Solutions

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

2.1

- $k = F/x$

$$k = \frac{20\text{ N}}{4.0\text{ cm}} = \mathbf{5.0}\text{ N/cm}$$

2.2

- for a balanced object, the total clockwise moment about the pivot equals the total anticlockwise moment

2.3

- the force between two surfaces that touch, which acts against (impedes) the motion
- it also produces heating of the surfaces

2.4

- no resultant force
- and no resultant moment

2.5

- extension = 15.5 cm − 12.0 cm = 3.5 cm
- $k = F/x$

$$k = \frac{7.0\text{ N}}{3.5\text{ cm}} = \mathbf{2.0}\text{ N/cm}$$

2.6

- the single point at which all of the weight of the object appears to act

2.7

- towards the centre of the circle
- it changes the direction of the velocity, not the speed

3.1 B

- constant speed in a straight line means zero resultant force, so the driving force balances the resistive forces
- **A** would make it accelerate; **D** would make it slow down; **C** cannot be right because friction and air resistance always act

3.2 B

- a wide base means the object can tilt further before the vertical line from the centre of gravity leaves the base
- **A** has the reasoning the wrong way round; **C** is untrue; **D** ignores the shape

3.3

(a) the change in velocity per unit time

(b) $t = \Delta v / a$

$$t = \frac{28 \text{ m/s} - 15 \text{ m/s}}{1.1 \text{ m/s}^2} = \mathbf{12} \text{ s}$$

(c) $F = ma$

$$F = (520\,000 \text{ kg})(1.1 \text{ m/s}^2) = \mathbf{570\,000} \text{ N}$$

(d) extra force is needed to overcome friction (or air resistance / drag), because $F = ma$ gives only the resultant force

(e) the resultant force is in the opposite direction to the motion

3.4

(a) the beam is uniform, so its centre of gravity is at its centre, directly above the pivot; the perpendicular distance is zero, so its moment is zero

(b) clockwise moment = anticlockwise moment

$$(40 \text{ N})(0.30 \text{ m}) = W \times (0.50 \text{ m})$$

$$12 \text{ N m} = (0.50 \text{ m})W \Rightarrow W = \mathbf{24} \text{ N}$$

(c) the anticlockwise moment becomes (40 N)(0.45 m) = 18 N m, which is larger than the clockwise (24 N)(0.50 m) = 12 N m

- so the beam turns anticlockwise: the left-hand side goes down

(d) balance a metre rule at its centre on a pivot

- hang a known weight on each side and adjust the distances until it balances, then measure both distances
- show that force × distance is the same on both sides, within the measurement errors

3.5

(a) hang the spring from a clamp with a ruler fixed beside it and record the position of the bottom with no load

- add loads one at a time, recording the load and the new length each time
- calculate the extension as new length minus original length

(b) a straight line through the origin

- a marked point where the line stops being straight, labelled "limit of proportionality"
- beyond it the line curves so that extension grows faster than load

(c) $k = F/x$

$$k = \frac{10 \text{ N}}{2.5 \text{ cm}} = 4.0 \text{ N/cm}$$

- $x = F/k$

$$x = \frac{6.0 \text{ N}}{4.0 \text{ N/cm}} = \mathbf{1.5} \text{ cm}$$

(d) a load of 60 N is beyond the limit of proportionality, so extension is no longer proportional to load