Solutions

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

2.1

- the centre of mass weights each position by its mass:

$$x_{cm} = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2} = \frac{(1.0\text{ kg})(0) + (4.0\text{ kg})(10\text{ m})}{1.0\text{ kg} + 4.0\text{ kg}}$$

- $x_{cm} = \mathbf{8.0}$ m, nearer the heavier mass

2.2

- internal (it acts between two parts of the system)

2.3

- midpoint, $x = 5.0$ m – the masses are equal, so the centre of mass is exactly halfway between them

3.1 B

- the net external force.

3.2 B

- by symmetry, $x_{cm} = 3.0$ m

3.3

(a)

- put the origin at the 60 kg skater:

$$x_{cm} = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2} = \frac{(60\text{ kg})(0) + (40\text{ kg})(5.0\text{ m})}{100\text{ kg}}$$

- $x_{cm} = \mathbf{2.0}$ m from the 60 kg skater

(b)

- They meet at the centre of mass, 2.0 m from the 60 kg skater – with no external horizontal force, the centre of mass stays fixed

3.4

(a)

- the centre of mass continues on the **same** parabola
- the explosion forces are internal; the only external force is still gravity, so $a_{cm} = g$ as before

(b)

- each fragment receives a different internal force from the explosion, so each has its own velocity; objects in a system can behave differently from the system as a whole

(c)

- for example: how far apart the fragments land; how the kinetic energy is shared among the fragments

3.5 A

- the car's internal structure does not affect its motion along the road; in B, C and D the motion of the parts is the question