Stopping distance

4.5.6.3.1 · Forces · revision notes

The stopping distance of a vehicle is the thinking distance plus the braking distance. You need to know what affects each part, how speed affects stopping distance, and how to calculate stopping distances from data. If you take GCSE Physics (not Combined Science), you also need to interpret graphs of stopping distance against speed for different vehicles.

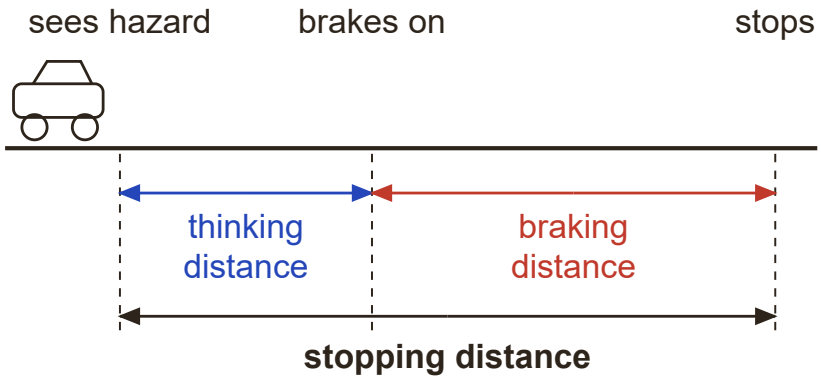
Key facts

- Stopping distance = thinking distance + braking distance
- Thinking distance ∝ speed (same reaction time)
- Greater speed → greater stopping distance
- Thinking distance = speed × reaction time
- Grade 8+ only Braking distance ∝ speed^2 (same braking force)
- Thinking distance: affected by reaction time. Braking distance: affected by road, weather, brakes, tyres, mass

Notes

Two parts

- **Stopping distance = thinking distance + braking distance**.
- **Thinking distance**: the distance the vehicle travels during the driver's reaction time, between seeing a hazard and applying the brakes.
- **Braking distance**: the distance the vehicle travels under the braking force, from applying the brakes until it stops.



Stopping distance = thinking distance + braking distance.

The effect of speed

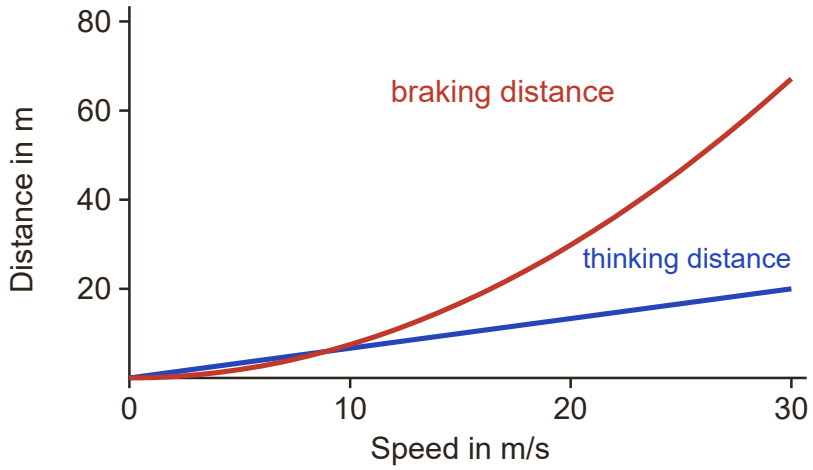
- For a given braking force, the greater the speed of the vehicle, the greater the stopping distance.
- Thinking distance = speed × reaction time. For the same reaction time, thinking distance is directly proportional to speed: double the speed, double the thinking distance.
- The work done by the brakes (braking force × braking distance) equals the kinetic energy (½ m v^2). So for the same braking force, braking distance is proportional to speed^2: double the speed, four times the braking distance. Grade 8+ only
- So at higher speeds, the braking distance makes up a bigger share of the stopping distance.

What affects each part

- Thinking distance depends on the speed and on the driver's reaction time, which is increased by tiredness, drugs, alcohol and distractions.
- Braking distance depends on the speed, the road and weather conditions (wet or icy), the condition of the brakes and tyres, and the mass of the vehicle.
- On a graph of distance against speed, a longer reaction time makes the thinking distance line steeper. Wet or icy roads, or worn brakes or tyres, make the braking distance curve steeper.

Graphs of stopping distance against speed

- A graph of thinking distance against speed is a straight line through the origin (for a constant reaction time).
- A graph of braking distance against speed is a curve that gets steeper, because braking distance increases faster than speed.



Thinking distance ∝ speed (straight line); braking distance rises much faster (curve).

- Graphs for different vehicles can be compared by reading each line at the same speed. For example, a heavily loaded lorry usually has a greater stopping distance than a car at the same speed, so it needs a bigger gap to the vehicle in front.

How to answer each type of question

Calculate a stopping distance

3 marks **Grade 5**

1. Thinking distance = speed × reaction time.
2. Add the braking distance.
3. Give the answer in m.

Example. A driver is travelling at 15 m/s. Her reaction time is 0.60 s. The braking distance of her car is 17 m.
Calculate the stopping distance.

