SOLUTION MANUAL CONTENTS

1–1.

Round off the following numbers to three significant figures: (a) 58 342 m, (b) 68.534 s, (c) 2553 N, and (d) 7555 kg.

SOLUTION

a) 58.3 km b) 68.5 s c) 2.55 kN d) 7.56 Mg **Ans.**

1–2.

Wood has a density of 4.70 slug/ft^3. What is its density expressed in SI units?

SOLUTION

$$(4.70 \text{ slug/ft}^3)\left\{\frac{(1 \text{ ft}^3)(14.59 \text{ kg})}{(0.3048 \text{ m})^3(1 \text{ slug})}\right\} = 2.42 \text{ Mg/m}^3$$ **Ans.**

1–3.

Represent each of the following combinations of units in the correct SI form using an appropriate prefix: (a) kN/μs, (b) Mg/mN, and (c) MN/(kg · ms).

SOLUTION

a) $\text{kN}/\mu\text{s} = \dfrac{(10^3)\ \text{N}}{(10^{-6})\ \text{s}} = \dfrac{(10^9)\ \text{N}}{\text{s}} = \text{GN/s}$ **Ans.**

b) $\text{Mg/mN} = \dfrac{(10^6)\ \text{g}}{(10^{-3})\ \text{N}} = \dfrac{(10^9)\ \text{g}}{\text{N}} = \text{Gg/N}$ **Ans.**

c) $\text{MN}/(\text{kg} \cdot \text{ms}) = \dfrac{(10^6)\ \text{N}}{\text{kg} \cdot (10^{-3})\ \text{s}} = \dfrac{(10^9)\ \text{N}}{\text{kg} \cdot \text{s}} = \text{GN}/(\text{kg} \cdot \text{s})$ **Ans.**

***1–4.**

Represent each of the following combinations of units in the correct SI form using an appropriate prefix: (a) m/ms, (b) μkm, (c) ks/mg, and (d) km $\cdot$ μN.

SOLUTION

a) $\text{m/ms} = \left(\dfrac{\text{m}}{(10)^{-3}\,\text{s}}\right) = \left(\dfrac{(10)^3\,\text{m}}{\text{s}}\right) = \text{km/s}$ **Ans.**

b) $\mu\text{km} = (10)^{-6}(10)^3\,\text{m} = (10)^{-3}\,\text{m} = \text{mm}$ **Ans.**

c) $\text{ks/mg} = \left(\dfrac{(10)^3\,\text{s}}{(10)^{-6}\,\text{kg}}\right) = \left(\dfrac{(10)^9\,\text{s}}{\text{kg}}\right) = \text{Gs/kg}$ **Ans.**

d) $\text{km}\cdot\mu\text{N} = [(10)^3\,\text{m}][(10)^{-6}\,\text{N}] = (10)^{-3}\,\text{m}\cdot\text{N} = \text{mm}\cdot\text{N}$ **Ans.**

1–5.

Represent each of the following quantities in the correct SI form using an appropriate prefix: (a) 0.000 431 kg, (b) $35.3(10^3)$ N, and (c) 0.005 32 km.

SOLUTION

a) $0.000\,431\text{ kg} = 0.000\,431\left(10^3\right)\text{ g} = 0.431\text{ g}$ **Ans.**

b) $35.3\left(10^3\right)\text{ N} = 35.3\text{ kN}$ **Ans.**

c) $0.005\,32\text{ km} = 0.005\,32\left(10^3\right)\text{ m} = 5.32\text{ m}$ **Ans.**

1–6.

If a car is traveling at 55 mi/h, determine its speed in kilometers per hour and meters per second.

