1.2 Momentum safety and moments (P)

Name: _____ Class: _____ Date: _____ **Total: 27 marks**

KEY WORDS momentum • terminal velocity

Objective

Build the skills to answer exam questions on **momentum, safety, terminal velocity and moments** 、 、 : conservation of momentum, force and change of momentum, stopping distances, falling objects, stability and balanced moments.

You must be able to:

- use $p = mv$ and conservation of momentum
- use $F = \frac{\Delta p}{t}$ to explain safety features
- explain stopping distances and terminal velocity
- use the centre of mass and balanced moments

1 Key knowledge and worked examples

Momentum and moments

idea	equation or rule
momentum	$p = mv$ (kg m/s); a vector
conservation	in a collision or explosion, total momentum before = total momentum after
force and momentum	$F = \frac{\Delta p}{t}$: the same change of momentum over a longer time needs a smaller force
stopping distance	thinking distance + braking distance; tiredness, alcohol and phones make thinking distance longer; wet roads and worn tyres make braking distance longer
terminal velocity	the weight equals the air resistance, so the resultant force is zero and the speed stays the same
centre of mass	the point where the weight acts; an object topples when its weight acts outside its base
moment	$M = Fd$, d = perpendicular distance from the pivot; balanced: clockwise moments = anticlockwise moments

Worked example 1: a collision. A 2.0 kg trolley at 3.0 m/s hits a still 1.0 kg trolley. They stick together. Find their speed.

1. Known: momentum before $= 2.0 \times 3.0 = 6.0$ kg m/s; total mass after 3.0 kg.
2. Rule: momentum before = momentum after.
3. Numbers: $v = \frac{6.0}{3.0}$.
4. Result: $v = 2.0$ **m/s**.

Worked example 2: a moment. A force of 30 N acts 0.40 m from a pivot. Find its moment.

1. Known: $F = 30$ N, $d = 0.40$ m.
2. Rule: $M = Fd$.
3. Numbers: 30×0.40.
4. Result: $M = 12$ **N m**.

Answer shapes: for momentum, choose one direction as positive; for moments, write "clockwise = anticlockwise" first, then the numbers.

2 Practice

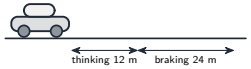
2.1 A ball of mass 0.15 kg moves at 20 m/s. Calculate its momentum. [2]



2.2 A child of weight 300 N sits 1.5 m from the pivot of a seesaw. How far from the pivot must a child of weight 450 N sit on the other side to balance it? [2]

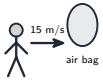


2.3 A car has a thinking distance of 12 m and a braking distance of 24 m. Calculate the stopping distance. Give one factor that makes the braking distance longer. [2]

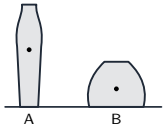


3 Exam-style questions

3.1 A passenger of mass 60 kg moves at 15 m/s. In a crash an air bag stops the passenger in 0.30 s. Calculate the force on the passenger. Explain why the air bag reduces injuries. [3]

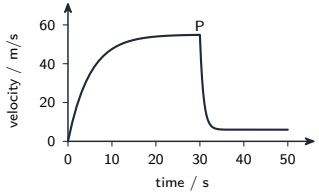


3.2 The diagram shows two vases. Explain which vase is more stable. [3]



3.3 A skydiver of mass 80 kg jumps from a plane. The velocity–time graph shows the fall. The parachute opens at P.

(a) Explain why the acceleration of the skydiver gets smaller during the first 15 s. [3]



(b) The terminal velocity is 55 m/s. Calculate the momentum at terminal velocity. Calculate the weight of the skydiver and write down the air resistance at this time. [3]

(c) After the parachute opens, the velocity falls from 55 m/s to 6 m/s in 4.0 s. Calculate the average resultant force on the skydiver. [3]

(d) Explain the motion of the skydiver from the moment the parachute opens until she lands. Use ideas about forces. [6]

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Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

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

2.1

- $p = mv = 0.15 \times 20$
- $= \mathbf{3.0}$ kg m/s

2.2

- $300 \times 1.5 = 450 \times d$
- $d = \mathbf{1.0}$ m

2.3

- $12 + 24 = \mathbf{36}$ m
- e.g. a wet or icy road, worn tyres or worn brakes

3.1

- change of momentum $= 60 \times 15 = 900$ kg m/s
- $F = 900 \div 0.30 = \mathbf{3000}$ N
- the air bag makes the stopping time longer, so the force is smaller for the same change of momentum

3.2

- vase **B** is more stable
- it has a lower centre of mass and a wider base
- it can tilt further before its weight acts outside the base

3.3

(a) air resistance increases as the speed increases; the resultant force (weight − air resistance) gets smaller; $a = \frac{F}{m}$, so the acceleration gets smaller

(b) $p = 80 \times 55 = \mathbf{4400}$ kg m/s; $W = 80 \times 9.8 = \mathbf{784}$ N; air resistance = **784** N

(c) $\Delta p = 80 \times (55 - 6) = 3920$ kg m/s; $F = 3920 \div 4.0 = \mathbf{980}$ N

(d) points to include:

- the parachute has a much larger area, so the air resistance suddenly increases
- air resistance is now larger than the weight, so the resultant force is upwards
- the skydiver decelerates (slows down)
- as the speed falls, the air resistance gets smaller
- when air resistance equals weight again, the resultant force is zero
- she falls at a new, lower terminal velocity of about 6 m/s until she lands

Levels: **5–6** a full, logical answer with correct physics and correct terms; **3–4** several correct points, partly linked; **1–2** one or two relevant points.

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