbf}$$

1-10 The acceleration of an aircraft is given in g's. The net upward force acting on a man in the aircraft is to be determined.

Analysis From the Newton's second law, the force applied is

$$F = ma = m(6\ \text{g}) = (90\ \text{kg})(6\times 9.81\ \text{m/s}^2)\left(\frac{1\ \text{N}}{1\ \text{kg}\cdot\text{m/s}^2}\right) = \mathbf{5297\ N}$$

PROPRIETARY MATERIAL © 2019 McGraw-Hill Education. Limited distribution permitted only to teachers and educators for course preparation. If you are a student using this Manual, you are using it without permission.

1-11 Gravitational acceleration g and thus the weight of bodies decreases with increasing elevation. The percent reduction in the weight of an airplane cruising at 13,000 m is to be determined.

Properties The gravitational acceleration g is given to be 9.807 m/s^2 at sea level and 9.767 m/s^2 at an altitude of 13,000 m.

Analysis Weight is proportional to the gravitational acceleration g, and thus the percent reduction in weight is equivalent to the percent reduction in the gravitational acceleration, which is determined from

$$\%\text{Reduction in weight} = \%\text{Reduction in } g$$
$$= \frac{\Delta g}{g} \times 100 = \frac{9.807 - 9.767}{9.807} \times 100 = \mathbf{0.41\%}$$

Therefore, the airplane and the people in it will weight 0.41% less at 13,000 m altitude.

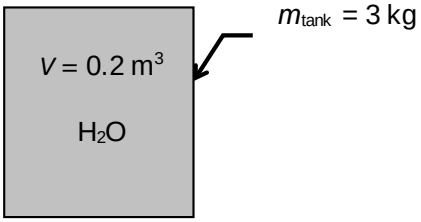
Discussion Note that the weight loss at cruising altitudes is negligible.

1-12 A plastic tank is filled with water. The weight of the combined system is to be determined.

Assumptions The density of water is constant throughout.

Properties The density of water is given to be $\rho = 1000$ kg/m^3.

Analysis The mass of the water in the tank and the total mass are



$$m_w = \rho V = (1000 \text{ kg/m}^3)(0.2 \text{ m}^3) = 200 \text{ kg}$$
$$m_{total} = m_w + m_{tank} = 200 + 3 = 203 \text{ kg}$$

Thus,

$$W = mg = (203 \text{ kg})(9.81 \text{ m/s}^2)\left(\frac{1 \text{ N}}{1 \text{ kg} \cdot \text{m/s}^2}\right) = \mathbf{1991 \text{ N}}$$

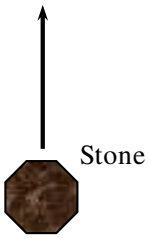
1-13 A rock is thrown upward with a specified force. The acceleration of the rock is to be determined.

Analysis The weight of the rock is

$$W = mg = (2 \text{ kg})(9.79 \text{ m/s}^2)\left(\frac{1 \text{ N}}{1 \text{ kg} \cdot \text{m/s}^2}\right) = 19.58 \text{ N}$$

Then the net force that acts on the rock is

$$F_{net} = F_{up} - F_{down} = 200 - 19.58 = 180.4 \text{ N}$$



From the Newton's second law, the acceleration of the rock becomes

$$a = \frac{F}{m} = \frac{180.4 \text{ N}}{2 \text{ kg}}\left(\frac{1 \text{ kg} \cdot \text{m/s}^2}{1 \text{ N}}\right) = \mathbf{90.2 \text{ m/s}^2}$$

PROPRIETARY MATERIAL © 2019 McGraw-Hill Education. Limited distribution permitted only to teachers and educators for course preparation. If you are a student using this Manual, you are using it without permission.

