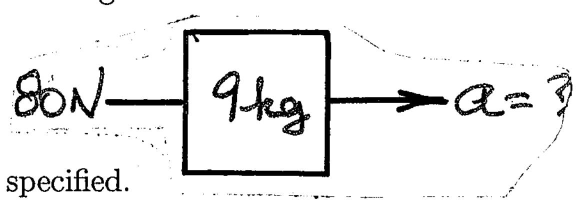
CHAPTER 2

PRELIMINARY CONCEPTS AND DEFINITIONS

Weight, Mass and Newton's Law

2.1: A force of 80 N is applied to a mass of 9 kg. Determine the acceleration of the mass.



Solution

Assumptions and Specifications

(1) The force and the mass are specified.

Here

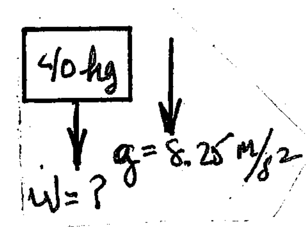
$$a = \frac{F}{m} = \frac{(80\,\text{N})(1\,\text{kg-m/N-s}^2)}{9\,\text{kg}} = 8.889\,\text{m/s} \Longleftarrow$$

■

2.2: Determine the weight of a 40 kg mass in a location where $g = 8.25\,\text{m/s}^2$

Solution

Assumptions and Specifications



(1) The acceleration of gravity is specified as $8.25\,\text{m/s}^2$.

From eq (2.6)

$$W = mg = (40\,\text{kg})(8.25\,\text{m/s}^2)(1\,\text{kg-m/N-s}^2) = 330\,\text{N} \Longleftarrow$$

■

2.3: An object weighs 400 N on the surface of the earth where $g = 9.81\,\text{m/s.}^2$ Determine its weight on a planet where the acceleration of gravity is $1.25\,\text{m/s}^2$

Solution

Assumptions and Specifications

(1) The acceleration of gravity at the surface of the earth is specified as $9.81\,\mathrm{m/s^2}$.
(2) The weight is specified as 400 N.

From eq (2.6)

$$m = \frac{W}{g} = \frac{(400\,\mathrm{N})(1\,\mathrm{kg\text{-}m/N\text{-}s^2})}{9.81\,\mathrm{m/s^2}} = 40.78\,\mathrm{kg}$$

This mass does not change when it is taken to another planet. Hence, when $g = 1.25\,\mathrm{m/s,}^2$

$$W = mg = (40.78\,\mathrm{kg})(1.25\,\mathrm{m/s^2})(1\,\mathrm{N\text{-}s^2/kg\text{-}m}) = 50.97\,\mathrm{N} \Longleftarrow$$

■

2.4: A system has a mass of 8 kg and is subjected to an external vertical force of 160 N. If the local gravitational acceleration is $9.47\,\mathrm{m/s^2}$ and frictional effects may be neglected, determine the acceleration of the mass if the external force is acting (a) upward and (b) downward.

Solution

Assumptions and Specifications

(1) The local acceleration of gravity is specified as $9.47\,\mathrm{m/s^2}$.
(2) Frictional effects may be neglected.

From eq (2.6)

$$\begin{aligned} W &= mg = (8\,\mathrm{kg})(9.47\,\mathrm{m/s^2})(1\,\mathrm{N\text{-}s^2/kg\text{-}m}) \\ &= 75.76\,\mathrm{N} \end{aligned}$$

(a) For a 160 N upward force

$$\begin{aligned} F &= 160\,\mathrm{N} - 75.76\,\mathrm{N} \\ &= 84.24\,\mathrm{N} \quad \text{(upward)} \end{aligned}$$

(b) For a 160 N downward force

$$F = 160\,\text{N} + 75.76\,\text{N} = 235.76\,\text{N} \quad \text{(downward)}$$

and from Newton's law

$$a = \frac{F}{m} = \frac{235.76\,\text{N}}{8\,\text{kg}} = 29.47\,\text{N/kg} = 29.47\,\text{m/s}^2 \quad \text{(downward)} \Longleftarrow$$

■

2.5: An inhabitant of another planet weighs 150 N on a spring type scale in his planet atmosphere where $g = 1.85\,\text{m/s}.^2$ If he appears at a location on earth where the local gravitational acceleration is 9.68 m/s,[2] determine (a) his mass on his planet, (b) his mass on earth and (c) his weight on a spring scale.

Solution

Assumptions and Specifications

(1) The acceleration of gravity at the surface of the earth is specified as $9.68\,\text{m/s}^2$.

(2) The acceleration of gravity on the unknown planet is specified as $1.85\,\text{m/s}^2$.

(a) On his native planet, from eq (2.6)

$$m = \frac{W}{g} = \frac{150\,\text{N}}{1.85\,\text{m/s}^2} = 81.08\,\text{N-s}^2/\text{m} = 81.08\,\text{kg} \Longleftarrow$$

(b) On earth. where $g = 9.68\,\text{m/s},^2$ the mass will not change

$$m = 81.08\,\text{kg} \Longleftarrow$$

(c) On earth using a spring scale, his weight will be

$$W = mg = (81.08\,\text{kg})(9.68\,\text{m/s}^2) = 784.87\,\text{kg-m/s}^2 = 784.87\,\text{N} \Longleftarrow$$

■

2.6: Given that the acceleration of gravity decreases at a rate of $3.318 \times 10^{-6}\,/\mathrm{s}^2$ for every meter of elevation, take the acceleration of gravity at sea level is $9.807\,\mathrm{m/s^2}$ and determine the weight of a 100 kg mass in Denver, Colorado where the altitude is 1609.3 m.

Solution

Assumptions and Specifications

(1) The acceleration of gravity at the surface of the earth is specified as $9.807\,\mathrm{m/s^2}$.

(2) The decrease in the acceleration of gravity with altitude is specified.

Here, the problem statement indicates that the acceleration of gravity, as a function of altitude, is $3.318 \times 10^{-6}\,/\mathrm{s}^2 h$.

$$g(h) = 9.807\,\mathrm{m/s^2} - (3.318 \times 10^{-6}\,/\mathrm{s}^2)h$$

At Denver where $h = 1609.3\,\mathrm{m}$

$$\begin{aligned} g(h = 1609.3\,\mathrm{m}) &= 9.807\,\mathrm{m/s^2} - (3.318 \times 10^{-6}\,/\mathrm{s}^2)(1609.3\,\mathrm{m}) \\ &= 9.807\,\mathrm{m/s^2} - 0.005\,\mathrm{m/s^2} \\ &= 9.802\,\mathrm{m/s^2} \end{aligned}$$

Then from eq (2.6)

$$W = mg = (100\,\mathrm{kg})(9.802\,\mathrm{m/s^2}) = 980.2\,\mathrm{kg\text{-}m/s^2} = 980.2\,\mathrm{N} \Longleftarrow$$

■

2.7: Given that the acceleration of gravity decreases at a rate of $3.318 \times 10^{-6}\,/\mathrm{s}^2$ for every meter of elevation, take the acceleration of gravity at sea level as $9.807\,\mathrm{m/s^2}$ and determine the altitude where the weight of an object is decreased by five percent.

