Factors affecting braking distance

4.5.6.3.3 · Forces · revision notes

Braking distance is how far a vehicle travels after the brakes are applied. You need to explain how speed, road and weather conditions and the condition of the brakes and tyres affect it, discuss what this means for safety, and estimate how emergency stopping distances change over a range of typical speeds.

Key facts

- Braking distance: the distance travelled under the braking force
- Wet or icy roads and worn tyres → less friction between the tyres and the road
- Car on a dry road: stopping distance ~25 m at 13 m/s, ~100 m at 31 m/s
- Increased by: greater speed, wet or icy roads, worn tyres, worn brakes, greater mass
- Worn brakes → smaller braking force → smaller deceleration
- Grade 8+ only Same braking force: braking distance ∝ speed^2

Notes

What braking distance is

- Braking distance is the distance a vehicle travels under the braking force, from when the brakes are applied until it stops.
- Braking depends on **friction**: between the brake pads and the discs on the wheels, and between the tyres and the road.

Factors that increase braking distance

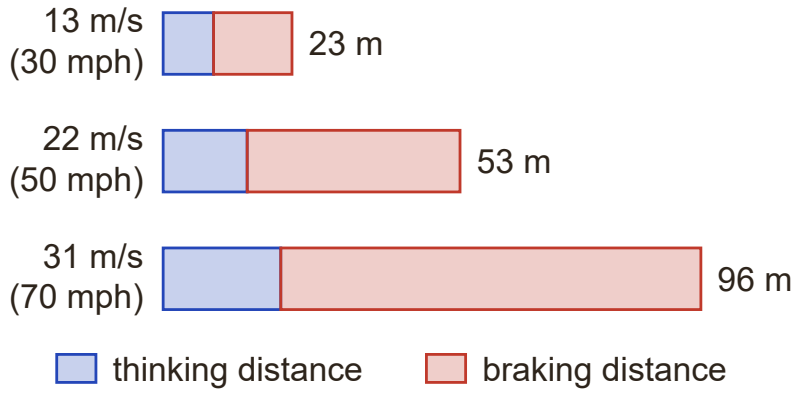
- **Greater speed**: the vehicle has more kinetic energy, so the brakes must do more work to stop it.
- **Adverse road and weather conditions**: wet or icy roads (and loose gravel or leaves) reduce the friction between the tyres and the road. The tyres may skid, so the braking force is smaller.
- **Poor condition of the tyres**: worn tyres with too little tread grip the road less, especially in the wet, because they cannot clear the water away.
- **Poor condition of the brakes**: worn brakes cannot produce as large a friction force, so the deceleration is smaller.
- **Greater mass**, e.g. a fully loaded vehicle: more kinetic energy at the same speed, so a longer braking distance for the same braking force.

Safety implications

- In wet or icy weather, drivers should slow down and leave a bigger gap to the vehicle in front.
- Speed limits are lower where hazards are likely, such as near schools, because stopping distance increases with speed.
- A lower speed also means less kinetic energy, so if a collision does happen it causes less damage and injury.
- Regular checks of the brakes and the tyre tread keep braking distances as short as possible.
- Rough, high-friction road surfaces are often laid on the approach to junctions and crossings.

Estimating emergency stopping distances

- Stopping distance increases steeply with speed. Rough values for a car on a dry road: about 25 m at 13 m/s (30 mph), about 50 m at 22 m/s (50 mph), about 100 m at 31 m/s (70 mph).



Typical stopping distances on a dry road (approximate). The braking part grows fastest.

- On a wet road the braking distance can be about twice as long, and on ice it can be many times longer.

How to answer each type of question

Name and explain factors affecting braking distance 2 to 4 marks **Grade 4**

1. Name a factor that affects the vehicle or the road, not the driver.
2. Explain its effect on friction (or on the kinetic energy to be removed).
3. Say that the braking distance increases.

