Braking Distance
Braking Distance

What is braking distance?

- Braking energy, forces and work
- Decelerating safely

What affects braking distance?

Summary activities
What is braking distance?

**Stopping distance** is the overall distance that a vehicle takes to stop. It is made up of two parts: **thinking distance** and **braking distance**.

\[
\text{stopping distance} = \text{thinking distance} + \text{braking distance}
\]

Thinking distance is how far the vehicle travels whilst the driver is making the decision to stop.

The braking distance is how far the vehicle travels after the driver has applied the brakes.

The **faster** a vehicle is going, the **longer** it will take to stop.
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Braking forces

When a vehicle is travelling at a constant velocity, the thrust produced by the engine is balanced by resistive forces. The net force is zero.

In order to stop the vehicle, the brakes must apply an additional force. When this happens, the forces on the vehicle are no longer balanced and the car decelerates.
How do brakes work?

Brakes work through **friction**. Friction is a resistive force that occurs whenever two surfaces try to move past each other.

When brakes are applied, the brake pads are squeezed together and come into contact with the brake discs.

Large frictional forces are generated between the brake pads and the brake discs. These **oppose** the movement of the tyre and the tyre stops spinning.
Work done by frictional forces

Because the vehicle has kinetic energy, it takes work to stop it.

\[
\text{work done} = \text{energy transferred}
\]

The work done by the brakes to stop the car is equal to the kinetic energy the car had before the brakes were applied.

Energy can’t be destroyed, only transformed from one form to another. In this case, the kinetic energy is converted into heat energy. The brake pads and brake discs become hot.
What affects the kinetic energy?

The **kinetic energy** of an object can be calculated using the equation:

\[
\text{kinetic energy} = \frac{1}{2} \times \text{mass} \times (\text{velocity})^2
= \frac{1}{2} \text{m} \text{v}^2
\]

As **mass** and **velocity** increase, the kinetic energy of the object also increases.

Therefore, for the same braking force, the stopping distance of a vehicle increases with its mass and velocity.

Which do you think has the greater effect – mass or velocity?
Kinetic energy calculation

How much work is done by the brakes to bring a 1750 kg car travelling at 30 m/s to a stop?

work done = energy transferred

All of the car’s kinetic energy is transferred to heat.

KE = \( \frac{1}{2} \times \text{mass} \times \text{velocity}^2 \)

work done = kinetic energy = \( \frac{1}{2} \times m \times v^2 \)

= \( \frac{1}{2} \times 1750 \times 30^2 \)

= 787,500 J or 787.5 kJ
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Braking and deceleration

**Remember**: the faster the vehicle, the more kinetic energy it has. The **more** kinetic energy it has, the **more** work needs to be done to bring it to a stop.

To do more work over the same braking distance, the force applied by the brakes has to be **larger**.

The more force applied, the faster the car will decelerate. However, large decelerations are **dangerous**. Brakes can overheat and be damaged if applied too heavily or for too long.
Large or sudden decelerations can also injure the people in the vehicle.

A large force acting briefly is more of a risk than a moderate force acting over a longer period of time.

For this reason, many vehicles have safety features designed to increase the stopping time or stopping distance for the passengers.
Estimating braking forces

Estimate the force needed to safely stop...

...a small car.  about 5kN
...a bicycle.  around 200 N
... a heavy lorry.  roughly 15kN
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What factors other than speed affect braking distance?

- Adverse road conditions
- Poor condition of the vehicle
- Wet or icy weather
- Condition of road
- Poor condition of the vehicle
- Condition of tyres or brakes
Braking distance and friction

When braking, the tyres of the car are in contact with the brakes and the road.

If the brakes are worn, this will reduce the amount of friction between the tyre and the brake disc. The car will take longer to stop.

If the road is slippery, this will reduce the friction between the tyre and the road. The car will take longer to stop and be more likely to skid.
Braking quickly

In an emergency, drivers need to be able to minimise their braking distance in order to stop quickly.

Because of the **squared relationship** between velocity and braking distance, a small decrease in velocity produces a bigger decrease in braking distance.

Drivers are advised to reduce their speed in wet or icy weather. Different **speed limits** are used on different roads and in different situations. Compare the speed limit on a motorway to a street outside a school.
Estimating braking distance

Estimate the braking distance for a car travelling at...

... 25 mph.  ... 50 mph.  ... 100 mph.
around 10 m  around 40 m  around 160 m

How would these estimates change if the road was wet?
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Braking: true or false