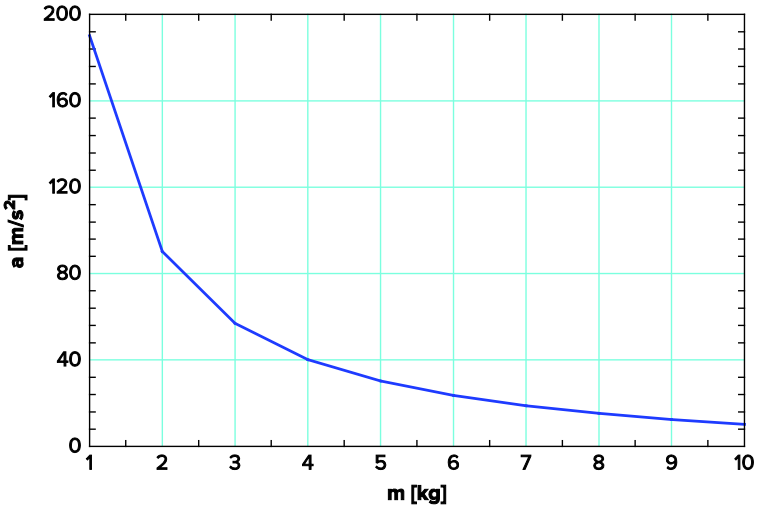
1-14 Problem 1-13 is reconsidered. The entire solution by appropriate software is to be printed out, including the numerical results with proper units.

Analysis The problem is solved using EES, and the solution is given below.

```
m=2 [kg]
F_up=200 [N]
g=9.79 [m/s^2]
W=m*g
F_net=F_up-F_down
F_down=W
F_net=m*a

SOLUTION
a=90.21 [m/s^2]
F_down=19.58 [N]
F_net=180.4 [N]
F_up=200 [N]
g=9.79 [m/s^2]
m=2 [kg]
W=19.58 [N]
```

m [kg]	a [m/s^2]
1	190.2
2	90.21
3	56.88
4	40.21
5	30.21
6	23.54
7	18.78
8	15.21
9	12.43
10	10.21



PROPRIETARY MATERIAL © 2019 McGraw-Hill Education. Limited distribution permitted only to teachers and educators for course preparation. If you are a student using this Manual, you are using it without permission.

1-15 A resistance heater is used to heat water to desired temperature. The amount of electric energy used in kWh and kJ are to be determined.

Analysis The resistance heater consumes electric energy at a rate of 4 kW or 4 kJ/s. Then the total amount of electric energy used in 3 hours becomes

$$\begin{aligned}\text{Total energy} &= (\text{Energy per unit time})(\text{Time interval})\\ &= (4\text{ kW})(3\text{ h})\\ &= \mathbf{12\text{ kWh}}\end{aligned}$$

Noting that 1 kWh = (1 kJ/s)(3600 s) = 3600 kJ,

$$\begin{aligned}\text{Total energy} &= (12\text{ kWh})(3600\text{ kJ/kWh})\\ &= \mathbf{43{,}200\text{ kJ}}\end{aligned}$$

Discussion Note kW is a unit for power whereas kWh is a unit for energy.

1-16E An astronaut took his scales with him to space. It is to be determined how much he will weigh on the spring and beam scales in space.

Analysis (*a*) A spring scale measures weight, which is the local gravitational force applied on a body:

$$W = mg = (150\text{ lbm})(5.48\text{ ft/s}^2)\left(\frac{1\text{ lbf}}{32.2\text{ lbm}\cdot\text{ft/s}^2}\right) = \mathbf{25.5\text{ lbf}}$$

(*b*) A beam scale compares masses and thus is not affected by the variations in gravitational acceleration. The beam scale will read what it reads on earth,

$$W = \mathbf{150\text{ lbf}}$$

1-17 A gas tank is being filled with gasoline at a specified flow rate. Based on unit considerations alone, a relation is to be obtained for the filling time.

Assumptions Gasoline is an incompressible substance and the flow rate is constant.

Analysis The filling time depends on the volume of the tank and the discharge rate of gasoline. Also, we know that the unit of time is 'seconds'. Therefore, the independent quantities should be arranged such that we end up with the unit of seconds. Putting the given information into perspective, we have

$$t\text{ [s]} \quad \leftrightarrow \quad V\text{ [L]},\ \text{and}\ \dot{V}\text{ [L/s]}$$

It is obvious that the only way to end up with the unit "s" for time is to divide the tank volume by the discharge rate. Therefore, the desired relation is

$$t = \frac{V}{\dot{V}}$$

Discussion Note that this approach may not work for cases that involve dimensionless (and thus unitless) quantities.

PROPRIETARY MATERIAL © 2019 McGraw-Hill Education. Limited distribution permitted only to teachers and educators for course preparation. If you are a student using this Manual, you are using it without permission.