1–1.

What is the weight in newtons of an object that has a mass of (a) 8 kg, (b) 0.04 kg, (c) 760 Mg?

SOLUTION

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

(b) $W = 9.81(0.04)\left(10^{-3}\right) = 3.92\left(10^{-4}\right)\ \text{N} = 0.392\ \text{mN}$ **Ans.**

(c) $W = 9.81(760)\left(10^{3}\right) = 7.46\left(10^{6}\right)\ \text{N} = 7.46\ \text{MN}$ **Ans.**

Ans:
78.5 N
0.392 mN
7.46 MN

1–2.

Represent each of the following combinations of units in the correct SI form using an appropriate prefix: (a) $kN/\mu s$, (b) Mg/mN, (c) $MN/(kg \cdot ms)$.

SOLUTION

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

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

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

Ans:
GN/s
Gg/N
$GN/(kg \cdot s)$

1–3.

Represent each of the following combinations of units in the correct SI form: (a) Mg/ms, (b) N/mm, (c) mN/(kg · μs).

SOLUTION

(a) $$\frac{\text{Mg}}{\text{ms}} = \frac{10^3\,\text{kg}}{10^{-3}\,\text{s}} = 10^6\,\text{kg/s} = \text{Gg/s}$$ **Ans.**

(b) $$\frac{\text{N}}{\text{mm}} = \frac{1\,\text{N}}{10^{-3}\,\text{m}} = 10^3\,\text{N/m} = \text{kN/m}$$ **Ans.**

(c) $$\frac{\text{mN}}{(\text{kg}\cdot\mu\text{s})} = \frac{10^{-3}\,\text{N}}{10^{-6}\,\text{kg}\cdot\text{s}} = \text{kN/(kg}\cdot\text{s)}$$ **Ans.**

Ans:
Gg/s
kN/m
kN/(kg · s)

***1–4.**

Convert: (a) 200 lb · ft to N · m, (b) 350 lb/ft^3 to kN/m^3, (c) 8 ft/h to mm/s. Express the result to three significant figures. Use an appropriate prefix.

SOLUTION

(a) $(200\ \text{lb} \cdot\ \text{ft})\left(\frac{4.4482\ \text{N}}{1\ \text{lb}}\right)\left(\frac{0.3048\ \text{m}}{1\ \text{ft}}\right) = 271\ \text{N} \cdot \text{m}$ **Ans.**

(b) $\left(\frac{350\ \text{lb}}{1\ \text{ft}^3}\right)\left(\frac{1\ \text{ft}}{0.3048\ \text{m}}\right)^3\left(\frac{4.4482\ \text{N}}{1\ \text{lb}}\right) = 55.0\ \text{kN/m}^3$ **Ans.**

(c) $\left(\frac{8\ \text{ft}}{1\ \text{h}}\right)\left(\frac{1\ \text{h}}{3600\ \text{s}}\right)\left(\frac{0.3048\ \text{m}}{1\ \text{ft}}\right) = 0.677\ \text{mm/s}$ **Ans.**

Ans:
271 N · m
55.0 kN/m^3
0.677 mm/s

1–5.

Represent each of the following as a number between 0.1 and 1000 using an appropriate prefix: (a) 45 320 kN, (b) $568(10^5)$ mm, (c) 0.00563 mg.

SOLUTION

(a) $45\,320\text{ kN} = 45.3\text{ MN}$ **Ans.**

(b) $568(10^5)\text{ mm} = 56.8\text{ km}$ **Ans.**

(c) $0.00563\text{ mg} = 5.63\ \mu\text{g}$ **Ans.**

Ans:
45.3 MN
56.8 km
5.63 μg

1–6.

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

SOLUTION

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

Ans:
58.3 km
68.5 s
2.55 kN
7.56 Mg

1–7.