Solution

Assumptions and Specifications

(1) The acceleration of gravity at the surface of the earth is specified as $9.807\,\mathrm{m/s^2}$.

(2) The decrease in the acceleration of gravity with altitude is specified.

Here, the problem statement indicates that the acceleration of gravity decreases as a function of altitude by $(3.318 \times 10^{-6}\,/\mathrm{s^2})h$. We use eq (2.6) denoting the altitude and sea level conditions respectively by the subscripts "alt" and "sl."

$$\frac{W_{\mathrm{alt}}}{W_{\mathrm{sl}}} = \frac{mg_{\mathrm{alt}}}{mg_{\mathrm{sl}}}$$

With

$$\frac{W_{\mathrm{alt}}}{W_{\mathrm{sl}}} = 0.950$$

we have

$$\begin{aligned}
g_{c,\mathrm{alt}} &= 0.95 g_{c,\mathrm{sl}} \\
9.807\,\mathrm{m/s^2} - (3.318 \times 10^{-6}\,/\mathrm{s^2})h &= (0.95)(9.807\,\mathrm{m/s^2}) \\
-(3.318 \times 10^{-6}\,\mathrm{m/s^2}h &= (0.95 - 1)(9.807\,\mathrm{m/s^2}) \\
h &= \frac{(0.05)(9.807\,\mathrm{m/s^2})}{3.318 \times 10^{-6}\,\mathrm{m/s^2}} \\
&= 1.478 \times 10^5\,\mathrm{m} \quad (147.8\,\mathrm{km}) \Longleftarrow
\end{aligned}$$

■

2.8: A 2 kg mass is "weighed" with a beam balance at a location where g is $9.75\,\mathrm{m/s^2}$. Determine (a) its weight and (b) its weight as determined by a spring scale that reads correctly for standard gravity of $9.81\,\mathrm{m/s^2}$.

Solution

Assumptions and Specifications

(1) The standard acceleration of gravity is is specified as $9.81\,\mathrm{m/s^2}$.

(2) At a different location, the acceleration is specified as $9.75\,\mathrm{m/s^2}$.

From eq (2.6)

$$W = mg$$

(a) Here we note that the beam balance does not
depend on the gravitational field and that the
mass does <u>not</u> change with gravitational acceleration.

$$W = mg = (2\,\mathrm{kg})(9.75\,\mathrm{m/s^2}) = 19.50\,\mathrm{kg\text{-}m/s^2} = 19.50\,\mathrm{N} \Longleftarrow$$

(b) However, with the spring scale

$$W = mg = (2\,\mathrm{kg})(9.81\,\mathrm{m/s^2}) = 19.62\,\mathrm{kg\text{-}m/s^2} = 19.62\,\mathrm{N} \Longleftarrow$$

■

2.9: An astronaut who weighs 1962 N at Cape Canaveral where $g = 9.81\,\mathrm{m/s^2}$ goes to a planet where $g = 5.25\,\mathrm{m/s^2}$. While on the planet, he gathers a bag of rocks weighing 105 N to be brought back as samples. Upon his return to earth, it is found that the rocks and the astronaut together weigh 2011 N. How much weight did the astronaut lose during the mission.

Solution

<u>Assumptions and Specifications</u>

(1) The standard acceleration of gravity is
is specified as $9.81\,\mathrm{m/s^2}$.

(2) The acceleration of gravity on the plamet
is specified as $5.25\,\mathrm{m/s^2}$.

(3) The weights of the astronaut and rocks are specified.

Here, we will designate the astronaut and the rocks respectively by the subscripts "a" and "r". Then eq (2.6) tells us that the mass of the astronaut will be

$$m_\mathrm{a} = \frac{W_\mathrm{a}}{g} = \frac{1962\,\mathrm{N}}{9.81\,\mathrm{m/s^2}} = 200\,\mathrm{N\text{-}s^2/m} = 200\,\mathrm{kg}$$

and the mass of the rocks will be

$$m_\mathrm{r} = \frac{W_\mathrm{r}}{g} = \frac{105\,\mathrm{N}}{5.25\,\mathrm{m/s^2}} = 20\,\mathrm{N\text{-}s^2/m} = 20\,\mathrm{kg}$$

When the mission is completed the astronaut and the rocks together weigh 2011 N so that

$$m_\mathrm{a} + m_\mathrm{r} = \frac{2011\,\mathrm{N}}{9.81\,\mathrm{m/s^2}} = 205\,\mathrm{N\text{-}s^2/m} = 205\,\mathrm{kg}$$

and because the mass of the rocks does not change, the mass of the astronaut is

$$m_a = 205\,\text{kg} - 20\,\text{kg} = 185\,\text{kg}$$

Thus, the astronaut loses

$$\Delta m = 200\,\text{kg} - 185\,\text{kg} = 15\,\text{kg}$$

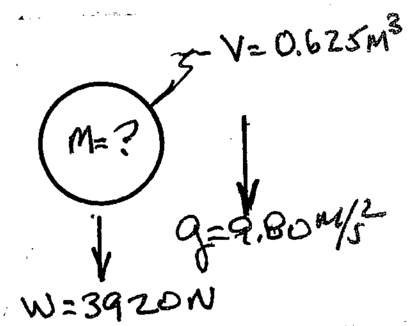
or a weight of

$$W = (\Delta m)g = (15\,\text{kg})(9.81\,\text{m/s}^2) = 147.15\,\text{kg-m/s}^2 = 147.15\,\text{N} \Longleftarrow$$

■

2.10: An object that occupies a volume of $0.625\,\text{m}^3$ weighs 3920 N where the acceleration of gravity is $9.80\,\text{m/s}^2$. Determine the mass of the object and its density.

Solution



Assumptions and Specifications

(1) The acceleration of gravity is is specified as $9.80\,\text{m/s}^2$.

From eq (2.6)

$$\begin{aligned} m &= \frac{W}{g} = \frac{3920\,\text{N}}{9.80\,\text{m/s}^2} \\ &= 400\,\text{N-s}^2/\text{m} = 400\,\text{kg} \Longleftarrow \end{aligned}$$

and the density will be

$$\rho = \frac{m}{V} = \frac{400\,\text{kg}}{0.625\,\text{m}^3} = 640\,\text{kg/m}^3 \Longleftarrow$$

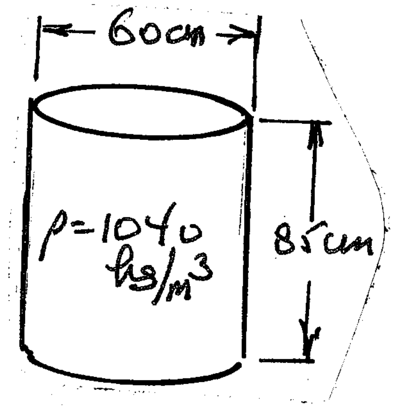
■

Density and Related Properties

■

2.11: A cylindrical drum that is 60 cm in diameter and 85 cm high is completely filled with a fluid whose density is $1040\,\text{kg/m}^3$. Determine (a) the total volume of the fluid, (b) the total mass of the fluid and (c) the specific volume of the fluid.