Model answer.

thinking distance = 15 × 0.60 (1) = 9.0 m (1)

stopping distance = 9.0 + 17 = 26 m (1)

Explain the effect of speed on stopping distance

3 marks **Grade 5**

1. Thinking distance: the car travels further during the reaction time.
2. Braking distance: more kinetic energy, so more work must be done by the brakes.
3. So the total stopping distance increases.

Example. Explain why a car travelling at a higher speed has a longer stopping distance, for the same braking force.

Model answer.

At a higher speed the car travels further during the driver's reaction time, so the thinking distance is greater (1).

The car has more kinetic energy, so more work must be done by the brakes and the braking distance is greater (1).

Stopping distance = thinking distance + braking distance, so it increases (1).

Evaluate a statement using data

3 marks **Grade 7**

1. Calculate the values the statement is about.
2. Compare them and say whether the statement is right.
3. Explain using the separate thinking and braking distances.

Example. The table gives data for a car.

Speed in m/s	Thinking distance in m	Braking distance in m
10	7	8
20	14	32

A student says: 'Doubling the speed doubles the stopping distance.' Use the data to evaluate this statement.

Model answer.

Stopping distance at 10 m/s = 15 m; at 20 m/s = 46 m (1).

46 m is about three times 15 m, so the statement is wrong (1).

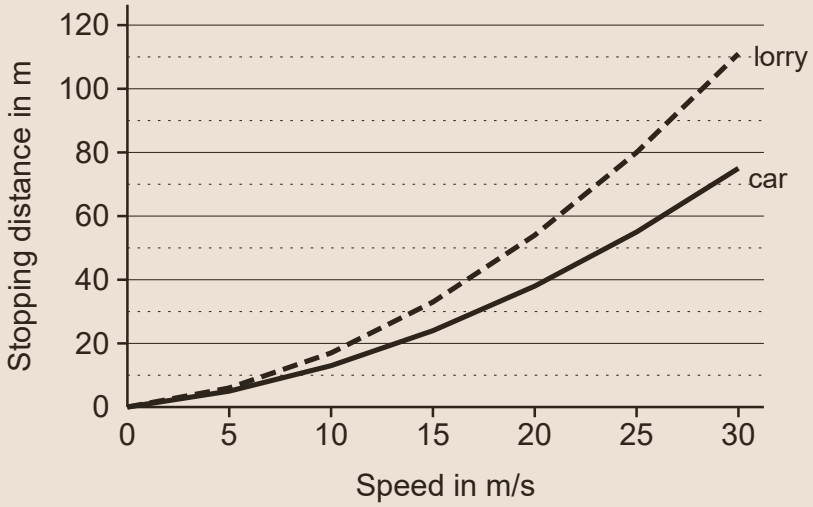
The thinking distance doubles (7 m to 14 m), but the braking distance is four times bigger (8 m to 32 m) (1).

Interpret a graph of stopping distance for different vehicles

2 to 3 marks | Grade 5

1. Read each line at the speed given.
2. Calculate or compare the values.
3. Explain the difference using mass, kinetic energy or braking force.

Example. The graph shows how the stopping distance varies with speed for a car (solid line) and for a fully loaded lorry (dashed line).



(a) Use the graph to calculate the difference in stopping distance between the two vehicles at 25 m/s.
(b) Suggest why the lorry's stopping distance is greater.

Model answer.

(a) lorry 80 m, car 55 m, so 80 − 55 = 25 m (1)

(b) The loaded lorry has a much greater mass, so it has more kinetic energy at the same speed (1)
so more work must be done by its brakes, giving a longer braking distance (1).

Don’t lose marks

- Saying alcohol or tiredness increases the braking distance. They increase the reaction time, and so the thinking distance.
- Saying wet roads increase the thinking distance. Road conditions affect the braking distance.
- Assuming that stopping distance is directly proportional to speed.
- Forgetting to add the thinking distance when the question asks for the stopping distance.

More tips

Memory tricks

- Stop = Think + Brake.
- Double the speed: thinking distance × 2, braking distance × 4.
- Thinking distance depends on the driver; braking distance depends on the vehicle and the road.

Exam technique

- Always say which part of the stopping distance a factor affects: thinking or braking.
- If you are given a speed and a reaction time, calculate the thinking distance with s = v t.
- When evaluating data or a graph, quote numbers from it to support your answer.

What each grade needs

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

Grade 3 — **Define stopping distance as thinking plus braking**
Thinking distance is covered during the reaction time; braking distance is covered while the brakes act.

Grade 4 — **Calculate stopping distance from given data**
Add the thinking distance and the braking distance.

Grade 5 — **Calculate thinking distance using s = v t**
Thinking distance = speed × reaction time.

Grade 5 — **Explain how speed affects stopping distance**
For a given braking force, a greater speed gives a greater thinking distance and a greater braking distance.

Grade 5 — **Interpret stopping distance data and graphs**
Thinking distance rises in proportion to speed; braking distance rises more and more steeply.

Grade 8 — **Explain why braking distance increases fastest**
For the same braking force, braking distance is proportional to speed squared, because kinetic energy is.

Free notes, Full packs, practice papers and mock exams at chhetriacademy.com. Written for this site; not taken from past papers. Stuck? 1-to-1 tutoring with a free 30-minute trial lesson.