Solutions

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

2.1

- pressure is the **normal force per unit area**

2.2

- density is mass per unit volume, $\rho = m/V$

$$\rho = \frac{m}{V} = \frac{2400 \text{ kg}}{0.30 \text{ m}^3} = \mathbf{8000} \text{ kg m}^{\mathbf{-3}}$$

2.3

- the force is the weight, $F_W = mg = 60 \times 9.81 = 589$ N
- it acts on two feet, a total area $A = 2 \times 0.020 = 0.040$ m^2

$$p = \frac{F}{A} = \frac{589 \text{ N}}{0.040 \text{ m}^2} = \mathbf{1.5 \times 10^4} \text{ Pa}$$

2.4

(a) hydrostatic pressure, $\Delta p = \rho g \Delta h$

$$\Delta p = \rho g \Delta h = 1000 \text{ kg m}^{-3} \times 9.81 \text{ m s}^{-2} \times 2.5 \text{ m} = \mathbf{2.5 \times 10^4} \text{ Pa}$$

(b) total pressure $p = p_{\text{atm}} + \rho g h = 1.0 \times 10^5 + 2.5 \times 10^4 = \mathbf{1.25 \times 10^5}$ Pa

2.5

- hydrostatic pressure, only the difference in depth matters: $\Delta p = \rho g \Delta h$

$$\Delta p = \rho g \Delta h = 850 \times 9.81 \times 0.40 = \mathbf{3.3 \times 10^3} \text{ Pa}$$

2.6

- same pressure at the level of the boundary: $\rho_{\text{oil}} g h_{\text{oil}} = \rho_{\text{water}} g h_{\text{water}}$

$$h_{\text{water}} = \frac{\rho_{\text{oil}} h_{\text{oil}}}{\rho_{\text{water}}} = \frac{820 \times 0.15}{1000} = \mathbf{0.123} \text{ m}$$

- difference between the free surfaces: $h_{\text{oil}} - h_{\text{water}} = 0.15 - 0.123 = \mathbf{0.027}$ m
- the **oil** surface is higher: the less dense liquid needs a taller column for the same pressure

3.1 B

- $\Delta p = \rho g \Delta h$: only the depth and the density of the liquid appear

- the area cancels in the derivation, so **A** and **C** are wrong; **D** confuses pressure with the weight of all the liquid A C D

3.2 B

- $p = F/A$: $\mathrm{N/m^2} = \mathrm{kg\ m\ s^{-2}/m^2} = \mathrm{kg\ m^{-1}\,s^{-2}}$ SI
- **A** is the newton; **D** is the joule A D

3.3

(a) a column of area A and height Δh has volume $A\Delta h$ and mass $m = \rho A \Delta h$

- its weight is $F_W = mg = \rho A \Delta h\, g$ g
- pressure $= \dfrac{F_W}{A} = \dfrac{\rho A \Delta h\, g}{A} = \rho g \Delta h$

(b) hydrostatic pressure, $\Delta p = \rho g \Delta h$

$$\Delta p = \rho g \Delta h = 1000 \times 9.81 \times 3.2 = \mathbf{3.1 \times 10^4}\ \mathrm{Pa}$$

(c) from the definition of pressure, $F = pA$

$$F = pA = 3.14 \times 10^4\ \mathrm{Pa} \times (0.40\ \mathrm{m})^2 = \mathbf{5.0 \times 10^3}\ \mathrm{N}$$

(d) the pressure is **unchanged**

- it depends only on the depth and the density of the water, not on the width of the tank

3.4

(a) density is **mass per unit volume**

(b) $V = xyz = 8.02 \times 4.15 \times 2.05 = 68.2\ \mathrm{cm^3} = 6.82 \times 10^{-5}\ \mathrm{m^3}$

- density, $\rho = m/V$

$$\rho = \frac{m}{V} = \frac{0.512\ \mathrm{kg}}{6.82 \times 10^{-5}\ \mathrm{m^3}} = \mathbf{7.5 \times 10^3}\ \mathrm{kg\ m^{-3}}$$

(c) the force is the weight, $F_W = mg = 0.512 \times 9.81 = 5.02$ N

- the largest face has area $A = xy = 8.02 \times 4.15 = 33.3\ \mathrm{cm^2} = 3.33 \times 10^{-3}\ \mathrm{m^2}$

$$p = \frac{F}{A} = \frac{5.02\ \mathrm{N}}{3.33 \times 10^{-3}\ \mathrm{m^2}} = \mathbf{1.5 \times 10^3}\ \mathrm{Pa}$$