Solution



Assumptions and Specifications

(1) The dimensions of the container are specified.
(2) The density of the fluid is specified.
(3) The volume of the drum is equal to the volume of the fluid.

(a) The volume of the drum to be taken as equal to the volume of the fluid will be

$$V = \frac{\pi}{4} d^2 h = \frac{\pi}{4}(0.60\,\text{cm})^2(85\,\text{cm}) = 0.2403\,\text{m}^3 \Longleftarrow$$

(b) The mass of the fluid will be

$$m = \rho V = (1040\,\text{kg/m}^3)(0.240\,\text{m}^3) = 249.91\,\text{kg} \Longleftarrow$$

(c) The specific volume is the reciprocal of the density

$$v = \frac{1}{\rho} = \frac{1}{1040\,\text{kg/m}^3} = 9.615 \times 10^{-4}\,\text{m}^3/\text{kg} \Longleftarrow$$

■

2.12: A fluid mass of 13.5 kg completely fills a 12 liter container. Given the acceleration of gravity as $9.81\,\text{m/s}^2$, determine (a) its density, (b) its specific volume, (c) its specific weight and (d) its specific gravity if the density of water is $1000\,\text{kg/m}^3$.

Solution

Assumptions and Specifications

(1) The acceleration of gravity is specified as as $9.81\,\text{m/s}^2$.
(2) The density of water is specified as $1000\,\text{kg/m}^3$.
(3) The mass of the fluid and the volume of the container are specified..

Here we note that 1 liter is $1000\,\text{cm}^3$ or $10^{-3}\,\text{m}.^3$

(a) The density of the fluid will be

$$\rho = \frac{m}{V} = \frac{13.5\,\text{kg}}{0.012\,\text{kg/m}^3} = 1125\,\text{kg/m}^3 \Longleftarrow$$

(b) The specific volume is the reciprocal of the density

$$v = \frac{1}{\rho} = \frac{1}{1125\,\text{kg/m}^3} = 8.889 \times 10^{-4}\,\text{m}^3/\text{kg} \Longleftarrow$$

(c) The specific weight is

$$\gamma = \rho g = (1125\,\text{kg/m}^3)(9.81\,\text{m/s}^2) = 1.104 \times 10^4\,\text{kg-s}^2/\text{m}^2$$

or

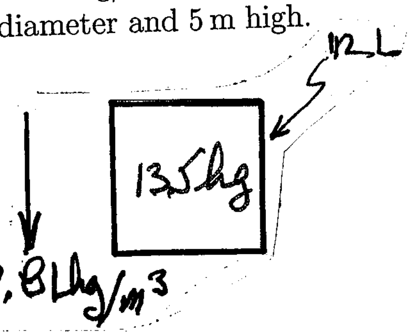
$$\gamma = 1.104 \times 10^4\,\text{N/m}^3 \Longleftarrow$$

(d) With the water density at $1000\,\text{kg/m}^3$

$$SG = \frac{\rho}{\rho_W} = \frac{1125\,\text{kg/m}^3}{1000\,\text{kg/m}^3} = 1.125 \Longleftarrow$$

■

2.13: A pump discharges 75 gallons/per minute of water whose density is $998\,\text{kg/m}^3$. Find (a) the mass flow rate of the water in kg/s and (b) the time required to fill a cylindrical vat that is 6 m in diameter and 5 m high.



Solution

Assumptions and Specifications

(1) The density of water is specified as $998\,\text{kg/m}^3$.

Before beginning, we note that 7.47 gal is equivalent to 3.7854 liters and that

$$1\,\text{gallon} \Longleftrightarrow 3.7854 \times 10^{-3}\,\text{m}^3$$

(a) The mass flow rate will be

$$\begin{aligned} \dot{m} &= \frac{(75\,\text{gallons/min})(3.7854 \times 10^{-3}\text{m}^3/\text{gallon})(998\,\text{kg/m}^3)}{60\,\text{s/min}} \\ &= 4.72\,\text{kg/s} \Longleftarrow \end{aligned}$$

(b) To find the time required to fill the vat, we need the volume of the vat

$$V = \frac{\pi}{4}d^2h = \frac{\pi}{4}(6\,\text{m})^2(5\,\text{m}) = 141.37\,\text{m}^3 \Longleftarrow$$

and this means that the vat can hold

$$\begin{aligned} m &= \rho V = (998\,\text{kg/m}^3)(141.37\,\text{m}^3) \\ &= 1.411 \times 10^5\,\text{kg} \Longleftarrow \end{aligned}$$

The time required to fill that vat will be

$$t = \frac{m}{\dot{m}} = \frac{1.411 \times 10^5\,\text{kg}}{4.72\,\text{kg/s}} = 2.989 \times 10^4\,\text{s} \quad (8.30\,\text{h}) \Longleftarrow$$

■

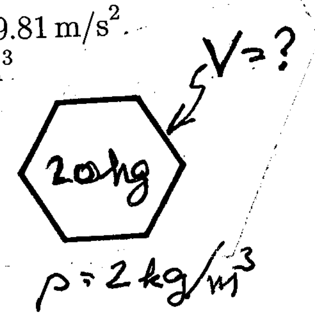
2.14: A fluid mass of 20 kg has a density of $2\,\text{kg/m}^3$. Determine (a) its volume, (b) its specific volume, (c) its specific weight and (d) its weight.

Solution

Assumptions and Specifications

(1) The acceleration of gravity is assumed to be $9.81\,\text{m/s}^2$.

(2) The density of the fluid is specified as $2\,\text{kg/m}^3$.



a) The volume may be obtained from the density

$$V = \frac{m}{\rho} = \frac{20\,\text{kg}}{2\,\text{kg/m}^3} = 10\,\text{m}^3 \Longleftarrow$$

(b) The specific volume is the reciprocal of the density

$$v = \frac{1}{\rho} = \frac{1}{2\,\text{kg/m}^3} = 0.50\,\text{m}^3/\text{kg} \Longleftarrow$$

(c) The calculation of the specific weight assumes that the acceleration of gravity is $9.81\,\mathrm{m/s^2}$

$$\gamma = \rho g = (2\,\mathrm{kg/m^3})(9.81\,\mathrm{m/s^2}) = 19.62\,\mathrm{kg\text{-}s^2/m^2} = 19.62\,\mathrm{N/m^3} \Longleftarrow$$

(d) With the water density at $1000\,\mathrm{m/s^2}$

$$W = \gamma V = (19.62\,\mathrm{N/m^3})(10\,\mathrm{m^3}) = 196.2\,\mathrm{N} \Longleftarrow$$

■

2.15: The mass of the earth has been estimated as $5.981 \times 10^{24}\,\mathrm{kg}$ and its mean radius is $6.38 \times 10^6\,\mathrm{m}$. Estimate its apparent density.

Solution

Assumptions and Specifications

(1) The earth is assumed to be spherical.
(2) The mass and radius of the earth are both specified.

