Solutions

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

2.1

- area $= 150 \times 10^{-4} = 0.0150$ m^2

$$p = \frac{540 \text{ N}}{0.0150 \text{ m}^2} = \mathbf{3.6 \times 10^4} \text{ Pa}$$

2.2

- pressure due to the water $= 3.00 \times 10^5 - 1.01 \times 10^5 = 1.99 \times 10^5$ Pa
- $\Delta p = \rho g h$

$$h = \frac{1.99 \times 10^5}{1030 \times 9.81} = \mathbf{19.7} \text{ m}$$

2.3

- the pressures of the layers add: $\Delta p = 1400 \times 9.81 \times 0.050 + 920 \times 9.81 \times 0.030$
- $\Delta p = 687 + 271 = \mathbf{960}$ Pa

2.4

- the same Δp means $\rho_{\text{water}}\, h_{\text{water}} = \rho_{\text{mercury}}\, h_{\text{mercury}}$

$$h = \frac{1000 \times 25.0}{13\,600} = \mathbf{1.84} \text{ cm}$$

2.5

(a) upthrust $= 12.0 - 7.5 = \mathbf{4.5}$ N

(b) $F = \rho g V$

$$V = \frac{4.5}{1000 \times 9.81} = \mathbf{4.6 \times 10^{-4}} \text{ m}^3$$

2.6

- the pressure on the top and the pressure on the bottom of the stone both increase by the same amount
- so the difference in pressure, and so the upthrust, stays the same; the volume of water displaced does not change either

3.1 C

- the extra atmospheric pressure is passed on through the water to every face, so p_1 and p_2 rise by the same amount and their difference does not change
- **D** is wrong because the water passes the atmospheric pressure on; **A** forgets that the top face gains the same pressure as the bottom face

3.2 B

- a floating boat has upthrust equal to its weight, and the weight does not change, so the upthrust stays the same

- $F = \rho g V$ with a larger ρ needs a smaller volume V under the water, so the boat floats **higher**

3.3

(a) floating: upthrust = weight, so $\rho g A d = mg$

- $A = \pi r^2 = \pi \times 0.50^2 = 0.785$ m^2

$$d = \frac{380}{1030 \times 0.785} = \mathbf{0.47} \text{ m}$$

(b) $\Delta p = \rho g h$

$$\Delta p = 1030 \times 9.81 \times 0.47 = \mathbf{4.7 \times 10^3} \text{ Pa}$$

(c) $F = pA = 4.75 \times 10^3 \times 0.785 = 3.73 \times 10^3$ N, and the weight is $380 \times 9.81 = 3.73 \times 10^3$ N, the same

- the top of the buoy is in the air, so this upward push on the bottom face is the whole upthrust, and a floating buoy is in equilibrium

(d) the total mass is 500 kg, so $d = \dfrac{500}{1030 \times 0.785}$

- $d = \mathbf{0.62}$ m

3.4

(a) the mass of the column is $m = \rho V = \rho A h$

- its weight $W = mg = \rho A h g$ acts on the area A

$$p = \frac{W}{A} = \frac{\rho A h g}{A} = \rho g h$$

(b) the gas pressure is larger than atmospheric pressure by the pressure of the 18.0 cm column: $\Delta p = 1000 \times 9.81 \times 0.180 = 1.77 \times 10^3$ Pa

- $p = 1.01 \times 10^5 + 1.77 \times 10^3 = \mathbf{1.03 \times 10^5}$ Pa

(c) the same Δp needs $h = \Delta p/(\rho g)$

$$h = \frac{1.77 \times 10^3}{800 \times 9.81} = 0.225 \text{ m} = \mathbf{22.5} \text{ cm}$$

3.5

(a) upthrust $= \rho_{\text{air}}\, g\, V$

$$F = 1.20 \times 9.81 \times 0.012 = \mathbf{0.14} \text{ N}$$

(b) weight $= 0.0040 \times 9.81 = 0.039$ N

- the balloon is in equilibrium: $T = F - W = 0.141 - 0.039 = \mathbf{0.10}$ N

(c) $F = 0.90 \times 9.81 \times 0.012 = 0.106$ N

- $T = 0.106 - 0.039 = \mathbf{0.067}$ N