Solutions for Engineering Mechanics Statics 15th Edition by Hibbeler

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Solutions

1–1.

Round off the following numbers to three significant figures: (a) 3.45555 m, (b) 45.556 s, (c) 5555 N, (d) 4525 kg.

SOLUTION

(a) 3.46 m (b) 45.6 s (c) 5.56 kN (d) 4.52 Mg **Ans.**

Ans:
a) 3.46 m
b) 45.6 s
c) 5.56 kN
d) 4.52 Mg

1–2.

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

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

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

Ans:
a) GN/s
b) Gg/N
c) GN/(kg · s)

1–3.

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:
a) Gg/m
b) kN/s
c) mm · kg

***1–4.**

What is the weight in newtons of an object that has a mass of (a) 8 kg, (b) 0.04 kg, and (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:
a) $W = 78.5$ N
b) $W = 0.392$ mN
c) $W = 7.46$ MN

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, and (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:
a) 45.3 MN
b) 56.8 km
c) 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, and (d) 7555 kg.

SOLUTION

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

Ans:
a) 58.3 km
b) 68.5 s
c) 2.55 kN
d) 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) $35.3(10^3)$ 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.**

Ans:
a) 0.431 g
b) 35.3 kN
c) 5.32 m

***1–8.**

Represent each of the following combinations of units in the correct SI form: (a) Mg/ms, (b) N/mm, and (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:
a) Gg/s
b) kN/m
c) kN/(kg · s)

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, 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.**

Ans:
a) km/s
b) mm
c) Gs/kg
d) mm $\cdot$ 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) $\mathrm{N/ks^2}$, (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:
a) $\mathrm{kN \cdot m}$
b) $\mathrm{Gg/m}$
c) $\mu\mathrm{N/s^2}$
d) $\mathrm{GN/s}$

1–11.

Represent each of the following combinations of units in the correct SI form using an appropriate prefix: (a) μMN, (b) N/μm, (c) MN/ks^2, and (d) kN/ms.

SOLUTION

a) $\mu\text{MN} = 10^{-6}(10^6)\,\text{N} = \text{N}$ **Ans.**

b) $\dfrac{\text{N}}{\mu\text{m}} = \dfrac{\text{N}}{10^{-6}\,\text{m}} = 10^6\,\text{N/m} = \text{MN/m}$ **Ans.**

c) $\dfrac{\text{MN}}{\text{ks}^2} = \dfrac{10^6\,\text{N}}{(10^3)^2\,\text{s}^2} = \text{N/s}^2$ **Ans.**

d) $\dfrac{\text{kN}}{\text{ms}} = \dfrac{10^3\,\text{N}}{10^{-3}\,\text{s}} = 10^6\,\dfrac{\text{N}}{\text{s}} = \text{MN/s}$ **Ans.**

Ans:
a) N
b) MN/m
c) N/s^2
d) MN/s

***1–12.**

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

Using Table 1–2, we have

$$\rho_w = \left(\frac{1.94 \text{ slug}}{\text{ft}^3}\right)\left(\frac{14.5938 \text{ kg}}{1 \text{ slug}}\right)\left(\frac{1 \text{ ft}^3}{0.3048^3 \text{ m}^3}\right)$$

$$= 999.8 \text{ kg/m}^3 = 1.00 \text{ Mg/m}^3 \quad \textbf{Ans.}$$

Ans:
$\rho_w = 1.00 \text{ Mg/m}^3$

1–13.

The density (mass/volume) of aluminum is $5.26\ \text{slug/ft}^3$. Determine its density in SI units. Use an appropriate prefix.

SOLUTION

$$5.26\ \text{slug/ft}^3 = \left(\frac{5.26\ \text{slug}}{\text{ft}^3}\right)\left(\frac{\text{ft}}{0.3048\ \text{m}}\right)^3\left(\frac{14.59\ \text{kg}}{1\ \text{slug}}\right)$$

$$= 2.71\ \text{Mg/m}^3 \qquad \textbf{Ans.}$$

Ans:
$2.71\ \text{Mg/m}^3$

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) $(52800\ \text{ms})^2$, and (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:
a) $44.9(10)^{-3}\ \text{N}^2$
b) $2.79\left(10^3\right)\ \text{s}^2$
c) 23.4 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.**

Evaluate each of the following to three significant figures and express each answer in SI units using an appropriate prefix: (a) $(200\ \text{kN})^2$, (b) $(0.005\ \text{mm})^2$, and (c) $(400\ \text{m})^3$.

SOLUTION

a) $(200\ \text{kN})^2 = 40\,000\left(10^6\right)\ \text{N}^2 = 0.04\left(10^{12}\right)\ \text{N}^2 = 0.04\ \text{MN}^2$ **Ans.**

b) $(0.005\ \text{mm})^2 = 25\left(10^{-12}\right)\ \text{m}^2 = 25\mu\text{m}^2$ **Ans.**

c) $(400\ \text{m})^3 = 0.064\left(10^9\right)\ \text{m}^3 = 0.064\ \text{km}^3$ **Ans.**

Ans:
a) $0.04\ \text{MN}^2$
b) $25\mu\text{m}^2$
c) $0.064\ \text{km}^3$

1–17.

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

SOLUTION

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

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

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

Ans:
88.5 km/h
24.6 m/s

1–18.

Evaluate (204 mm)(0.00457 kg)/(34.6 N) to three significant figures and express the answer in SI units using an appropriate prefix.

SOLUTION

$$(204\text{ mm})(0.004\,57\text{ kg})/(34.6\text{ N}) = \left(\frac{\left[204\left(10^{-3}\right)\text{ m}\right]\left[4.57\left(10^{-3}\right)\text{ kg}\right]}{34.6\text{ N}}\right)$$

$$= \left(\frac{26.9\left(10^{-6}\right)\text{ m}\cdot\text{ kg}}{1\text{ N}}\right)$$

$$= 26.9\ \mu\text{m}\cdot\text{ kg/N} \qquad \textbf{Ans.}$$

Ans:
$26.9\ \mu\text{m}\cdot\text{kg/N}$

1–19.

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

SOLUTION

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

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

Ans:
8.33 Mg/m^3

***1–20.**

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.**

Ans:
a) 4.81 slug
b) 70.2 kg
c) 689 N
d) 25.5 lb
e) 70.2 kg

1–21.

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:
$F = 10.0$ nN
$W_1 = 78.5$ N
$W_2 = 118$ N