For a sphere with volume

$$\begin{aligned} V &= \frac{4}{3}\pi r^3 \\ &= \frac{4}{3}\pi(6.38 \times 10^6\,\mathrm{m^3}) \\ &= 1.088 \times 10^{21}\,\mathrm{m^3} \end{aligned}$$

Then

$$\rho = \frac{m}{V} = \frac{5.981 \times 10^{24}\,\mathrm{kg}}{1.088 \times 10^{21}\,\mathrm{m^3}} = 5498\,\mathrm{kg/m^3} \Longleftarrow$$

■

2.16: Suppose that $2\,\mathrm{m^3}$ of liquid-A with a specific gravity of 1.24 and $3\,\mathrm{m^3}$ of liquid-B with a density of $880\,\mathrm{kg/m^3}$ are completely mixed. Determine (a) the density of the mixture and (b) the weight of the mixture contained in a volume of $7.38\,\mathrm{m^3}$.

Solution

Assumptions and Specifications

(1) The acceleration of gravity is assumed to be $9.81\,\text{m/s}^2$.
(2) The density of water is assumed to be $1000\,\text{kg/m}^3$.
(3) Either the density or the specific gravity of the components are specified.

(a) For the density of the mixture, we establish the total mass present. For liquid-A

$$\begin{aligned}\rho_A &= (SG_A)(\rho_W) = (1.24)(1000\,\text{kg/m}^3) \\ &= 1240\,\text{kg/m}^3\end{aligned}$$

and with $V_A = 2\,\text{m}^3$

$$m_A = \rho_A V_A = (1240\,\text{kg/m}^3)(2\,\text{m}^3) = 2480\,\text{kg}$$

For fluid-B with $\rho_B = 880\,\text{kg/m}^3$ and $V_B = 3\,\text{m}^3$

$$m_B = \rho_B V_B = (880\,\text{kg/m}^3)(3\,\text{m}^3) = 2640\,\text{kg}$$

The total mass is

$$m = m_A + m_B = 2480\,\text{kg} + 2640\,\text{kg} = 5120\,\text{kg}$$

and for

$$V = 2\,\text{m}^3 + 3\,\text{m}^3 = 5\,\text{m}^3$$

the density will be

$$\rho = \frac{m}{V} = \frac{5120\,\text{kg}}{5\,\text{m}^3} = 1024\,\text{kg/m}^3 \Longleftarrow$$

(b) The weight of the mixture in $7.38\,\text{m}^3$ will be

$$W = \gamma V = \rho g V = (1024\,\text{kg/m}^3)(9.81\,\text{m/s}^2)(7.38\,\text{m}^3)(1\,\text{N-s}^2/\text{kg-m})$$

or

$$W = 74,135\,\text{N} \Longleftarrow$$

■

2.17: A 150 kg mass in water ($\rho = 1000\,\text{kg/m}^3$) has a uniform density of $4250\,\text{kg/m}^3$. Determine (a) its weight, (b) its volume, and (c) its specific volume.

Solution

Assumptions and Specifications

(1) The acceleration of gravity is assumed to be $9.81\,\text{m/s}^2$.
(2) The density of the mass is specified as $4250\,\text{kg/m}^3$.

(a) The weight is obtained first

$$W = mg = (150\,\text{kg})(9.81\,\text{m/s}^2)(1\,\text{N-s}^2\text{kg-m}) = 1471.5\,\text{N} \Longleftarrow$$

(b) The volume may be obtained from the mass and the density

$$V = \frac{m}{\rho} = \frac{150\,\text{kg}}{4250\,\text{kg/m}^3} = 0.0353\,\text{m}^3 \Longleftarrow$$

(c) The specific volume is the reciprocal of the density

$$v = \frac{1}{\rho} = \frac{1}{4250\,\text{kg/m}^3} = 2.353 \times 10^{-4}\,\text{m}^3/\text{kg} \Longleftarrow$$

■

2.18: A liquid has a specific volume of $8 \times 10^{-4}\,\text{m}^3/\text{kg}$. Taking the acceleration of gravity as $9.80\,\text{m/s}^2$ and the density of water as $1000\,\text{kg/m}^3$, determine (a) its density, (b) its specific weight and (c) its specific gravity.

Solution

Assumptions and Specifications

(1) The acceleration of gravity is specified at $9.8\,\text{m/s}^2$
(2) The density water is specified at $1000\,\text{kg/m}^3$.
(3) The specific volume of the liquid is specified.

(a) The density is the reciprocal of the specific volume

$$\rho = \frac{1}{v} = \frac{1}{8 \times 10^{-4}\,\text{kg/m}^3/kg} = 1250\,\text{kg/m}^3 \Longleftarrow$$

(b) With $g = 9.81\,\mathrm{m/s^2}$, the specific weight is

$$\begin{aligned}\gamma &= \rho g = (1250\,\mathrm{kg/m^3})(9.80\,\mathrm{m/s^2}) \\ &= 12,250\,\mathrm{kg\text{-}s^2/m^2} = 12,250\,\mathrm{N/m^3} \Longleftarrow\end{aligned}$$

(c) The specific gravity is

$$SG = \frac{\rho}{\rho_W} = \frac{1250\,\mathrm{kg/m^3}}{1000\,\mathrm{kg/m^3}} = 1.250 \Longleftarrow$$

■

2.19: A glass tube with an inner diameter of 1 cm contains 8 grams of water ($\rho = 1000\,\mathrm{kg/m^3}$) and 14 grams of gage oil with a specific gravity of 1.40. Taking the acceleration of gravity as $9.807\,\mathrm{m/s^2}$, determine the height of the liquid in the tube.

Solution

Assumptions and Specifications

(1) The acceleration of gravity is specified as $9.807\,\mathrm{m/s^2}$.
(2) The density water is specified as $1000\,\mathrm{kg/m^3}$.
(3) The specific gravity of the oil is specified as 1.40.

First determine the cross sectional area of the tube

$$A_i = \frac{\pi}{4}d_i^2 = \frac{\pi}{4}(0.01\,\mathrm{m})^2 = 7.854 \times 10^{-5}\,\mathrm{m}^2$$

Then, for the water (subscript 1)

$$V_1 = \frac{m_1}{\rho_1} = \frac{8 \times 10^{-3}\,\mathrm{kg}}{1000\,\mathrm{kg/m^3}} = 8 \times 10^{-6}\,\mathrm{m}^3$$

For the oil (subscript 2)

$$\rho_2 = (SG_2)\rho_1 = (1.40)(1000\,\mathrm{kg/m^3} = 1400\,\mathrm{kg/m^3}$$

so that

$$V_2 = \frac{m_2}{\rho_2} = \frac{14 \times 10^{-3}\,\mathrm{kg}}{1400\,\mathrm{kg/m^3}} = 1 \times 10^{-5}\,\mathrm{m}^3$$

The total volume is

$$\begin{aligned} V &= V_1 + V_2 \\ &= 8 \times 10^{-6}\,\mathrm{m}^3 + 1 \times 10^{-5}\,\mathrm{m}^3 \\ &= 1.8 \times 10^{-5}\,\mathrm{m}^3 \end{aligned}$$

and the height of the column, h, will be

$$h = \frac{V}{A_i} = \frac{1.8 \times 10^{-5}\,\mathrm{m}^3}{7.854 \times 10^{-5}\,\mathrm{m}^2} = 0.229\,\mathrm{m} \quad (22.9\,\mathrm{cm})$$

■

2.20: A cylindrical container with a diameter of 2 m contains three fluids:

Fluid	ρ, kg/m^3	SG	γ, N/m^3	Weight, N
(1) water	1000			27,500
(2) oil			1420	2000
(3) mercury		13.6		40,000

Determine the total height of the fluids in the cylinder.

