TEACHER WORKBOOK

Safer by Design - Years 9/10
Investigating Forces, Motion and Road Safety

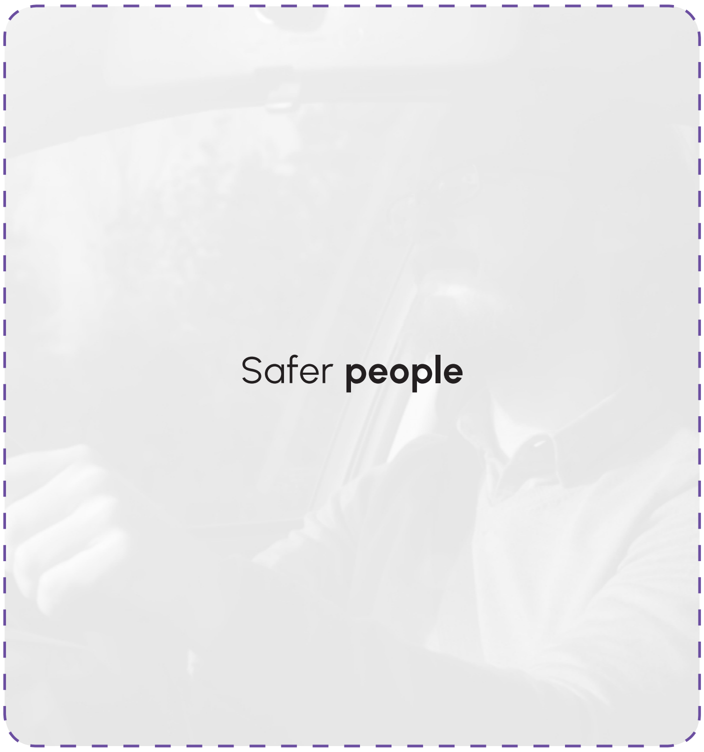
TABLE OF CONTENTS

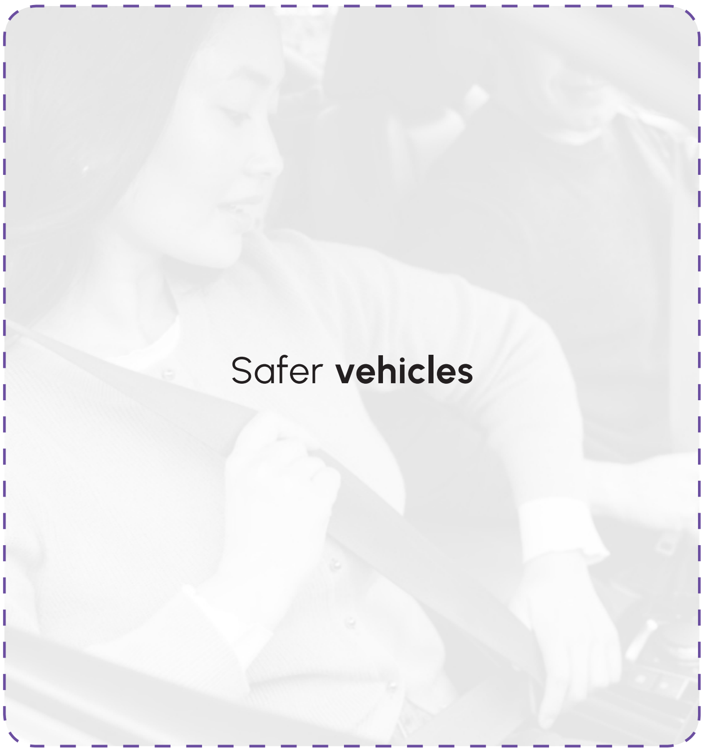
ROAD SAFETY EDUCATION VICTORIA

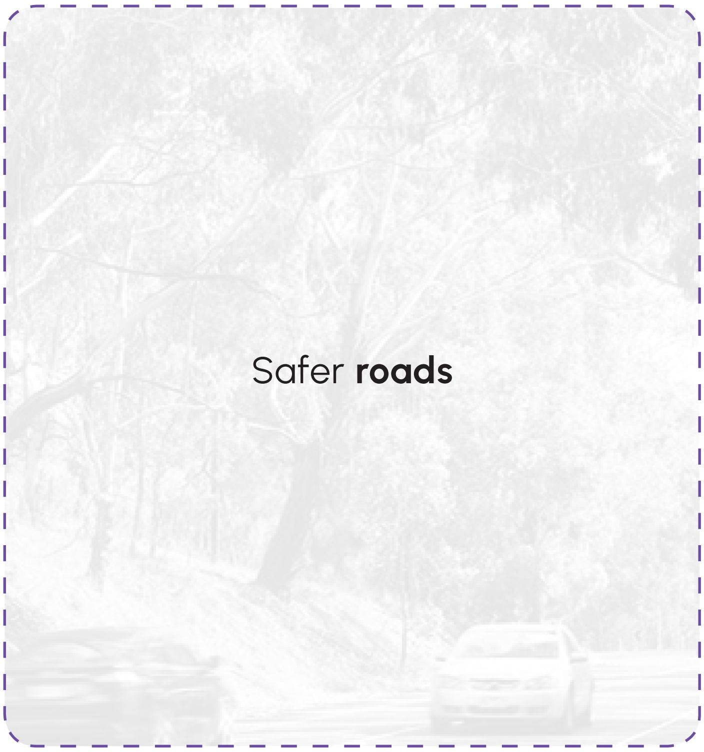
Unit Assessment Rubric

Content Focus (Lessons)	1 Foundations	2 Acquisition	3 Fluency	4 Generalisation & Application
Safe System (Lesson 1)	Names the four components of the safe system	Sorts road safety strategies into the correct safe system component	Explains how specific strategies reduce the likelihood or severity of crashes	Connects the need for safe system strategies to road safety data
Speed & Kinetic Energy (Lesson 2)	Recalls types of energy and energy conservation	Calculates kinetic energy	Explains why small speed increases lead to large kinetic energy increases	Connects kinetic energy increases to potential crash severity
Stopping Distance (Lesson 3)	Identifies the two components of stopping distance	Calculates stopping distance from given speed and acceleration values	Explains how speed, road surface and reaction time each effect stopping distance	Predicts how changing conditions alter stopping distance
Reaction Times (Lesson 4)	Lists factors that increase reaction time	Follows a method to collect and record reaction time data	Calculates reaction times and identifies trends across conditions	Evaluates the validity of the experiment and connects findings to driver distraction
Active Safety (Lesson 5)	Distinguishes between active and passive safety features	Describes the function of a specific active safety feature	Explains how an active safety feature reduces crash risk using scientific reasoning	Connects active safety technologies to the safe system
Passive Safety & Forces (Lesson 6)	Names passive safety features found in vehicles	Describes how seatbelts, airbags or crumple zones protect occupants in a crash	Explains passive safety features using force, acceleration, work and energy	Applies Newton's laws to explain how passive features improve safety