Represent each of the following quantities in the correct SI form using an appropriate prefix: (a) 0.000 431 kg, (b) $35.3\left(10^3\right)$ N, (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.**

Ans:
0.431 g
35.3 kN
5.32 m

***1–8.**

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

SOLUTION

(a) $\text{Mg/mm} = \dfrac{10^3\,\text{kg}}{10^{-3}\text{m}} = \dfrac{10^6\,\text{kg}}{\text{m}} = \text{Gg/m}$ **Ans.**

(b) $\text{mN}/\mu\text{s} = \dfrac{10^{-3}\,\text{N}}{10^{-6}\,\text{s}} = \dfrac{10^3\,\text{N}}{\text{s}} = \text{kN/s}$ **Ans.**

(c) $\mu\text{m} \cdot \text{Mg} = \left[10^{-6}\,\text{m}\right] \cdot \left[10^3\,\text{kg}\right] = (10)^{-3}\,\text{m} \cdot \text{kg}$

$= \text{mm} \cdot \text{kg}$ **Ans.**

Ans:
Gg/m
kN/s
mm · kg

1–9.

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, (d) km · 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.**

Ans:
km/s
mm
Gs/kg
mm · N

1–10.

Represent each of the following combinations of units in the correct SI form using an appropriate prefix: (a) $\mathrm{GN \cdot \mu m}$, (b) $\mathrm{kg/\mu m}$, (c) $\mathrm{N/ks^2}$, and (d) $\mathrm{kN/\mu s}$.

SOLUTION

(a) $\mathrm{GN \cdot \mu m} = 10^9(10^{-6})\ \mathrm{N \cdot m} = \mathrm{kN \cdot m}$ **Ans.**

(b) $\mathrm{kg/\mu m} = 10^3\ \mathrm{g}/10^{-6}\ \mathrm{m} = \mathrm{Gg/m}$ **Ans.**

(c) $\mathrm{N/ks^2} = \mathrm{N}/10^6\ \mathrm{s^2} = 10^{-6}\ \mathrm{N/s^2} = \mu\mathrm{N/s^2}$ **Ans.**

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

Ans:
$\mathrm{kN \cdot m}$
$\mathrm{Gg/m}$
$\mu\mathrm{N/s^2}$
$\mathrm{GN/s}$

1–11.

Represent each of the following with SI units having an appropriate prefix: (a) 8653 ms, (b) 8368 N, (c) 0.893 kg.

SOLUTION

(a) $8653\ \text{ms} = 8.653(10)^3(10^{-3})\ \text{s} = 8.653\ \text{s}$ **Ans.**

(b) $8368\ \text{N} = 8.368\ \text{kN}$ **Ans.**

(c) $0.893\ \text{kg} = 893(10^{-3})(10^3)\ \text{g} = 893\ \text{g}$ **Ans.**

Ans:
8.653 s
8.368 kN
893 g

***1–12.**

Evaluate each of the following to three significant figures and express each answer in SI units using an appropriate prefix: (a) (684 μm)/(43 ms), (b) (28 ms)(0.0458 Mm)/(348 mg), (c) (2.68 mm)(426 Mg).

SOLUTION

(a) $(684\ \mu\text{m})/43\ \text{ms} = \dfrac{684(10^{-6})\ \text{m}}{43(10^{-3})\ \text{s}} = \dfrac{15.9(10^{-3})\ \text{m}}{\text{s}}$

$= 15.9\ \text{mm/s}$ **Ans.**

(b) $(28\ \text{ms})(0.0458\ \text{Mm})/(348\ \text{mg}) = \dfrac{\left[28(10^{-3})\ \text{s}\right]\left[45.8(10^{-3})(10)^{6}\ \text{m}\right]}{348(10^{-3})(10^{-3})\ \text{kg}}$

$= \dfrac{3.69(10^{6})\ \text{m}\cdot\text{s}}{\text{kg}} = 3.69\ \text{Mm}\cdot\ \text{s/kg}$ **Ans.**

(c) $(2.68\ \text{mm})(426\ \text{Mg}) = \left[2.68\left(10^{-3}\right)\ \text{m}\right]\left[426\left(10^{3}\right)\ \text{kg}\right]$

$= 1.14\left(10^{3}\right)\ \text{m}\cdot\ \text{kg} = 1.14\ \text{km}\cdot\text{kg}$ **Ans.**

Ans:
15.9 mm/s
3.69 Mm · s/kg
1.14 km · kg

1–13.