Solution

<u>Assumptions and Specifications</u>

(1) The acceleration of gravity is assumed to be $9.81\,\mathrm{m/s^2}$.
(2) The density of water is specified as $1000\,\mathrm{kg/m^3}$.

We assume that the acceleration of gravity is $9.81\,\mathrm{m/s^2}$. For the water

$$V_1 = \frac{m_1}{\rho_1} = \frac{W_1}{\rho_1 g} = \frac{(27,500\,\mathrm{N})(1\,\mathrm{kg\text{-}m/N\text{-}s^2})}{(1000\,\mathrm{kg/m^3})(9.81\,\mathrm{m/s^2})} = 2.803\,\mathrm{m}^3$$

For the oil

$$V_2 = \frac{W_2}{\gamma_2} = \frac{2000\,\mathrm{N}}{1420\,\mathrm{N/m^3}} = 1.408\,\mathrm{m}^3$$

and for the mercury

$$V_3 = \frac{m_3}{\rho_3 g} = \frac{(40,000\,\mathrm{N})(1\,\mathrm{kg\text{-}m/N\text{-}s^2})}{(13.6)(1000\,\mathrm{kg/m^3})(9.81\,\mathrm{m/s^2})} = 0.300\,\mathrm{m}^3$$

The total volume is

$$
\begin{aligned}
V &= V_1 + V_2 + V_3 \\
&= 2.803\,\mathrm{m}^3 + 1.408\,\mathrm{m}^3 + 0.300\,\mathrm{m}^3 \\
&= 4.511\,\mathrm{m}^3
\end{aligned}
$$

and with a container cross section of

$$A = \frac{\pi}{4} d_i^2 = \frac{\pi}{4}(2\,\mathrm{m})^2 = 3.142\,\mathrm{m}^2$$

we obtain the height, h

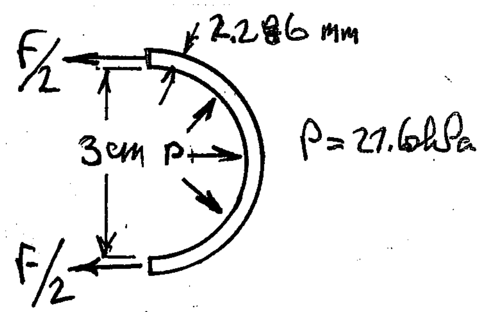
$$h = \frac{V}{A} = \frac{5.746\,\mathrm{m}^3}{3.142\,\mathrm{m}^2} = 1.83\,\mathrm{m} \Longleftarrow$$

■

Pressure

■

2.21: A pipe with an inner diameter of 3 cm and a wall thickness of 2.286 mm contains air at a ;pressure of 27.6 kPa. Determine the tensile stress in the pipe wall.



Solution

Assumptions and Specifications:

(1) The pressure is uniform.
(2) Equilibrium exists.

The force exerted by air on a one meter basis will be

$$F = PA = (27.6\,\mathrm{kPa})(0.03\,\mathrm{m})(1.0\,\mathrm{m}) = 828\,\mathrm{N}$$

and, as indicated in the free body diagram

$$F/2 = 414\,\mathrm{N}$$

For the pipe wall on a 1 m basis

$$A = (0.002286\,\mathrm{m})(1.0\,\mathrm{m}) = 0.002286\,\mathrm{m}^2$$

and the tensile stress will be

$$\sigma = \frac{F/2}{A} - \frac{414\,\mathrm{N}}{0.002286\,\mathrm{m}^2} = 181.1\,\mathrm{kPa} \Longleftarrow$$

■

2.22: A penstock, 1.75 m in diameter is built of longitudinal wood staves held together by circumferential steel hoops spaced 10 cm center-to-center apart. The water pressure is 56 kPa and and the allowable tensile stress in the hoops is 136 MPa. The hoops are threaded for nuts. Determine their root diameter.

Solution

Assumptions and Specifications:

(1) The pressure is uniform.
(2) Equilibrium exits.

Here, on a one meter basis,

$$\frac{F}{2} = \frac{Pd}{2} = \frac{(56\,\mathrm{kPa})(1.75\,\mathrm{m})(1.0\,\mathrm{m})}{2} = 49,000\,\mathrm{N}$$

and the number of hoops per meter is $n = 10$. Thus, with $F/2 = nA_h\sigma_h$

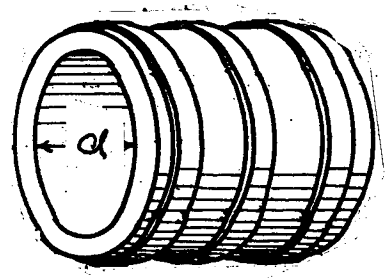
$$A_h = \frac{49,000\,\mathrm{N}}{(10)(136\,\mathrm{MPa})} = 3.6029 \times 10^{-5}\,\mathrm{m}^2$$

This makes the hoop diameter

$$\begin{aligned} d_h &= \left(\frac{4A_h}{\pi}\right)^{1/2} \\ &= \left(\frac{4(3.6029 \times 10^{-5}\,\mathrm{m}^2)}{\pi}\right)^{1/2} \\ &= (4.5874 \times 10^{-5}\,\mathrm{m}^2)^{1/2} = 0.00677\,\mathrm{m} \quad (0.677\,\mathrm{cm}) \Longleftarrow \end{aligned}$$

■

2.23: A wood stave pipe, 75 cm in diamater, is to operate under a water pressure of 350 kPa. The pipe will be wound spirally with 0.635 cm diameter steel wire at a tensile strength of 168 MPa. What spacing of wire is required.



Solution

Assumptions and Specifications:

(1) The pressure is uniform.
(2) Equilibrium exists.