SOLUTION

$$55 \text{ mi/h} = \left(\frac{55 \text{ mi}}{1 \text{ h}}\right)\left(\frac{5280 \text{ ft}}{1 \text{ mi}}\right)\left(\frac{0.3048 \text{ m}}{1 \text{ ft}}\right)\left(\frac{1 \text{ km}}{1000 \text{ m}}\right)$$

$$= 88.5 \text{ km/h} \qquad \textbf{Ans.}$$

$$88.5 \text{ km/h} = \left(\frac{88.5 \text{ km}}{1 \text{ h}}\right)\left(\frac{1000 \text{ m}}{1 \text{ km}}\right)\left(\frac{1 \text{ h}}{3600 \text{ s}}\right) = 24.6 \text{ m/s} \qquad \textbf{Ans.}$$

1–7.

The *pascal* (Pa) is actually a very small unit of pressure. To show this, convert $1\ \text{Pa} = 1\ \text{N/m}^2$ to lb/ft^2. Atmospheric pressure at sea level is $14.7\ \text{lb/in}^2$. How many pascals is this?

SOLUTION

Using Table 1–2, we have

$$1\ \text{Pa} = \frac{1\ \text{N}}{\text{m}^2}\left(\frac{1\ \text{lb}}{4.4482\ \text{N}}\right)\left(\frac{0.3048^2\ \text{m}^2}{1\ \text{ft}^2}\right) = 20.9\left(10^{-3}\right)\ \text{lb/ft}^2 \qquad \textbf{Ans.}$$

$$1\ \text{ATM} = \frac{14.7\ \text{lb}}{\text{in}^2}\left(\frac{4.448\ \text{N}}{1\ \text{lb}}\right)\left(\frac{144\ \text{in}^2}{1\ \text{ft}^2}\right)\left(\frac{1\ \text{ft}^2}{0.3048^2\ \text{m}^2}\right)$$

$$= 101.3\left(10^3\right)\ \text{N/m}^2$$

$$= 101\ \text{kPa} \qquad \textbf{Ans.}$$

***1–8.**

The specific weight (wt./vol.) of brass is $520\ \text{lb/ft}^3$. Determine its density (mass/vol.) in SI units. Use an appropriate prefix.

SOLUTION

$$520\ \text{lb/ft}^3 = \left(\frac{520\ \text{lb}}{\text{ft}^3}\right)\left(\frac{1\ \text{ft}}{0.3048\ \text{m}}\right)^3\left(\frac{4.448\ \text{N}}{1\ \text{lb}}\right)\left(\frac{1\ \text{kg}}{9.81\ \text{N}}\right)$$

$$= 8.33\ \text{Mg/m}^3 \qquad \textbf{Ans.}$$

1–9.

A rocket has a mass of $250(10^3)$ slugs on earth. Specify (a) its mass in SI units and (b) its weight in SI units. If the rocket is on the moon, where the acceleration due to gravity is $g_m = 5.30\ \text{ft/s}^2$, determine to three significant figures (c) its weight in SI units and (d) its mass in SI units.

SOLUTION

Using Table 1–2 and applying Eq. 1–3, we have

a) $250\left(10^3\right)\text{ slugs} = \left[250\left(10^3\right)\text{ slugs}\right]\left(\dfrac{14.59\text{ kg}}{1\text{ slugs}}\right)$

$= 3.6475\left(10^6\right)\text{ kg}$

$= 3.65\text{ Gg}$ **Ans.**

b) $W_e = mg = \left[3.6475\left(10^6\right)\text{ kg}\right]\left(9.81\text{ m/s}^2\right)$

$= 35.792\left(10^6\right)\text{ kg}\cdot\text{m/s}^2$

$= 35.8\text{ MN}$ **Ans.**

c) $W_m = mg_m = \left[250\left(10^3\right)\text{ slugs}\right]\left(5.30\text{ ft/s}^2\right)$

$= \left[1.325\left(10^6\right)\text{ lb}\right]\left(\dfrac{4.448\text{ N}}{1\text{ lb}}\right)$

$= 5.894\left(10^6\right)\text{ N} = 5.89\text{ MN}$ **Ans.**

Or

$$W_m = W_e\left(\frac{g_m}{g}\right) = (35.792\text{ MN})\left(\frac{5.30\text{ ft/s}^2}{32.2\text{ ft/s}^2}\right) = 5.89\text{ MN}$$

d) Since the mass is independent of its location, then

$m_m = m_e = 3.65\left(10^6\right)\text{ kg} = 3.65\text{ Gg}$ **Ans.**

1–10.

