Solutions

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

2.1

- the **resultant force** is zero
- **and** the **resultant moment** about any point is zero

2.2

- principle of moments: **total clockwise moment** about any point = **total anticlockwise moment** about that point

2.3

- take moments about the pivot

$$(40\text{ N})(1.5\text{ m}) = (30\text{ N})d \Rightarrow d = \mathbf{2.0}\text{ m}$$

2.4

- the three forces are **in equilibrium** (resultant zero)

3.1 B

- in equilibrium the three forces have zero resultant, so tip-to-tail they close into a **triangle**
- **D** is the trap: the resultant of two must be equal and **opposite** to the third, not in the same direction

3.2

- the beam's weight acts at the pivot, so it has **no moment**

$$(40\text{ N})(1.5\text{ m}) = (30\text{ N})d$$

$$d = \frac{60\text{ N m}}{30\text{ N}} = \mathbf{2.0}\text{ m}$$

3.3

- take moments about **A** so the force at A drops out

$$B \times 4.0\text{ m} = (60\text{ N})(2.0\text{ m}) + (40\text{ N})(1.0\text{ m}) = 160\text{ N m}$$

$$B = \frac{160\text{ N m}}{4.0\text{ m}} = \mathbf{40}\text{ N}$$

3.4

- the rod's weight acts at its **centre of gravity**, a distance from the pivot
- so it contributes a **moment** that must be included

3.5

(a) for a body in **equilibrium**

- sum of **clockwise moments** about any point = sum of **anticlockwise moments** about that same point

(b)

- arrow **down** at the middle of the board (2.0 m from A) labelled *weight of board* / 800 *N*
- arrow **up** at P labelled *support force*
- arrow **down** at B labelled *weight of swimmer* / 620 *N*

(c) moments about A (hinge force has no moment)

- clockwise = (800 N)(2.0 m) + (620 N)(4.0 m) = 4080 N m
- anticlockwise = $P \times 1.2$ m

$$P = \frac{4080\text{ N m}}{1.2\text{ m}} = \mathbf{3400}\text{ N}$$

(d) vertical equilibrium: up = down

- $3400\text{ N} + F_{\text{hinge}} = 800\text{ N} + 620\text{ N}$
- $F_{\text{hinge}} = -1980$ N, so **1980** N **downwards**

(e) the hinge force is unknown; moments **about** A give it zero moment, so it drops out

(f) no hinge: take moments about **P**

- board's weight is 2.0 m − 1.2 m = 0.80 m to the right of P
- clockwise: (800 N)(0.80 m) = 640 N m
- swimmer must be on the **other** side of P, a distance $(1.2\text{ m} - x)$ from it

$$(620\text{ N})(1.2\text{ m} - x) = 640\text{ N m} \Rightarrow x = \mathbf{0.17}\text{ m}$$

from A