

5.8 Forces and braking

Name: _____ Class: _____ Date: _____

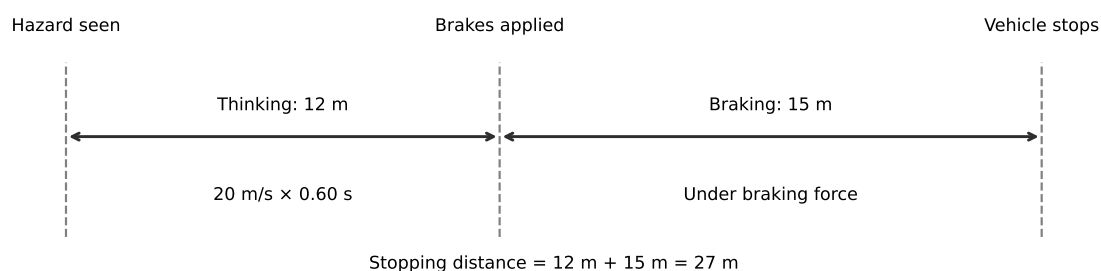
Total: 27 marks

KEY WORDS force

Objective

Split stopping distance into thinking and braking parts, measure reaction time, explain the factors that lengthen each part, and explain large-deceleration dangers. Original questions for spec statements 4.5.6.3.1–4.5.6.3.4.

1 Key knowledge and worked examples



The split the exam asks about.

stopping distance = thinking distance + braking distance

Part	Depends on
thinking	reaction time × speed – reaction time 0.2–0.9 s typical; lengthened by tiredness, drugs, alcohol, distractions
braking	speed (for a given braking force), road conditions (wet, icy), vehicle condition (worn brakes or tyres)

Measuring reaction time (credited methods): drop a ruler between a partner's fingers – the distance caught gives the time from $s = \frac{1}{2}at^2$ (so $t = \sqrt{2s/a}$); or use an electronic timer / computer test. Compare people's results; evaluate distractions (talking, phone) by testing with and without.

Braking physics: the friction force between brakes and wheel does work on the kinetic store – the vehicle slows and the **brakes' temperature rises**. The greater the speed, the greater the braking force needed to stop in a given distance; the greater

the braking force, the **greater the deceleration** – large decelerations can **overheat the brakes** (loss of braking) or cause **loss of control**.

Worked example. At 20 m/s a driver reacts in 0.6 s and brakes for 15 m.

- Thinking: $s = vt = 20 \times 0.6 = 12$ m.
- Stopping distance: $12 + 15 = 27$ m.

Worked example (HT). A 1500 kg car from 30 m/s stops in 60 m.

- With initial motion positive, $a = (v^2 - u^2)/(2s) = (0 - 30^2)/(2 \times 60) = -7.5$ m/s².
The deceleration magnitude is 7.5 m/s².
- Braking force: $F = ma = 1500 \times 7.5 = 11\,250 \approx 11\,000$ N.

2 Practice

2.1 State the two parts of the stopping distance and what the first part equals. [2]

2.2 A driver travels at 15 m/s with a 0.5 s reaction time. Calculate the thinking distance. [2]

2.3 Give two vehicle-condition factors and two road factors that lengthen the braking distance. [4]

3 Exam-style questions

3.1 Speed cameras record a car's average speed over 500 m as 24 m/s.

(a) Explain why an average-speed measurement may hide a dangerous moment. [1]

(b) The speed limit is 20 m/s. Using thinking = $v \times t$ and the supplied value: at 20 m/s the braking distance is 12 m. Estimate the stopping distance with a 0.7 s reaction time. [3]

(c) Give two factors that could have lengthened this driver's thinking distance. [2]

3.2 Explain why the brakes of a vehicle heat up during braking, and why heavier braking is more dangerous. [4]

3.3 A 1200 kg car travelling at 25 m/s decelerates uniformly to rest over a braking distance of 50 m.

(a) Calculate the deceleration. [2]

(b) Estimate the braking force. [2]

(c) The same car at 50 m/s stops with the same braking force. Show that the braking distance is about four times larger. [3]

(d) Explain one danger of this large deceleration. [2]

Solutions

2.1 Thinking distance + braking distance; thinking distance = reaction time $\times$ speed.

2.2 $s = vt = 15 \times 0.5 = \mathbf{7.5}$ m (C1, A1).

2.3 Vehicle: worn brakes; worn tyres. Road: wet; icy.

3.1 (a) Averaging hides short bursts of speeding above the limit between cameras. (b) Thinking: $20 \times 0.7 = 14$ m (C1); stopping = $14 + 12 = \mathbf{26}$ m (C1, A1). (c) Any two: tiredness, alcohol, drugs, distractions (phone, passengers).

3.2 The friction force between brake pads and wheel does work; the kinetic store of the car empties into the thermal store of the brakes – temperature rises. Heavier braking means a larger deceleration ($F = ma$); the brakes can overheat – losing braking power – and the tyres may lose grip, causing loss of control.

3.3 (a)

$$a = \frac{v^2 - u^2}{2s} = \frac{0 - 25^2}{100} = \mathbf{-6.25} \text{ m/s}^2$$

(C1, A1) (b) $F = ma = 1200 \times 6.25 = \mathbf{7500}$ N (C1, A1). (c) Same force $\rightarrow$ same deceleration; doubling u quadruples u^2 (C1):

$$s = \frac{u^2}{2|a|} = \frac{2500}{12.5} = 200 \text{ m} = 4 \times 50 \text{ m} \checkmark$$

(quadrupling shown C1, A1) (d) Any well-explained: brakes overheat and fade; or deceleration throws occupants forward – injury without restraint; or tyres break traction – skid and loss of steering.