Evaluate each of the following to three significant figures and express each answer in SI units using an appropriate prefix: (a) $(0.631\ \text{Mm})/(8.60\ \text{kg})^2$, (b) $(35\ \text{mm})^2(48\ \text{kg})^3$.

SOLUTION

a) $$(0.631\ \text{Mm})/(8.60\ \text{kg})^2 = \left(\frac{0.631\left(10^6\right)\text{m}}{(8.60)^2\ \text{kg}^2}\right) = \frac{8532\ \text{m}}{\text{kg}^2}$$

$$= 8.53\left(10^3\right)\text{m/kg}^2 = 8.53\ \text{km/kg}^2 \qquad \textbf{Ans.}$$

b) $$(35\ \text{mm})^2(48\ \text{kg})^3 = \left[35\left(10^{-3}\right)\text{m}\right]^2(48\ \text{kg})^3 = 135\ \text{m}^2\cdot\text{kg}^3 \qquad \textbf{Ans.}$$

1–11.

Evaluate each of the following to three significant figures and express each answer in Sl units using an appropriate prefix: (a) 354 mg(45 km)/(0.0356 kN), (b) (0.004 53 Mg) (201 ms), and (c) 435 MN/23.2 mm.

SOLUTION

a) $(354\text{ mg})(45\text{ km})/(0.0356\text{ kN}) = \dfrac{\left[354\left(10^{-3}\right)\text{ g}\right]\left[45\left(10^{3}\right)\text{ m}\right]}{0.0356\left(10^{3}\right)\text{ N}}$

$= \dfrac{0.447\left(10^{3}\right)\text{ g}\cdot\text{m}}{\text{N}}$

$= 0.447\text{ kg}\cdot\text{m/N}$ **Ans.**

b) $(0.00453\text{ Mg})(201\text{ ms}) = \left[4.53\left(10^{-3}\right)\left(10^{3}\right)\text{ kg}\right]\left[201\left(10^{-3}\right)\text{ s}\right]$

$= 0.911\text{ kg}\cdot\text{s}$ **Ans.**

c) $435\text{ MN}/23.2\text{ mm} = \dfrac{435\left(10^{6}\right)\text{ N}}{23.2\left(10^{-3}\right)\text{ m}} = \dfrac{18.75\left(10^{9}\right)\text{ N}}{\text{m}} = 18.8\text{ GN/m}$ **Ans.**

***1–12.**

Convert each of the following and express the answer using an appropriate prefix: (a) 175 lb/ft^3 to kN/m^3, (b) 6 ft/h to mm/s, and (c) 835 lb · ft to kN · m.

SOLUTION

a) $175\ \text{lb/ft}^3 = \left(\frac{175\ \text{lb}}{\text{ft}^3}\right)\left(\frac{1\ \text{ft}}{0.3048\ \text{m}}\right)^3\left(\frac{4.448\ \text{N}}{1\ \text{lb}}\right)$

$= \left(\frac{27.5(10)^3\ \text{N}}{\text{m}^3}\right) = 27.5\ \text{kN/m}^3$ **Ans.**

b) $6\ \text{ft/h} = \left(\frac{6\ \text{ft}}{1\ \text{h}}\right)\left(\frac{0.3048\ \text{m}}{1\ \text{ft}}\right)\left(\frac{1\ \text{h}}{3600\ \text{s}}\right)$

$= 0.508(10)^{-3}\ \text{m/s} = 0.508\ \text{mm/s}$ **Ans.**

c) $835\ \text{lb} \cdot \text{ft} = (835\ \text{lb} \cdot \text{ft})\left(\frac{4.448\ \text{N}}{1\ \text{lb}}\right)\left(\frac{0.3048\ \text{m}}{1\ \text{ft}}\right)$

$= 1.13(10)^3\ \text{N} \cdot \text{m} = 1.13\ \text{kN} \cdot \text{m}$ **Ans.**

1–13.

