



LESSON PLAN

Lesson 3: Stopping distances

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UNIT TITLE: Safer by Design - Investigating Forces, Motion and Road Safety



LEVEL

Years 9-10



LESSON NUMBER

3 of 9



LESSON LENGTH

60 minutes



VICTORIAN CURRICULUM 2.0 CONTENT DESCRIPTIONS

- **Physical sciences:** Newton's laws of motion can be used to quantitatively analyse the relationship between force, mass and acceleration of objects. (VC2SI0U17).



VICTORIAN CURRICULUM 2.0 ACHIEVEMENT STANDARDS

- **Science:** Students use Newton's laws to describe and predict the motion of objects in a system. (Level 9 & 10).

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KEY VOCABULARY

- **stopping** – coming to rest from a state of motion
- **speed** – the distance an object travels per unit of time (e.g. metres per second, m s⁻¹)
- **distance** – how far an object has travelled (measured in metres, m)
- **time** – the measured duration between two events (measured in seconds, s)
- **acceleration** – the rate of change of velocity; how quickly an object speeds up, slows down, or changes direction (measured in m s⁻²)
- **reaction** – a response to a stimulus; in driving, the time between noticing a hazard and beginning to apply the brakes
- **braking** – applying the brakes to reduce a vehicle's speed
- **friction** – a force that opposes motion between two surfaces in contact
- **initial** – occurring at the start; e.g. initial speed is the speed of a vehicle before braking begins



MATERIALS REQUIRED FOR THE LESSON

Student

- Recap of describing motion (Resource 3.1) Worksheet – 1 per student, printed
- Calculating stopping distance (Resource 3.2) Worksheet – 1 per student, printed
- Analysing stopping distance (Resource 3.3) Worksheet – 1 per student, printed

Teacher

- Supporting Slide Deck – as needed, display on screen or use a document camera or write on whiteboard
- Teacher Workbook – as needed for reference, including for display on screen or with a document camera
- TAC Video: [How can Auto Emergency Braking reduce crashes?](#) (Supporting Slide Deck Slide 22, or [on YouTube](#))



LEARNING OBJECTIVE

- We will analyse vehicle stopping distances in different conditions.

SUCCESS CRITERIA

- I can describe motion using speed, distance, time and acceleration.
- I can calculate the stopping distance of a vehicle.
- I can explain the factors that influence stopping distance.



TEACHING CONSIDERATIONS

- Further resources: The following may be useful to supplement the material in this lesson:
 - [It's a drag - stopping distances online simulator](#) (ESA, Scootle)
 - [Creating safe distances](#) (Vic Roads, MyLearners)

ADDITIONAL RESOURCES

- [Road to Zero Physics challenge](#)
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Structure of lesson:

1

INTRODUCTION



TIMING: 5 mins

Activate prior knowledge

- **Show** students the warm up question on Slide 22 of the Supporting Slide Deck. **Ask** them to select the best answer without looking at their notes or workbooks. **Check for understanding** by sampling all student responses using mini whiteboards or another suitable mode of response. **Respond** by addressing errors, clarifying any misconceptions and reteaching if necessary.

Introduce learning objective

- **Show** the learning objective.
- **Explain** how students can achieve this through the success criteria.

Explicitly teach vocabulary

- **Show** students the definition for stopping. **Elaborate** on the term.
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2

REVISITING DESCRIBING MOTION



TIMING: 10 mins

Explicitly teach vocabulary

- **Show** students the definitions for speed, distance, time and acceleration. **Elaborate** on the terms.

Explanation and modelling

- **Distribute** the Recap of Describing Motion Worksheet (Resource 3.1) to students (or if using the Workbook, direct students to page 25).
- **Explain** that we can use our knowledge of describing motion to calculate the distance it will take a vehicle to stop. Explain that to do this we need to be confident in our use of motion terminology and performing calculations.
- **Model** use of the formula for speed to calculate speed using the worked example provided in Part 1.

Guided and independent practice

- **Guide** students to complete the speed calculations using the worked example in Part 1 to help them as needed.
- **Check for understanding** by sampling all student responses using mini whiteboards or another suitable mode of response. **Respond** by addressing errors, clarifying any misconceptions and reteaching if necessary.

Explanation and modelling

- **Explain** that when we want to calculate distance, we can rearrange the relationship for speed. **Model** this for students, using a think aloud.
- **Model** calculating distance using the worked example provided in Part 2.

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Guided and independent practice

- **Guide** students to complete the distance calculations using the worked examples in Part 2 to help them as needed.
- **Check for understanding** by sampling all student responses using mini whiteboards or another suitable mode of response. **Respond** by addressing errors, clarifying any misconceptions and reteaching if necessary.

Explanation and modelling

- **Explain** that we will often encounter speeds, distances and times that are in other units. Ask students to recall that we practiced converting speeds in the previous lesson. Explain to students that we want to be using consistent units in our calculations. That normally means metres and seconds.
- **Model** unit conversions for distance, time and speed using the worked example provided in Part 3.

