Solutions

Each answer shows the steps, then the **result**.

2.1

- the five SI **base quantities** and their units:
- mass — kg; length — m; time — s; current — A; temperature — K

2.2

- force from $F = ma$: $\text{kg} \times \text{m s}^{-2} = \mathbf{kg\ m\ s^{-2}}$
- pressure from $p = F/A$: $\text{kg m s}^{-2}/\text{m}^2 = \mathbf{kg\ m^{-1}\ s^{-2}}$

2.3

- $\text{m} = 10^{-3}$, so $5\ \text{mA} = 5 \times 10^{-3}\ \text{A} = \mathbf{5 \times 10^{-3}}\ \text{A}$
- $\text{G} = 10^{9}$, so $2.0\ \text{GHz} = \mathbf{2.0 \times 10^{9}}\ \text{Hz}$

2.4

- $W = Fs$ and $1\ \text{N} = 1\ \text{kg m s}^{-2}$

$$1\ \text{J} = 1\ \text{N m} = (\text{kg m s}^{-2})(\text{m}) = \mathbf{kg\ m^2\ s^{-2}}$$

2.5

- replace each prefix, and raise a prefix inside a power

$$3.0\ \text{g cm}^{-3} = 3.0 \times \frac{10^{-3}\ \text{kg}}{(10^{-2}\ \text{m})^3} = 3.0 \times \frac{10^{-3}}{10^{-6}}\ \text{kg m}^{-3} = \mathbf{3.0 \times 10^{3}}\ \text{kg m}^{-3}$$

2.6

- rearrange: $k = P/(\rho v^3)$; P is a power so $[P] = \text{kg m}^2\,\text{s}^{-3}$

$$k = \frac{\text{kg m}^2\,\text{s}^{-3}}{(\text{kg m}^{-3})(\text{m s}^{-1})^3} = \frac{\text{kg m}^2\,\text{s}^{-3}}{\text{kg s}^{-3}} = \mathbf{m^2}$$

3.1 B

- kg, m, s, A, K are the SI **base** units
- the **coulomb** is derived: $1\ \text{C} = 1\ \text{A s}$
- **A**, **C**, **D** are base units

3.2 A

- force has base units kg m s^{-2}
- energy / distance:

$$\frac{\text{kg m}^2\,\text{s}^{-2}}{\text{m}} = \mathbf{kg\ m\ s^{-2}}$$

- **B** is power ($\text{kg m}^2\,\text{s}^{-3}$); **C** is $\text{kg m}^2\,\text{s}^{-1}$; **D** is kg m

3.3 C

- k $= 10^3$, c $= 10^{-2}$; square the prefix on cm

$$6.0 \text{ kN cm}^{-2} = 6.0 \times \frac{10^3 \text{ N}}{(10^{-2} \text{ m})^2} = 6.0 \times \frac{10^3}{10^{-4}} \text{ N m}^{-2} = \mathbf{6.0 \times 10^7 \text{ N m}^{-2}}$$

3.4 C

- $[p] = \text{kg m}^{-1}\,\text{s}^{-2}$, $[\rho] = \text{kg m}^{-3}$

$$\left[\frac{p}{\rho}\right] = \frac{\text{kg m}^{-1}\,\text{s}^{-2}}{\text{kg m}^{-3}} = \text{m}^2\,\text{s}^{-2}$$

- v is a speed, so $(\text{m}^2\,\text{s}^{-2})^n = \text{m s}^{-1}$
- $2n = 1 \Rightarrow n = \mathbf{\frac{1}{2}}$

3.5

(a) complete the table

- water temperature: K, **scalar**
- water pressure: kg m^{-1} s^{-2}, **scalar**
- drag force: kg m s^{-2}, **vector**

(b) upthrust = weight of water displaced $= \rho V g$

$$U = (1030 \text{ kg m}^{-3})(0.25 \text{ m}^3)(9.81 \text{ m s}^{-2}) = 2526 \text{ N} \approx \mathbf{2.5} \text{ kN}$$

(c) weight $W = 2.1$ kN $= 2100$ N

- resultant $F = U - W = 2526 \text{ N} - 2100 \text{ N} = 426 \text{ N}$ **upwards**

$$m = \frac{W}{g} = \frac{2100 \text{ N}}{9.81 \text{ m s}^{-2}} = 214 \text{ kg}$$

$$a = \frac{F}{m} = \frac{426 \text{ N}}{214 \text{ kg}} = \mathbf{2.0} \text{ m s}^{-2}$$

upwards

(d) rearrange $F = kv^2$

$$k = \frac{F}{v^2} = \frac{\text{kg m s}^{-2}}{(\text{m s}^{-1})^2} = \mathbf{kg\ m^{-1}}$$

(e) kv^2 has the units of force, kg m s^{-2}; m has the unit kg

- terms that are **added** must have the same units, so the equation is not homogeneous