

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 anti-clockwise 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

- $3400 \text{ N} + F_{\text{hinge}} = 800 \text{ N} + 620 \text{ N}$
- $F_{\text{hinge}} = -1980 \text{ N}$, 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 $2.0 \text{ m} - 1.2 \text{ m} = 0.80 \text{ m}$ 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 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