1.3 Momentum and moments (P)

Name: _____ Class: _____ Date: _____ **Total: 19 marks**

Objective

Cover the separate-science (P) extension (1.25P–1.33P): momentum and its conservation, force as rate of change of momentum, safety features, Newton's third law, moments, centre of gravity and beam supports. Original practice.

1 Key knowledge and worked examples

■ Momentum is conserved

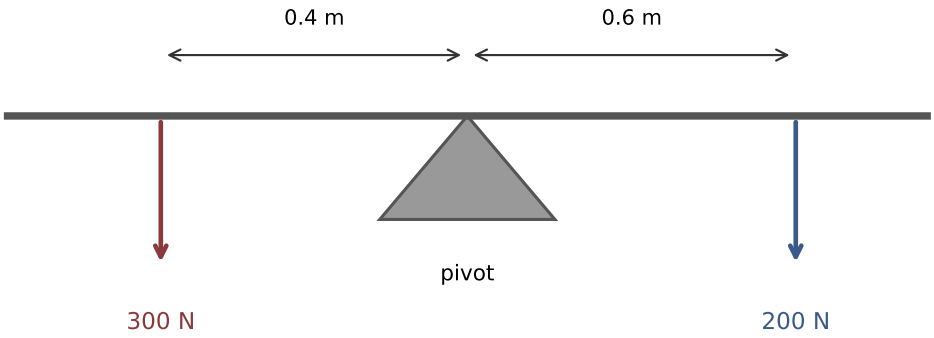
$$p = mv \qquad F = \frac{mv - mu}{t}$$

In a collision the total momentum before equals the total after. **Worked check.** A 2 kg trolley at 3 m/s hits a stationary 1 kg trolley and they stick: before $= 2 \times 3 = 6$; after, mass 3 kg moves at $6/3 = 2$ m/s.

■ Safety features buy time

Crumple zones, airbags and seat belts all **lengthen the collision time**; since force = change in momentum ÷ time, the same change spread over more time means a smaller force.

Moments balance



anticlockwise 300 N × 0.4 m = clockwise 200 N × 0.6 m = 120 N m

Moment = force × perpendicular distance from the pivot. Equilibrium: clockwise moments = anticlockwise moments. Weight acts through the **centre of gravity**; on a beam supported at both ends, the nearer support carries more of the load.

2 Practice

2.1 Calculate the momentum of a 0.5 kg ball moving at 6 m/s. [2]

2.2 (P) State Newton's third law. [1]

2.3 A 4 kg object at 5 m/s is brought to rest in 2.5 s. Calculate the force. [3]

2.4 State the principle of moments. [1]

2.5 Through what point does the weight of a body act? [1]

3 Exam-style questions

3.1 A 900 kg car at 20 m/s collides with a stationary 1100 kg car; they move off together. Calculate their common speed and the total momentum before and after. [4]

3.2 Explain, using momentum ideas, how an airbag reduces injury. [3]

3.3 A uniform 4 m beam rests on supports at its ends. A 600 N load sits 1 m from the left support. Taking moments, find the force each support exerts. [4]

Solutions

2.1 $p = 0.5 \times 6 = 3$ kg m/s.

2.2 (P) For every action there is an equal and opposite reaction.

2.3 Momentum change $= 4 \times 5 = 20$ kg m/s; $F = 20/2.5 = 8$ N.

2.4 For equilibrium, the sum of clockwise moments about a point equals the sum of anticlockwise moments.

2.5 Its centre of gravity.

3.1 Before: $p = 900 \times 20 = 18\,000$ kg m/s. After, combined mass 2000 kg: $v = 18\,000/2000 = 9$ m/s; momentum is conserved – after $= 18\,000$ too.

3.2 The passenger's momentum change in the crash is fixed; the airbag slows them over a longer time; force = change in momentum ÷ time, so the force on the body is smaller.

3.3 Moments about the left support: load $600 \times 1 = 600$ N m clockwise; right support force R at 4 m: $4R = 600 \rightarrow R = 150$ N. Left support: $600 - 150 = 450$ N.