ROAD TO ZERO

POST-VISIT ACTIVITY:
STOPPING DISTANCE AND SPEED

This investigation will explore the relationship between stopping distance and speed.

Students use the graph and table in the spreadsheet (Stopping_distance.xlsx) to test the impact on stopping distances of different speeds and compare their findings to their *Road to Zero* VR test track stopping distance data.

Learning context

Science classes

Victorian curriculum learning areas and level

Science	**Level 9–10**
Capabilities	**Level 9–10**

- Critical and Creative Thinking

Victorian curriculum strands and sub-strands

Science

Science Understanding

Physical sciences

- Newton's laws of motion can be used to quantitatively analyse the relationship between force, mass and acceleration of objects (VC2S10U17)

Science Inquiry Skills

Planning and conducting

- Equipment can be selected and used to generate and record data sets that show precision, including consideration of sample size and using digital tools as appropriate (VC2S10I03)

Processing, modelling and analysing

- Data and information can be organised, processed and summarised by selecting and constructing representations including tables, graphs, descriptive statistics, models, symbols, formulas and mathematical relationships (VC2S10I04)
- Information and processed data can be analysed and compared to identify and explain qualitative and quantitative patterns, trends, relationships and anomalies (VC2S10I05

Evaluating

- the validity and reproducibility of investigation methods and the validity of conclusions and claims can be evaluated, including by identifying assumptions, conflicting evidence, biases that may influence observations and conclusions, sources of error and areas of uncertainty (VC2S10I06)

Capabilities	Critical and Creative Thinking *Questions and Possibilities* • Strategies for generating new ideas and possibilities including identifying links and patterns across multiple information sources and perspectives (VC2CC10Q03)

Learning intention

Understand the role that vehicle speed plays in determining car stopping distance

Success criteria

- Collect and record data on vehicle stopping distances at different speeds
- Understand the impact that vehicle speed has on stopping distance
- Consider the differences between the data from this investigation and the stopping distance data and the data collected from the *Road to Zero* VR test track experiment

Resources

Student investigation sheet	**Stopping distance and speed**
Excel spreadsheet file (available from roadtozero.vic.gov.au)	**Stopping distance**

Learning activity description

The simulator provided in the spreadsheet (Stopping_distance.xlsx) is designed to model a series of vehicle stopping scenarios and the variables controlling them. This activity only explores stopping distances at different speeds, but you may like to have students investigate other variables.

When using the spreadsheet simulator please note the following.

Perception-reaction times: These are a vital part of stopping because while a driver is perceiving a hazard and reacting, the vehicle does not reduce its speed. The time taken will vary between and within individuals. Experimentally this has been shown to depend significantly on the level of alertness in the person reacting.

The reaction times recorded in the *Road to Zero* VR test track experiment are much faster than those in a real driving situation. Similarly, reaction times determined in catching a falling ruler can often be found to be 0.2 to 0.3 seconds. In general for driving, reaction times will be longer, and not all alert drivers will react in the same time. A common reaction time for most drivers is around 1.2 seconds.

Road surface: The road surface will limit the braking force which can be applied.

Braking system quality: The system of brakes, tyres and road interacts with the road surface in producing the basic braking process, and the lower value given for these two factors is chosen in producing a simulated result.

This result produced on a good road is similar to the braking percentage used for roadworthy certificates. It refers to a deceleration comparable in magnitude to the acceleration of a falling object – 100% indicates braking at 9.8 m s^{-2}.

Brake application: The force applied by the driver, and its control of braking forces produced by the vehicle's engine, will determine the actual application of the braking force which can be generated.

Vehicle mass: This is actually a minor factor in terms of braking distance. Several reasons lie behind this.

Firstly, the roads are shared by a range of vehicles with a large range of masses, yet all have to move similarly in the same space. This is perhaps similar to small children, with short paces walking alongside long paced adults.

