Solutions

2.1

- The force is perpendicular, so the moment is force times perpendicular distance from the pivot:

$$\text{moment} = Fx = 25\ \text{N} \times 0.30\ \text{m} = \mathbf{7.5}\ \text{N m}$$

2.2

- Only the component of the force perpendicular to the spanner, $F\sin\theta$, turns it:

$$\text{moment} = F\sin\theta \times x = 25\ \text{N} \times \sin 50^\circ \times 0.30\ \text{m} = \mathbf{5.7}\ \text{N m}$$

2.3

- the resultant force on the body is zero
- the resultant moment about any point is zero

2.4

- The beam is uniform and pivoted at its centre, so its weight acts through the pivot and has no moment about it.
- Principle of moments about the pivot, with the second child a distance x to the left:

$$W_1 d_1 = W_2 x: \quad 300\ \text{N} \times 1.5\ \text{m} = 400\ \text{N} \times x$$

$$x = \frac{W_1 d_1}{W_2} = \frac{450\ \text{N m}}{400\ \text{N}} = \mathbf{1.1}\ \text{m to the left of the pivot}$$

3.1 B. The pivot holds the beam's centre in place, so its upward force still balances the total weight: the resultant force is zero. About the pivot, the left weight's moment Wd is now larger than the right weight's Wd' with $d' < d$, so the left end turns down: an anticlockwise resultant moment. A ignores the smaller right-hand moment, C has the sense reversed and D forgets the pivot force.

3.2 C. The door needs a fixed moment $M = Fd\sin\theta$, so the force needed is $F = \dfrac{M}{d\sin\theta}$: it falls when d or $\sin\theta$ grows. C raises both (d from 0.40 m to 0.80 m, $\sin\theta$ from $\sin 60^\circ$ to 1). A shrinks d; B shrinks $\sin\theta$; D makes $\theta = 0$, so no force can turn the door.

3.3

(a) for a body in equilibrium, the sum of the clockwise moments about any point equals the sum of the anticlockwise moments about that point

(b)

- Take moments about the string: the rule is uniform, so its weight acts at the 50 cm mark, on the string, and has no moment.
- Distances from the string: dish $50 - 20 = 30$ cm $= 0.30$ m; counterweight $85 - 50 = 35$ cm $= 0.35$ m.

$$F_{\text{dish}}\, d_{\text{dish}} = F_W\, d_W: \quad 1.8\ \text{N} \times 0.30\ \text{m} = F_W \times 0.35\ \text{m}$$

$$F_W = \frac{F_{\text{dish}} d_{\text{dish}}}{d_W} = \frac{0.54\ \text{N m}}{0.35\ \text{m}} = \mathbf{1.5}\ \text{N}$$

(c)

- **No**.
- With the string at 60 cm, the dish is now farther from the string (0.40 m) and the counterweight nearer (0.25 m); the rule's own weight, at 50 cm, now also acts on the dish side. Every change adds to the anticlockwise (dish-side) moment or takes from the clockwise one, so the dish side's moment exceeds the counterweight's and the rule tips towards the dish.