Convert each of the following to three significant figures: (a) $20\ \text{lb}\cdot\text{ft}$ to $\text{N}\cdot\text{m}$, (b) $450\ \text{lb/ft}^3$ to kN/m^3, and (c) 15 ft/h to mm/s.

SOLUTION

Using Table 1–2, we have

a) $$20\ \text{lb}\cdot\text{ft} = (20\ \text{lb}\cdot\text{ft})\left(\frac{4.448\ \text{N}}{1\ \text{lb}}\right)\left(\frac{0.3048\ \text{m}}{1\ \text{ft}}\right)$$

$$= 27.1\ \text{N}\cdot\text{m}$$ **Ans.**

b) $$450\ \text{lb/ft}^3 = \left(\frac{450\ \text{lb}}{1\ \text{ft}^3}\right)\left(\frac{4.448\ \text{N}}{1\ \text{lb}}\right)\left(\frac{1\ \text{kN}}{1000\ \text{N}}\right)\left(\frac{1\ \text{ft}^3}{0.3048^3\ \text{m}^3}\right)$$

$$= 70.7\ \text{kN/m}^3$$ **Ans.**

c) $$15\ \text{ft/h} = \left(\frac{15\ \text{ft}}{1\ \text{h}}\right)\left(\frac{304.8\ \text{mm}}{1\ \text{ft}}\right)\left(\frac{1\ \text{h}}{3600\ \text{s}}\right) = 1.27\ \text{mm/s}$$ **Ans.**

1–14.

Evaluate each of the following and express with an appropriate prefix: (a) $(430\text{ kg})^2$, (b) $(0.002\text{ mg})^2$, and (c) $(230\text{ m})^3$.

SOLUTION

a) $(430\text{ kg})^2 = 0.185(10^6)\text{ kg}^2 = 0.185\text{ Mg}^2$ **Ans.**

b) $(0.002\text{ mg})^2 = [2(10^{-6})\text{ g}]^2 = 4\ \mu\text{g}^2$ **Ans.**

c) $(230\text{ m})^3 = [0.23(10^3)\text{ m}]^3 = 0.0122\text{ km}^3$ **Ans.**

1–15.

Determine the mass of an object that has a weight of (a) 20 mN, (b) 150 kN, and (c) 60 MN. Express the answer to three significant figures.

SOLUTION

Applying Eq. 1–3, we have

a) $m = \dfrac{W}{g} = \dfrac{20\left(10^{-3}\right)\ \text{kg} \cdot \text{m/s}^2}{9.81\ \text{m/s}^2} = 2.04\ \text{g}$ **Ans.**

b) $m = \dfrac{W}{g} = \dfrac{150\left(10^{3}\right)\ \text{kg} \cdot \text{m/s}^2}{9.81\ \text{m/s}^2} = 15.3\ \text{Mg}$ **Ans.**

c) $m = \dfrac{W}{g} = \dfrac{60\left(10^{6}\right)\ \text{kg} \cdot \text{m/s}^2}{9.81\ \text{m/s}^2} = 6.12\ \text{Gg}$ **Ans.**

***1–16.**

What is the weight in newtons of an object that has a mass of: (a) 10 kg, (b) 0.5 g, and (c) 4.50 Mg? Express the result to three significant figures. Use an appropriate prefix.

SOLUTION

a) $W = \left(9.81\ \text{m/s}^2\right)(10\ \text{kg}) = 98.1\ \text{N}$ **Ans.**

b) $W = \left(9.81\ \text{m/s}^2\right)(0.5\ \text{g})(10^{-3}\ \text{kg/g}) = 4.90\ \text{mN}$ **Ans.**

c) $W = \left(9.81\ \text{m/s}^2\right)(4.5\ \text{Mg})\left(10^3\ \text{kg/Mg}\right) = 44.1\ \text{kN}$ **Ans.**

1–17.