Design, Build & Test (Lessons 7–8)	Identifies design requirements from the brief	Produces a design and constructs it according to the brief	Tests the design against brief requirements and records outcomes	Evaluates performance using test evidence and proposes justified improvements
Road Safety Communication (Lesson 9)	Identifies a road safety feature and states its purpose	Describes how a chosen feature reduces road harm for a general audience	Constructs a clear explanation of a safety feature drawing on relevant scientific understanding	Connects the feature to the safe system and makes a case for its use

Safe System Worksheet







Vocabulary Worksheet

EVERYDAY TERMS

Word	Explanation	Picture or Diagram

ROAD SAFETY TERMS

Word	Explanation	Alternative words or phrases	Picture or Diagram

SCIENTIFIC TERMS

Word	Explanation	Units	Symbol (and Formula)	Picture or Diagram

Active and Passive Safety

Active Crash Avoidance	**Passive** Crash Protection
Prevent or reduce the severity of a crash	**Protect** those involved in the event of a crash
Including preventing crashes and reducing severity by improving: · braking performance · vehicle control · driver attention and reactions	**Including protecting vehicle occupants and road users by:** · avoiding collisions between occupants and the vehicle interior · reducing the force on occupants · dissipating energy
Worked example: Anti-lock braking systems improve safety by improving the braking performance of a vehicle. This can decrease the braking distance, meaning the vehicle comes to a stop sooner. This can prevent or reduce how severe a crash is.	**Worked example:** Seatbelts improve safety by the event of a crash by providing a distributed force on the vehicle occupant. This brings the occupant to a stop with the car, so they do not continue moving. This reduces the likelihood of them experiencing large, concentrated forces from colliding with other parts of the car such as the windscreen. It can also reduce the force required to stop the occupant by increasing the collision duration.
Your turn (1):	**Your turn (1):** Airbags
Your turn (2):	**Your turn (2):** Crumple zones