Here, on a one meter length basis

$$\frac{F/2}{2} = \frac{Pd}{2} = \frac{(350\,\text{kPa})(0.75\,\text{m})(1.0\,\text{m})}{2} = 131,250\,\text{N}$$

With A_h equal to

$$A_h = \frac{\pi}{4}d^2 = \frac{\pi}{4}(0.00635\,\text{m})^2 = 3.1669 \times 10^{-5}\,\text{m}^2$$

we can obtain the number of hoops (also on a per meter basis)

$$n = \frac{F/2}{\sigma_h A_h} = \frac{131,250\,\text{N}}{(168,000\,\text{kPa})(3.1669 \times 10^{-5}\,\text{m}^2)} = 24.67\,\text{hoops}$$

Thus, the spacing required will be

$$\text{spacing} = \frac{1.00\,\text{m}}{24.67\,\text{hoops}} = 0.0405\,\text{m} \quad (4.05\,\text{cm}) \Longleftarrow$$

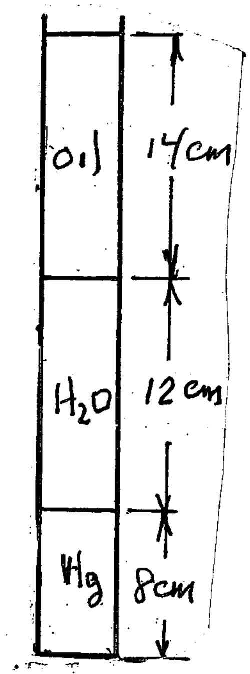
■

2.24: A composite vertical fluid column which is open to the atmosphere is composed of 8 cm of mercury with a specific gravity of 13.6, 12 cm of water with a density of $\rho = 1000\,\text{kg/m}^3$ and 14 cm of oil with a specific gravity of 0.831. Taking the acceleration of gravity as $9.81\,\text{m/s}^2$, determine (a) the pressure at the base of the column, (b) the pressure at the oil-water interface and (c) the pressure at the water-mercury interface.

Solution

Assumptions and Specifications

(1) The acceleration of gravity is specified as $9.81\,\mathrm{m/s^2}$.
(2) The density of water is specified as $1000\,\mathrm{kg/m^3}$.
(3) The specific gravity of the oil and mercury are specified.
(4) The heights of the constituent fluids are specified.



The heaviest fluid is at the bottom of the column. Thus the oil is at the top, the water is in the middle and the mercury is at the bottom. We designate the oil, water and mercury respectively by the subscripts 1, 2, and 3. Thus, the gage pressure at the oil-water interface will be P_1

$$\begin{aligned}
P_1 &= \gamma_1 h_1 = \rho_1 g h_1 = (SG_1)\rho_2 g h_1 \\
&= (0.831)(1000\,\mathrm{kg/m^3})(9.81\,\mathrm{m/s^2})(0.14\,\mathrm{m}) \\
&= 1141.3\,\mathrm{N/m^2}
\end{aligned}$$

The gage pressure at the water-mercury interface will be P_2

$$\begin{aligned}
P_2 &= P_1 + \gamma_2 h_2 = P_1 + \rho_2 g h_2 \\
&= 1141.3\,\mathrm{N/m^2} + (1000\,\mathrm{kg/m^3})(9.81\,\mathrm{m/s^2})(0.12\,\mathrm{m})(1\,\mathrm{N\text{-}s^2/kg\text{-}m}) \\
&= 1141.3\,\mathrm{N/m^2} + 1177.2\,\mathrm{N/m^2} \\
&= 2318.5\,\mathrm{N/m^2}
\end{aligned}$$

Finally, the gage pressure at the base of the column is P_3

$$\begin{aligned}
P_3 &= P_1 + P_2 + \gamma_3 h_3 = P_1 + P_2 + (SG_3)\rho_2 g h_3 \\
&= 1141.3\,\mathrm{N/m^2} + 1177.4\,\mathrm{N/m^2} \\
&\qquad (13.6)(1000\,\mathrm{kg/m^3})(9.81\,\mathrm{m/s^2})(0.08\,\mathrm{m})(1\,\mathrm{N\text{-}s^2/kg\text{-}m}) \\
&= 1141.3\,\mathrm{N/m^2} + 1177.2\,\mathrm{N/m^2} + 10{,}673.3\,\mathrm{N/m^2} \\
&= 12{,}991.8,\mathrm{N/m^2}
\end{aligned}$$

Hence with $1\,\mathrm{Pa} = 1\,\mathrm{N/m^2}$

(a) $P_3 = 12{,}991.8\,\mathrm{Pa} \Longleftarrow$
(b) $P_1 = 1141.3\,\mathrm{Pa} \Longleftarrow$
(c) $P_2 = 2318.5\,\mathrm{Pa} \Longleftarrow$

2.25: Can you determine the density of mercury from the observation that a pressure of 1.01325 bar supports a column of mercury that is 760 mm high?

Solution

<u>Assumptions and Specifications</u>

(1) The acceleration of gravity is $9.807\,\mathrm{m/s^2}$.
(2) The density of water is $1000\,\mathrm{kg/m^3}$.

Yes, here's how:

$$\rho = \frac{P}{gh} = \frac{101,325\,\mathrm{N/m^2})(1\,\mathrm{kg\text{-}m/s^2\text{-}N})}{9.807\,\mathrm{m/s^2})(0.760\,\mathrm{m})} = 13,595\,\mathrm{kg/m^3} \Longleftarrow$$

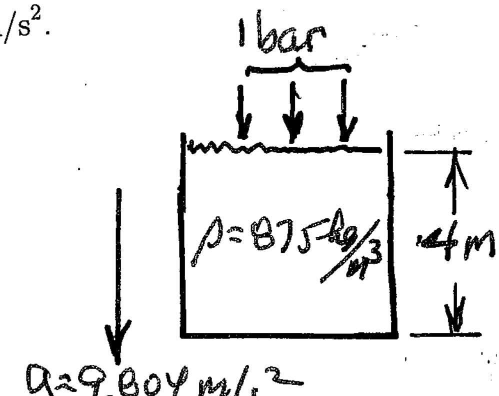
Notice that when we divide by the density of water, we obtain

$$SG = \frac{\rho}{\rho_W} = \frac{13,595\,\mathrm{kg/m^3}}{1000\,\mathrm{m/s^2}} = 13.6$$

which is the value tabulated in the handbooks.

■

2.26: Determine the absolute pressure exerted by a liquid having a depth of 4 m and a density of $875\,\mathrm{kg/m^3}$ when the atmospheric pressure is 1 bar and the acceleration of gravity is $9.804\,\mathrm{m/s^2}$.



Solution

<u>Assumptions and Specifications</u>

(1) The acceleration of gravity is specified as $9.804\,\mathrm{m/s^2}$.
(2) The density of the liquid is specified as $875\,\mathrm{kg/m^3}$.

Here

$$\begin{aligned} P_1 &= P_{atm} + \rho g h \\ &= 1\,\mathrm{bar} + (875\,\mathrm{kg/m^3})(9.804\,\mathrm{m/s^2})(4.0\,\mathrm{m})(1\,\mathrm{N\text{-}s^2/kg\text{-}m}) \\ &= 1\,\mathrm{bar} + 0.343\,\mathrm{bar} = 1.343\,\mathrm{bar} \Longleftarrow \end{aligned}$$

■

2.27: The pressure of a system is indicated by a pressure gage reading a vacuum pressure of 600 mbar when the atmospheric pressure is 1.025 bar. Determine the absolute pressure of the system.

Solution

Assumptions and Specifications

(1) An atmospheric pressure of 1.025 bar is specified.
(2) A gage pressure of 600 mbar (vac) is specified.