If an object has a mass of 40 slugs, determine its mass in kilograms.

SOLUTION

$$40 \text{ slugs } (14.59 \text{ kg/slug}) = 584 \text{ kg}$$ **Ans.**

1–18.

Using the SI system of units, show that Eq. 1–2 is a dimensionally homogeneous equation which gives F in newtons. Determine to three significant figures the gravitational force acting between two spheres that are touching each other. The mass of each sphere is 200 kg and the radius is 300 mm.

SOLUTION

Using Eq. 1–2,

$$F = G\frac{m_1 m_2}{r^2}$$

$$\mathrm{N} = \left(\frac{\mathrm{m}^3}{\mathrm{kg}\cdot\mathrm{s}^2}\right)\left(\frac{\mathrm{kg}\cdot\mathrm{kg}}{\mathrm{m}^2}\right) = \frac{\mathrm{kg}\cdot\mathrm{m}}{\mathrm{s}^2} \qquad \textit{(Q.E.D.)}$$

$$F = G\frac{m_1 m_2}{r^2}$$

$$= 66.73\left(10^{-12}\right)\left[\frac{200(200)}{0.6^2}\right]$$

$$= 7.41\left(10^{-6}\right)\mathrm{N} = 7.41\ \mu\mathrm{N} \qquad \textbf{Ans.}$$

1–19.

Water has a density of 1.94 slug/ft^3. What is the density expressed in SI units? Express the answer to three significant figures.

SOLUTION

$$\rho_w = \left(\frac{1.94 \text{ slug}}{1 \text{ ft}^3}\right)\left(\frac{14.59 \text{ kg}}{1 \text{ slug}}\right)\left(\frac{1 \text{ ft}^3}{0.3048^3 \text{ m}^3}\right)$$

$$= 999.6 \text{ kg/m}^3 = 1.00 \text{ Mg/m}^3 \qquad \textbf{Ans.}$$

***1–20.**

Two particles have a mass of 8 kg and 12 kg, respectively. If they are 800 mm apart, determine the force of gravity acting between them. Compare this result with the weight of each particle.

SOLUTION

$$F = G\frac{m_1 m_2}{r^2}$$

Where $G = 66.73\left(10^{-12}\right)\ \text{m}^3/(\text{kg}\cdot\text{s}^2)$

$$F = 66.73\left(10^{-12}\right)\left[\frac{8(12)}{(0.8)^2}\right] = 10.0\left(10^{-9}\right)\text{N} = 10.0\ \text{nN}$$ **Ans.**

$$W_1 = 8(9.81) = 78.5\ \text{N}$$ **Ans.**

$$W_2 = 12(9.81) = 118\ \text{N}$$ **Ans.**

1–21.

If a man weighs 155 lb on earth, specify (a) his mass in slugs, (b) his mass in kilograms, and (c) his weight in newtons. If the man is on the moon, where the acceleration due to gravity is $g_m = 5.30\ \text{ft/s}^2$, determine (d) his weight in pounds, and (e) his mass in kilograms.

SOLUTION

a) $m = \dfrac{155}{32.2} = 4.81\ \text{slug}$ **Ans.**

b) $m = 155\left[\dfrac{14.59\ \text{kg}}{32.2}\right] = 70.2\ \text{kg}$ **Ans.**

c) $W = 155(4.4482) = 689\ \text{N}$ **Ans.**

d) $W = 155\left[\dfrac{5.30}{32.2}\right] = 25.5\ \text{lb}$ **Ans.**

e) $m = 155\left[\dfrac{14.59\ \text{kg}}{32.2}\right] = 70.2\ \text{kg}$ **Ans.**

Also,

$m = 25.5\left[\dfrac{14.59\ \text{kg}}{5.30}\right] = 70.2\ \text{kg}$ **Ans.**