Convert each of the following to three significant figures. (a) 20 lb · ft to N · m, (b) 450 lb/ft^3 to kN/m^3, (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.**

Ans:
27.1 N · m
70.7 kN/m^3
1.27 mm/s

1–14.

Evaluate each of the following to three significant figures and express each answer in SI units using an appropriate prefix: (a) $(212\ \text{mN})^2$, (b) $(52\,800\ \text{ms})^2$, (c) $[548(10^6)]^{1/2}\ \text{ms}$.

SOLUTION

(a) $(212\ \text{mN})^2 = \left[212(10)^{-3}\ \text{N}\right]^2 = 0.0449\ \text{N}^2 = 44.9(10)^{-3}\ \text{N}^2$ **Ans.**

(b) $(52\,800\ \text{ms})^2 = \left[52\,800(10)^{-3}\right]^2\ \text{s}^2 = 2788\ \text{s}^2 = 2.79\left(10^3\right)\ \text{s}^2$ **Ans.**

(c) $\left[548(10)^6\right]^{\frac{1}{2}}\ \text{ms} = (23\,409)(10)^{-3}\ \text{s} = 23.4(10)^3(10)^{-3}\ \text{s} = 23.4\ \text{s}$ **Ans.**

Ans:
$44.9(10)^{-3}\ \text{N}^2$
$2.79\left(10^3\right)\ \text{s}^2$
$23.4\ \text{s}$

1–15.

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,

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

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

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

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

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

Ans:
7.41 μN

***1–16.**

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

SOLUTION

Using Table 1–2, we have

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

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

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

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

Ans:
$20.9\left(10^{-3}\right)\ \text{lb/ft}^2$
101 kPa

1–17.

What is the weight in newtons of an object that has a mass of: (a) 10 kg, (b) 0.5 g, (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.**

Ans:
98.1 N
4.90 mN
44.1 kN

1–18.

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

SOLUTION

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

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

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

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

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

(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.**

Ans:
0.447 kg · m/N
0.911 kg · s
18.8 GN/m

1–19.

A concrete column has a diameter of 350 mm and a length of 2 m. If the density (mass/volume) of concrete is 2.45 Mg/m^3, determine the weight of the column in pounds.

SOLUTION

$$V = \pi r^2 h = \pi\left(\tfrac{0.35}{2}\text{ m}\right)^2 (2\text{ m}) = 0.1924\text{ m}^3$$

$$m = \rho V = \left(\frac{2.45(10^3)\text{kg}}{\text{m}^3}\right)\left(0.1924\text{ m}^3\right) = 471.44\text{ kg}$$

$$W = mg = (471.44\text{ kg})\left(9.81\text{ m/s}^2\right) = 4.6248\left(10^3\right)\text{ N}$$

$$W = \left[4.6248\left(10^3\right)\text{ N}\right]\left(\frac{1\text{ lb}}{4.4482\text{ N}}\right) = 1.04\text{ kip}$$ **Ans.**

Ans:
1.04 kip

***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.**

Ans:
$F = 10.0\ \text{nN}$
$W_1 = 78.5\ \text{N}$
$W_2 = 118\ \text{N}$

1–21.

If a man weighs 155 lb on earth, specify (a) his mass in kilograms, and (b) 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 (c) his weight in pounds, and (d) his mass in kilograms.

SOLUTION

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

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

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

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

Also,

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

Ans:
70.2 kg
689 N
25.5 lb
$m = 70.2$ kg