Solutions

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

2.1

- moment = force × the **perpendicular distance** from the pivot to the line of action of the force

2.2

- $M = Fd$

$$M = (20\text{ N})(0.30\text{ m}) = \mathbf{6.0}\text{ N m}$$

2.3

- the two forces are **equal** in size and **opposite** in direction
- their lines of action are a **perpendicular distance apart** (not the same line)

2.4

- at its **centre of gravity** — the midpoint of a uniform rod

3.1 B

- the SI unit of moment (and of torque) is the **newton-metre**, N m

3.2

- the perpendicular distance is $r\sin\theta$

$$M = Fr\sin\theta = (50\text{ N})(0.40\text{ m})(\sin 30^\circ) = 50 \times 0.40 \times 0.50 = \mathbf{10}\text{ N m}$$

3.3

- $\tau = Fd$

$$\tau = (8.0\text{ N})(0.25\text{ m}) = \mathbf{2.0}\text{ N m}$$

3.4

- two equal forces in the **same** direction have a resultant $2F \neq 0$
- they cause translation, not turning only — a couple needs the forces **opposite**

3.5

(a) torque of a couple = **one of the forces** × the **perpendicular distance between the two lines of action**

(b) the single point at which the **whole weight** of the sheet may be taken to act

(c) the applied torque balances the moment of the weight about the rod: $\tau = mgd$

$$d = \frac{1.9\text{ N m}}{(1.6\text{ kg})(9.81\text{ m s}^{-2})} = \mathbf{0.12}\text{ m}$$

(d) **anticlockwise**

- the centre of gravity is to the right of the rod, so the weight turns the sheet **clockwise**; the applied torque must oppose it

(e) $V = m/\rho$

$$V = \frac{1.6 \text{ kg}}{2700 \text{ kg m}^{-3}} = 5.93 \times 10^{-4} \text{ m}^3$$

- square sheet: $V = L^2 t$

$$L^2 = \frac{5.93 \times 10^{-4} \text{ m}^3}{3.0 \times 10^{-3} \text{ m}} = 0.198 \text{ m}^2 \Rightarrow L = \mathbf{0.44} \text{ m}$$

(f) directly **below** that corner, on the vertical line through it

(g)

$$V = L^2 t = (0.44 \text{ m})^2 (5.0 \times 10^{-3} \text{ m}) = 9.68 \times 10^{-4} \text{ m}^3$$

$$m = \rho V = (2700 \text{ kg m}^{-3})(9.68 \times 10^{-4} \text{ m}^3) = 2.61 \text{ kg}$$

$$W = mg = (2.61 \text{ kg})(9.81 \text{ m s}^{-2}) = \mathbf{26} \text{ N}$$