The system pressure is

$$P_{\text{sys}} = -0.600\,\text{bar} \quad \text{(vacuum)}$$

The atmospheric pressure is given as 1.025 bar. Hence, the absolute pressure will be

$$P_{\text{abs}} = -0.600\,\text{bar} + 1.025\,\text{bar} = 0.425\,\text{bar} \Longleftarrow$$

■

2.28: Figure 2P.28 shows a piston having a mass of 160 kg which is raised on the inside of a 40 cm diameter vertical cylinder. The lower end of the cylinder is held in a pool of water whose density is 1000 kg/m^3. The pool of water is exposed to the atmosphere at 1.034 bar and the acceleration of gravity is 9.76 m/s^2. If the water rises to a height of 6 m as shown and friction is to be neglected, find (a) the pull on the piston and (b) the pressure exerted by the water on the piston.

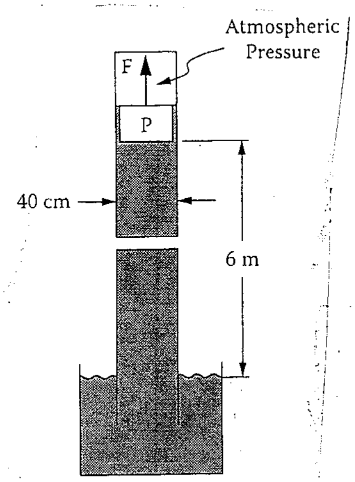


FIGURE P2.28

Solution

Assumptions and Specifications

(1) The acceleration of gravity is specified as 9.76 m/s^2.
(2) The density water is specified as 1000 kg/m^3.
(3) An atmospheric pressure of 1.034 bar is specified.
(4) Friction may be neglected.

Let the mass of the piston be m_P and the mass of the water be m_W. The area of the piston is

$$A = \frac{\pi}{4}d^2 = \frac{\pi}{4}(0.40\,\text{m})^2 = 0.1257\,\text{m}^2$$

and the volume of the water will be

$$V = Az = (0.1257\,\text{m}^2)(6\,\text{m}) = 0.7540\,\text{m}^3$$

The mass of water is

$$m_W = \rho V = (1000\,\text{kg/m}^3)(0.7540\,\text{m}^3) = 754\,\text{kg}$$

(a) The upward force required to lift the piston is F, Hence

$$\begin{aligned} F &= m_P g + m_W g = (m_P + m_W)g \\ &= (160\,\text{kg} + 754\,\text{kg})(9.76\,\text{m/s}^2) \\ &= (914\,\text{kg})(9.76\,\text{m/s}^2)(1\,\text{N-s}^2/\text{kg-m}) \\ &= 8920.6\,\text{N} \Longleftarrow \end{aligned}$$

(b) A force balance yields

$$PA + m_W g = p_{\text{atm}} A$$

so that

$$\begin{aligned} P &= P_{\text{atm}} - \frac{m_W g}{A} \\ &= 1.034\,\text{bar} - \frac{(754\ \text{kg})(9.76\,\text{m/s}^2)(1\,\text{N-s}^2/\text{kg-m})}{0.1257\,\text{m}^2} \\ &= 1.034\,\text{bar} - 0.586\,\text{bar} \\ &= 0.449\,\text{bar} \Longleftarrow \end{aligned}$$

■

2.29: A vertical tube contains 86 cm of mercury having a specific gravity of 13.6 and a layer of oil at a density of 875 g/m.[3] Taking the acceleration of gravity as $9.81\,\mathrm{m/s^2}$, determine the height of the oil layer if the tube is open to the atmosphere and the pressure at the bottom of the mercury layer is 1.225 bar

Solution

Assumptions and Specifications

(1) The acceleration of gravity is specified as $9.81\,\mathrm{m/s^2}$.
(2) The density of the oil layer is specified as $875\,\mathrm{kg/m^3}$.
(3) The specific gravity of the mercury is based on a water density, $\rho_w = 1000\,\mathrm{kg/m^3}$.

Let the subscripts 1 and 2 pertain to mercury and oil respectively. For the mercury layer

$$\begin{aligned} P_1 &= (SG_1)\rho_2 g h_1 \\ &= (13.6)(1000\,\mathrm{kg/m^3})(9.81\,\mathrm{m/s^2})(0.86\,\mathrm{m})(1\,\mathrm{N\text{-}s^2/kg\text{-}m}) \\ &= 1.147\,\mathrm{bar} \end{aligned}$$

The oil layer pressure contribution is P_2

$$P_2 = P - P_1 = 1.225\,\mathrm{bar} - 1.147\,\mathrm{bar} = 0.078\,\mathrm{bar}$$

With

$$P_2 = \rho_2 g h_2$$

the value of h_2 will be

$$\begin{aligned} h_2 &= \frac{P_2}{\rho_2 g} \\ &= \frac{0.078\,\mathrm{bar}}{(875\,\mathrm{kg/m^3})(9.81\,\mathrm{m/s^2})(1\,\mathrm{N\text{-}s^2/kg\text{-}m})} \\ &= 0.909\,\mathrm{m} \quad (90.9\,\mathrm{cm}) \Longleftarrow \end{aligned}$$

■

2.30: Determine the height of a column of water at a density of $1000\,\mathrm{kg/m^3}$ that can be supported by the atmosphere at 1.0135 bar with the acceleration of gravity equal to $9.807\,\mathrm{m/s^2}$.

Solution

Assumptions and Specifications

(1) The acceleration of gravity is specified as $9.807\,\mathrm{m/s^2}$.
(2) The density of water is specified as $1000\,\mathrm{kg/m^3}$.

From eq (2.17)

$$P = \rho g h$$

so that

$$h = \frac{P}{\rho g} = \frac{(1.0135 \times 10^5\,\mathrm{N/m^2})(1\,\mathrm{kg\text{-}m/N\text{-}s^2})}{(1000\,\mathrm{kg/m^3})(9.81\,\mathrm{m/s^2})} = 10.33\,\mathrm{m}$$

■

Temperature

■

2.31: At what point are the Celsius and Fahrenheit temperatures identical?

Solution

Assumptions and Specifications

(1) This is a temperature scale conversion problem and no assumptions are necessary.

Use eq (2.23b)

$$T_F = \frac{9}{5}T_C - 32\,°\mathrm{C}$$

and let $T_F = T_C$

$$\begin{aligned} T_C &= \frac{9}{5}T_C - 32\,°\mathrm{C} \\ -\frac{4}{5} &= 32\,°\mathrm{C} \\ T_C &= -40\,°\mathrm{C} \end{aligned}$$

and the result is

$$T_C = T_F = -40° \Longleftarrow$$

■

2.32: Fahrenheit and Celsius thermometers are immersed in a fluid and give readngs such that the Fahrenheit reading is 2.2 times the Celsius reading. Determine the two readings.

Solution

(1) This is a temperature scale conversion problem and no assumptions are necessary.