Vocabulary Worked Examples

EVERYDAY TERMS

Word	Explanation	Picture or Diagram
Safe	not in danger or likely to be harmed	
System	a set of connected things or devices that operate together	

ROAD SAFETY TERMS

Word	Explanation	Alternative words or phrases	Picture or Diagram
Brakes	A device that applies friction to the wheels of a vehicle to slow it down or bring it to a stop		
Reaction	A response to a stimulus; in driving, the time between noticing a hazard and beginning to apply the brakes	Response, reflex	
Braking	Applying the brakes to reduce the speed of a vehicle	Slowing down	
Stopping	Coming to a complete rest from a state of motion	Halting, coming to rest	

SCIENTIFIC TERMS

Word	Explanation	Units	Symbol (and Formula)	Picture or Diagram
Speed	The distance an object travels per unit of time	$m\ s^{-1}$	$v = \frac{d}{t}$	
Energy	The capacity to do work; can be stored, transferred and transformed but not created or destroyed	J	E_	
Work	The transfer of energy when a force moves an object over a distance	J	W_	
Kinetic energy	The energy an object has due to its motion; depends on both mass and speed	J	$E_k = \frac{1}{2} mv^2$	

Safe System Worked Examples

PARTIAL WORKED EXAMPLE

Safer **speeds**

School speed zones

Safer **people**

P-plate restrictions

Safer **vehicles**

Airbags

Safer **roads**

Roadside safety barriers

Safe System Worked Examples

COMPLETE WORKED EXAMPLE (SAMPLE RESPONSES FOR TEACHER USE)

Safer **speeds**

School speed zones
Speed cameras
Speed signage
Average speed cameras
Enforcement campaigns
Advisory speed signs on curves

Safer **people**

P-plate restrictions
L-plate logbooks
Driver education programs
Graduated Licencing System
Wearing seatbelts correctly
Wearing a properly fitted helmet (bike/scooter)
Not using a mobile phone while driving
Driving without alcohol or drugs in your system
Following road rules and signals
Managing fatigue (rest breaks on long trips)
High-visibility clothing for pedestrians/cyclists
Crossing the road safely (Stop, Look, Listen, Think)

Safer **vehicles**

Airbags
Anti lock braking system
Seatbelts
Electronic stability control
Autonomous emergency braking (AEB)
Reversing cameras and sensors
Lane departure warning systems
Adaptive cruise control
Child restraint systems
Vehicle safety ratings (ANCAP)

Safer **roads**

Roadside safety barriers
Rumble strips
Reflectors
Pedestrian crossings
Bike lanes and shared paths
Roundabouts
Speed humps
Street Lighting
reflective road markers
Median strips

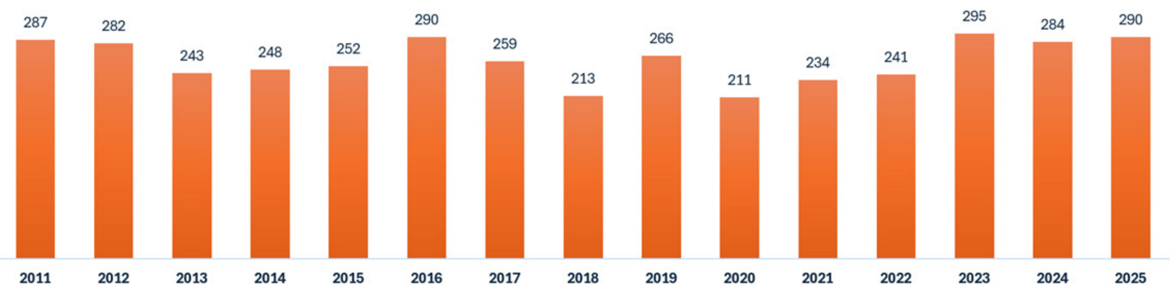
Data Analysis using DIAL

The DIAL structure can be used when analysing data.