Guided and independent practice

- **Guide** students to complete the unit conversions in Part 3.
 - **Check for understanding** by sampling all student responses using mini whiteboards or another suitable mode of response. **Respond** by addressing errors, clarifying any misconceptions and reteaching if necessary.
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3

CALCULATING STOPPING DISTANCE



TIMING: 15 mins

Explicitly teach vocabulary

- **Show** students the definitions for reaction and braking. **Elaborate** on the terms. Clarify that the reaction has a number of meanings, even in science; as appropriate acknowledge and explain that the reaction we are talking about here is different to a reaction force in the sense of Newton's Third Law.

Explanation and modelling

- **Distribute** the Calculating Stopping Distance Worksheet (Resource 3.2) to students (or if using the Workbook, direct students to page 28).
- **Explain** that stopping distance is a combination of reaction distance and braking distance.
- **Explain** that reaction distance is how far a vehicle travels while the driver reacts to what has occurred, up until they respond by applying the brakes. During this time the vehicle speed can be assumed to remain constant.
- **Model** the calculation of reaction distance using the worked example in Part 1. Provide additional instructional examples if needed.

Guided and independent practice

- **Guide** students to complete the reaction distance calculations using the worked examples in Part 1 to support them.
- **Check for understanding** by sampling all student responses using mini whiteboards or another suitable mode of response. **Respond** by addressing errors, clarifying any misconceptions and reteaching if necessary.

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Explanation and modelling

- **Explain** that during braking, the friction force from the road on the tyres causes an acceleration opposing the forwards motion of the vehicle. This acceleration can be assumed to be constant for the purposes of estimating braking distance.
- **Explain** that we can derive a relationship for braking distance, and that it depends on the initial speed of the vehicle and the acceleration provided by the friction during braking. Show students the formula and explain what each term represents. Explain that students will learn how to derive this formula in VCE Physics, and that it is only for straight line motion at a constant acceleration. Explain that this formula has been specifically derived and simplified for braking distance scenarios and takes in the magnitude of the initial speed and acceleration (no negative signs).
- **Model** the calculation of braking distance using the worked example in Part 2. Provide additional instructional examples if needed. Explain that we need to choose a positive direction, and that is normally the direction that the vehicle is moving. The acceleration will be in the opposite direction, so it will have a negative sign.

Guided and independent practice

- **Guide** students to complete the braking distance calculations using the worked examples in Part 2 to support them.
 - **Check for understanding** by sampling all student responses using mini whiteboards or another suitable mode of response. **Respond** by addressing errors, clarifying any misconceptions and reteaching if necessary.
 - **Guide** students to recall stopping distance is a combination of reaction distance and braking distance. Explain that these two calculations can be combined into a single relationship for stopping distance.
 - **Ask** students to complete the stopping distance calculations using the worked examples in Part 3 to support them.
 - **Check for understanding** by sampling all student responses using mini whiteboards or another suitable mode of response. **Respond** by addressing errors, clarifying any misconceptions and reteaching if necessary.
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ANALYSING STOPPING DISTANCE



TIMING: 20 mins

Explanation and modelling

- **Distribute** the Analysing Stopping Distance Worksheet (Resource 1.10) to students (or if using the Workbook, direct students to page 31).
- **Explain** that we can analyse how different factors effect stopping distance using the relationships that we have just practiced doing calculations with. Explain that this requires some assumptions, so we will assume a reaction time of 1.5 seconds and keep this constant.
- **Explain** that the road conditions effect the friction force between the tyres and the road, which in turn effects the acceleration during braking. For dry roads assume an acceleration of 6 m s^{-2} . Wet roads provide less friction, so assume a lower acceleration value of 4.5 m s^{-2} .
- **Model** the calculation of stopping distance for these assumptions using the worked example in Part 1.
- **Explain** to students that **to compare different scenarios it is useful to create a visual comparison**. **Model** how to create the stopping distance visualisation at the end of the worked example in Part 1.

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Guided and independent practice

- **Guide** students to calculate the stopping distances for the different scenarios given in Part 2, using the space available to show their working and recording their results in the table. Explain that they can use the worked example in Part 1 to assist them.
 - **Guide** students to represent their results in the visualisation at the end of Part 2. **Check for understanding** by sampling the completed visualisations.
 - **Ask** students to reflect on how the different variables effected stopping distance. **Facilitate** discussion of what made a difference (speed, road conditions), and to what extent (changing speed leads to a large increase in stopping distance as it is a squared term in the calculation).
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CONCLUSION



TIMING: 10 mins

Reflection on learning

- **Show** the learning objectives and success criteria.
 - **Ask** students access their copy of the Safe System Worksheet (or if using the Workbook, direct students to page 2). **Guide** students to reflect on how stopping distances connect to different parts of the safe system. Use prompting questions such as 'which parts of the system can effect reaction distance?', 'how might safer vehicles effect braking distance?', 'what are some of the choices that a driver makes that effect stopping distance?', or similar.
 - **Show** students the graphic on the three second rule on Slide 24 of the Supporting Slide Deck. Briefly explain the 3 second rule to students. **Guide** students to think-pair-share their answers to the question on the slide about the connection between stopping distances and the 3 second rule. Ensure that students have adequate solo thinking time first, that the sharing in pairs is focussed and both get a turn to share.
 - **Check for understanding** by sampling all student responses using mini whiteboards or another suitable mode of response. **Respond** by prompting students to make connections and extend their thinking. Address any errors and misconceptions.
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