In the case of trucks and cars, this is achieved with different designs for braking systems together with wheels and tyres which vary greatly in the force delivered to stop the vehicle.

Secondly, when a vehicle load changes, braking force also changes, at least at the level understood by secondary students.

There are further factors involved which you could discuss with your students.

- At higher load the tyre flattens more and increases the area of contact, potentially increasing grip.
- The braking system may not be capable of applying this extra braking force through limits on its mechanics. This would, at some level, be regarded as overloading. This would reduce the maximum braking force.
- In some cases, an extra load does not contribute to the frictional grip. This is the case of small un-braked trailers. The load is carried on free rolling wheels. Worse, if the load is not balanced it can lift the back or even front wheels reducing the load and changing the car's braking system.
- Load issues can contribute to other problems: imbalance on the wheels, steering problems and a tendency to topple the vehicle for example.

Analysis answers

1. Braking, total: parabolic, quadratic, rises more steeply with increased speed

   Reaction: linear.
2. Under these conditions, braking distance becomes greater than half of the total stopping distance around 100 km/h.

   Both braking and total distances are increasing, but the braking graph is rising to approach the total distance graph.

   The reaction time distance is linear, dependent on the speed only.
3. Separation of cars, bikes, pedestrians

   Speed control nearer to intersections, etc.

   Traffic calming at more dangerous locations, such as intersections, pedestrian crossings.
4. The distance travelled during reaction in the *Road to Zero* VR test track experiment is much shorter. This is because the reaction time using the controller with your hand is much faster than for a driver reacting and applying brakes with their foot.

Student worksheet

Name:

STUDENT INVESTIGATION SHEET: STOPPING DISTANCE AND SPEED

Aim

To show the relationship between total stopping distance and speed.

Method

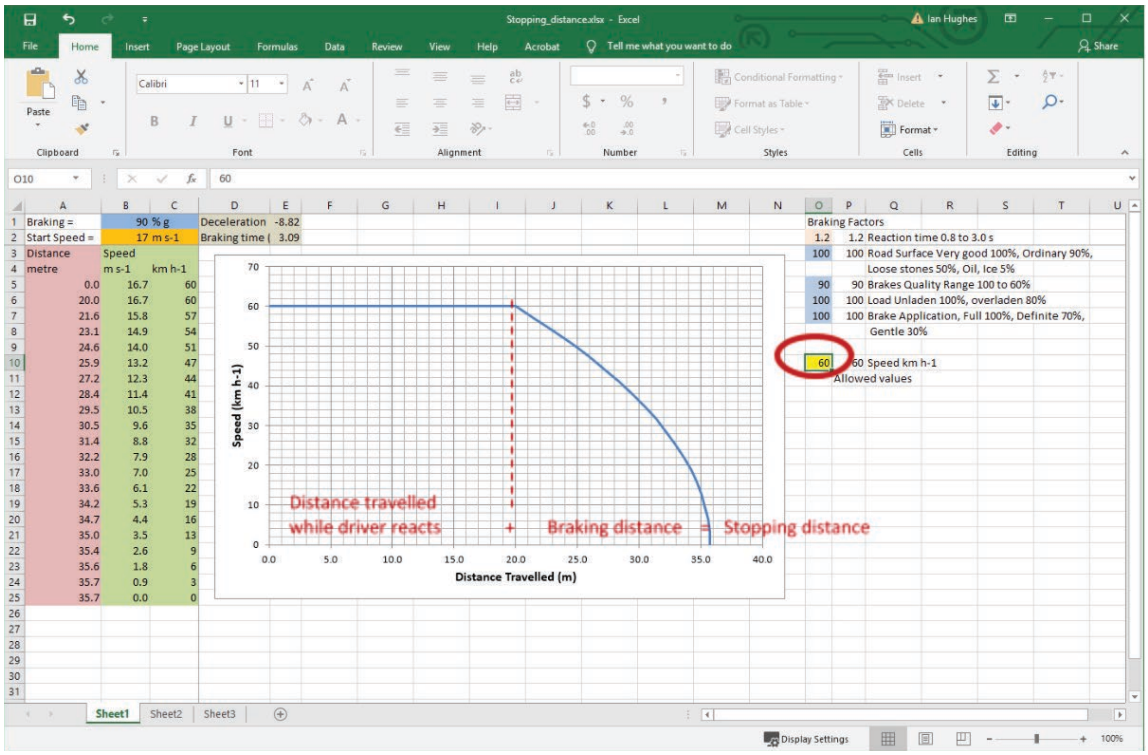
Use the graph and table in the spreadsheet (Stopping_distance.xlsx) to explore how vehicle speed changes stopping distance.