Example. Give **two** factors, other than speed, that could increase the braking distance of a car. Explain why each factor increases the braking distance.

Model answer.

An icy road (1): there is less friction between the tyres and the road, so the braking force is smaller (1).

Worn brakes (1): the brakes produce a smaller friction force, so the deceleration is smaller (1).

Explain safety advice

3 marks | Grade 5

1. Say how the condition affects friction.
2. Say how this affects braking distance.
3. Link the advice (slower speed, bigger gap) to stopping safely.

Example. Explain why drivers are advised to drive more slowly and leave bigger gaps in wet weather.

Model answer.

Wet roads reduce the friction between the tyres and the road (1)

so the braking force is smaller (the tyres may skid) and the braking distance is longer (1).

Driving more slowly reduces the stopping distance, and a bigger gap gives room to stop in (1).

Estimate a stopping distance

3 marks | Grade 7

1. Thinking distance = speed × reaction time.
2. Braking distance from $v^2 - u^2 = 2\,a\,s$, with a negative acceleration.
3. Add the two and round sensibly.

Example. A car travels at 30 m/s on a dry road. Estimate its stopping distance. Use a reaction time of about 0.7 s and a deceleration of about 6 m/s^2 when braking.

Model answer.

thinking distance ≈ 30 × 0.7 = 21 m (1)

braking distance: $0 - 30^2 = 2 \times (-6) \times s$, so s = 75 m (1)

stopping distance ≈ 21 + 75 ≈ 100 m (1)

Explain the effect of doubling the speed

3 marks | Grade 8

1. Kinetic energy depends on speed squared.
2. The work done by the brakes must equal the kinetic energy.
3. Work done = force × distance, so with the same force the distance changes in the same way as the kinetic energy.

Example. The speed of a car doubles. The braking force stays the same.
Explain why the braking distance becomes four times as long.

Model answer.

$E_k = \frac{1}{2}\,m\,v^2$, so doubling the speed makes the kinetic energy four times as big (1).

The work done by the brakes must equal the kinetic energy (1).

Work done = force × distance, so with the same force the braking distance must be four times as long (1).

Don’t lose marks

- Listing tiredness, alcohol or phones as factors that affect braking distance. They affect the thinking distance.
- Writing 'the road is slippery' without explaining that there is less friction between the tyres and the road.
- Writing 'bad tyres' without saying what is wrong (worn, too little tread) and what it does (less grip, less friction).
- Forgetting that a heavier, loaded vehicle has a longer braking distance at the same speed and braking force.

More tips

Memory tricks

- Braking distance factors are about the vehicle and the road: speed, mass, brakes, tyres, surface.
- Every factor comes back to one of two ideas: more kinetic energy to remove, or less friction to remove it with.
- Rough guide: wet roads can double the braking distance.

Exam technique

- Structure your answer: factor → effect on friction or kinetic energy → effect on braking distance.
- In estimate questions, state any values you assume and round your answer sensibly.
- Say 'friction between the tyres and the road' rather than just 'grip'.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3 — **Name factors that increase braking distance**
Higher speed, wet or icy roads, worn brakes and worn tyres.

Grade 4 — **Explain how wet or icy roads affect braking**
There is less friction between the tyres and the road, so the braking distance is longer.

Grade 5 — **Explain the effects of worn tyres and brakes**
Worn tyres grip the road less; worn brakes produce a smaller friction force.

Grade 5 — **Explain the effect of speed on braking distance**
A faster vehicle has more kinetic energy, so more work must be done to stop it.

Grade 5 — **Explain the safety implications of braking distances**
Lower speeds and bigger gaps are needed in bad conditions and near hazards.

Grade 7 — **Estimate stopping distances at typical speeds**
A car on a dry road needs roughly 25 m to stop from 13 m/s and roughly 100 m from 31 m/s.

Grade 8 — **Explain why braking distance depends on speed squared**
Braking force × braking distance = ½ m v^2, so for a constant force, distance ∝ v^2.

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