Use eq (2.23b)

$$T_F = \frac{9}{5}T_C + 32\,°\mathrm{C}$$

If $T_F = 2.2T_C = (11/5)T_C$, then

$$\begin{aligned}
\frac{11}{5}T_C &= \frac{9}{5}T_C + 32\,°\mathrm{C} \\
\frac{2}{5} &= 32\,°\mathrm{C} \\
T_C &= 80\,°\mathrm{C} \Longleftarrow
\end{aligned}$$

and

$$T_F = 2.2(80\,°\mathrm{C}) = 176\,°\mathrm{C} \Longleftarrow$$

■

2.33: Convert a reading of 77 °F to K.

Solution

(1) This is a temperature scale conversion problem and no assumptions are necessary.

Use eq (2.23a)

$$\begin{aligned}
T_C &= \frac{5}{9}(T_F - 32\,°\mathrm{F}) \\
&= \frac{5}{9}(77\,°\mathrm{F} - 32\,°\mathrm{F}) \\
&= \frac{5}{9}(45\,°\mathrm{F}) \\
&= 25\,°\mathrm{C}
\end{aligned}$$

Then

$$
\begin{aligned}
K &= 273 + T_C \\
&= 273\,\mathrm{K} + 25\,^\circ\mathrm{C} \\
&= 298\,\mathrm{K} \Longleftarrow
\end{aligned}
$$

■

2.34: Convert a reading of 86 °C to °R.

Solution

(1) This is a temperature scale conversion problem and no assumptions are necessary.

Use eq (2.23b)

$$
\begin{aligned}
T_F &= \frac{9}{5}(T_C) + 32\,^\circ\mathrm{F} \\
&= \frac{9}{5}(85\,^\circ\mathrm{C}) + 32\,^\circ\mathrm{F} \\
&= 153\,^\circ\mathrm{F} + 32\,^\circ\mathrm{F} \\
&= 185\,^\circ\mathrm{F}
\end{aligned}
$$

Then

$$
\begin{aligned}
^\circ\mathrm{R} &= 460 + T_F \\
&= 460^\circ R + 185\,^\circ\mathrm{F} \\
&= 645^\circ\mathrm{R} \Longleftarrow
\end{aligned}
$$

■

2.35: A new proposed absolute temperature scale is known as the **Beaver scale** (°B). In the Beaver scale, water turns to ice at 6279°B. Determine (a) the boiling point of water and (b) the temperature in °C at 10, 810°B.

Solution

(1) This is a temperature scale conversion problem and no assumptions are necessary.

Here

$$\begin{aligned} 273\,°\text{C} &\longrightarrow 6279°\,\text{B} \\ 1\,°\text{C} &\longrightarrow 23°\,\text{B} \end{aligned}$$

(a) The boiling point of water in °B will be

$$°\text{B} = 23(373\,\text{K}) = 8579°\,\text{B} \Longleftarrow$$

(b) A temperature of 10, 810°B will be

$$K = \frac{10,810°\,\text{B}}{23\,°\text{B/K}} = 470\,\text{K}$$

or

$$T_C = 470\,\text{K} = 197\,°\text{C} \Longleftarrow$$

■

2.36: Define a new linear temperature scale, say °Z, where the freezing and boiling points of water are 200°Z and 500°Z. Determine a correlation between the Z scale and the Celsius scale.

Solution

(1) This is a temperature scale conversion problem and no assumptions are necessary.

We have the data

$$\begin{aligned} 0\,°\text{C} &\longrightarrow 200°\,\text{Z} \\ 100\,°\text{C} &\longrightarrow 500°\,\text{Z} \end{aligned}$$

For a linear temperature scale

$$Z = mC + b$$

we obtain a pair of equations in the two unknowns, C and Z

$$\begin{aligned} 0 &= 200m + b\,°\text{C} \\ 100 &= 500m + b\,°\text{C} \end{aligned}$$

Subtract the first equation from the second to obtain

$$300m = 100\,^{\circ}\mathrm{C}$$

or

$$m = \frac{1}{3}\,^{\circ}\mathrm{C}/^{\circ}\mathrm{Z}$$

and from the first equation we have

$$b = -\frac{200}{3}\,^{\circ}\mathrm{C}$$

Thus, the required correlation is

$$T_C = \frac{1}{3}T_Z - \frac{200}{3}\,^{\circ}\mathrm{C} \Longleftarrow$$

■

2.37: An element boils at 480 °C. Using the Z scale developed in Problem 2.36, determine the boiling point in ° Z.

Solution

(1) This is a temperature scale conversion problem and no assumptions are necessary.

For a substance boiling at 480 °C

$$\begin{aligned}
T_C &= \frac{1}{3}T_Z - \frac{200}{3}\,^{\circ}\mathrm{C} \\
480\,^{\circ}\mathrm{C} &= \frac{1}{3}T_Z - \frac{200}{3}\,^{\circ}\mathrm{C} \\
^{\circ}\mathrm{Z} &= 3(480\,^{\circ}\mathrm{C}) + 200\,^{\circ}\mathrm{Z} \\
&= 1440^{\circ}Z + 200^{\circ}Z \\
&= 1640^{\circ}Z \Longleftarrow
\end{aligned}$$

■

2.38: If a substance boils at 800°Z (Problem 2.36), determine the boiling point in °C.

Solution

(1) This is a temperature scale conversion problem
and no assumptions are necessary.

$$\begin{aligned} T_C &= \frac{1}{3}T_Z - \frac{200}{3}\,{}^\circ\mathrm{C} \\ &= \frac{1}{3}800^\circ\mathrm{Z} - \frac{200}{3}\,{}^\circ\mathrm{C} \\ &= \frac{1}{3}(800\,{}^\circ\mathrm{C} - 200\,{}^\circ\mathrm{C}) \\ &= \frac{1}{3}(600\,{}^\circ\mathrm{C}) \\ &= 200\,{}^\circ\mathrm{C} \end{aligned}$$

■

2.39: Determine the Celsius equivalent of 248 °F.

Solution

(1) This is a temperature scale conversion problem
and no assumptions are necessary.

Use eq (2.23a)

$$T_C = \frac{5}{9}(T_F - 32\,{}^\circ\mathrm{F})$$

Then

$$\begin{aligned} T_C &= \frac{5}{9}(248\,{}^\circ\mathrm{F} - 32\,{}^\circ\mathrm{F}) \\ &= \frac{5}{9}(216\,{}^\circ\mathrm{F}) \\ &= 120\,{}^\circ\mathrm{C} \Longleftarrow \end{aligned}$$

■

2.40: Determine the Fahrenheit equivalent of 380 °C.

Solution

(1) This is a temperature scale conversion problem
and no assumptions are necessary.

Use eq (2.23b)

$$\begin{aligned} T_F &= \frac{9}{5}T_C + 32\,^\circ\mathrm{F} \\ &= \frac{9}{5}(380\,^\circ\mathrm{C}) + 32\,^\circ\mathrm{F}\,^\circ\mathrm{C} \\ &= 684\,^\circ\mathrm{F} + 32\,^\circ\mathrm{F} \\ &= 716\,^\circ\mathrm{F} \Longleftarrow \end{aligned}$$