Open the spreadsheet: **Stopping_distance.xlsx**

The graph in the Sheet 1 shows vehicle stopping distance. Stopping distance is made up of the distance travelled while a driver reacts and the distance travelled while braking to a stop.

The cells on the right show some of the different variables that impact on stopping distance, but for this activity you will mainly be focusing on speed.

By changing the speed in the cell circled and highlighted yellow, you will be able to observe changes in vehicle stopping distance.



Activities

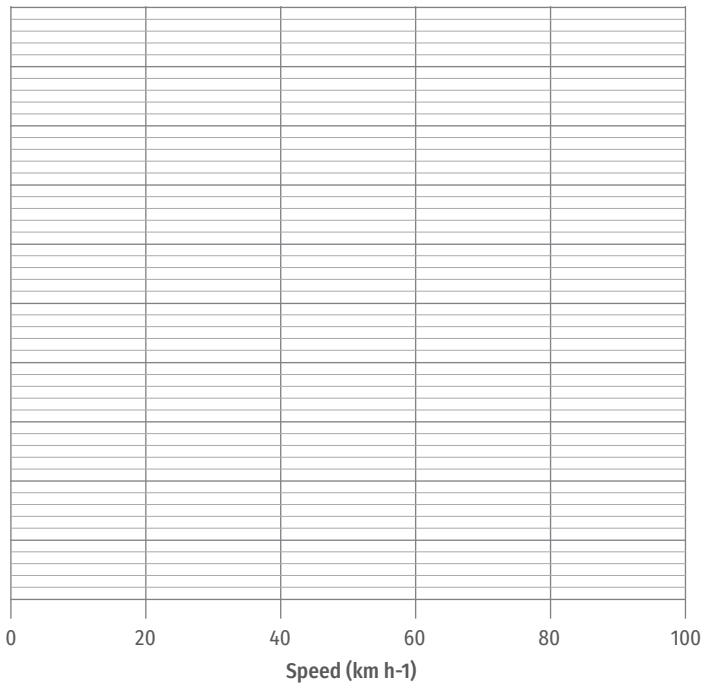
Using the spreadsheet, complete the following table for each speed from 10 km/h to 100 km/h.

Vehicle speed (km/h)	**Total stopping distance** (m)	**Reaction time distance** (m)	**Braking distance** (m)
0	0	0	0
10			
20			
30			
40			
50			
60	36	20	16
70			
80			
90			
100			

Plot the three sets of data from your completed table on the graph grid below or use a spreadsheet. Put values on the vertical scale (y axis) and label this axis. Indicate which colour or line format represents each set of data.

Analysis

Graph 1 Total distance (m) Graph 2 Reaction time distance (m) Graph 3 Braking distance (m)



1. **What trend appears in the three graphs as speeds get higher?**

2. **At high speed, what is mostly determining the total stopping distance: reaction time distance or braking distance? Is this the same at low speeds? Explain your answers.**

3. **What sort of design features are needed for higher speed roads? Consider issues which you have discussed in class or seen at *Road to Zero*.**

4. **Compare the data in your table to the data collected for a dry road at different speeds during the *Road to Zero* VR test track experiment. What are the main differences and why is this the case?**