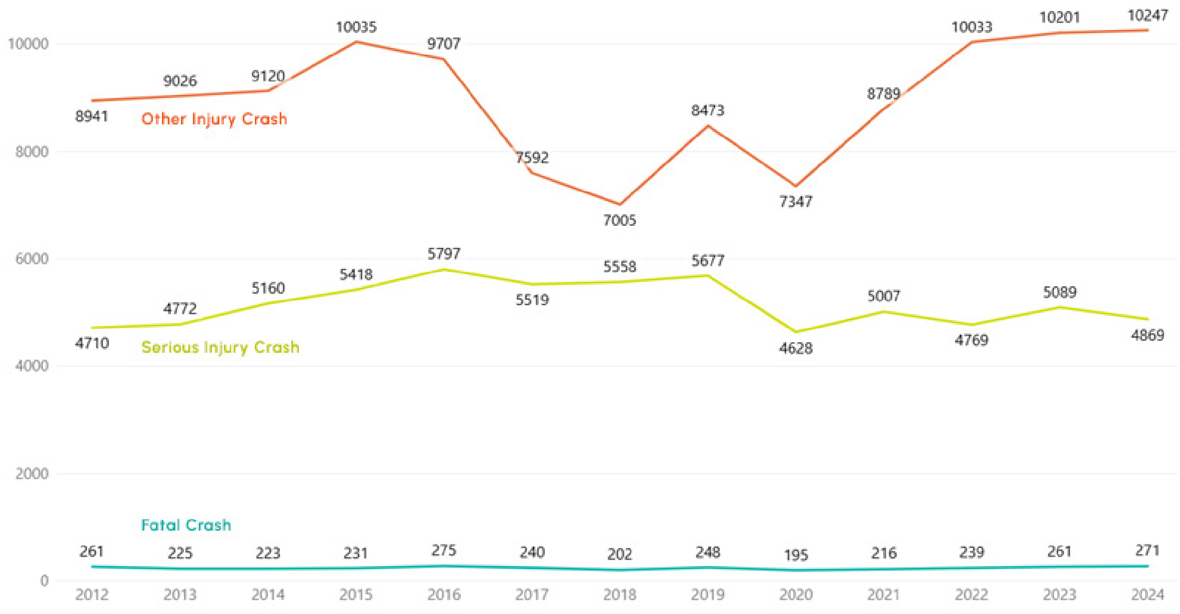
D	Data	*What is the raw information and what is its source?*
I	Interpretation	*What do we notice in the data? What patterns, trends, outliers or information stand out?*
A	Analysis	*What might the data suggest about what is happening? What conclusions, inferences, arguments, predictions or hypotheses might we make based on the data?*
L	Limitations	*What limitations are there in the data? How might this impact our analysis? What more might we need to have greater confidence?*

Source: Michael Rosenbrock https://michaelrosenbrock.com

DATASET 1 - LIVES LOST BY YEAR (WORKED EXAMPLE)

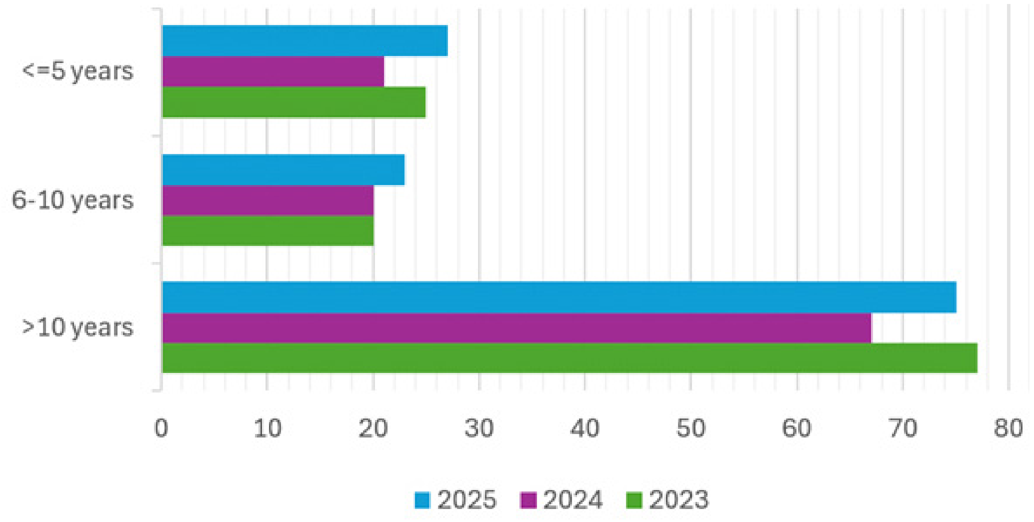
D	Data	*What is the raw information and what is its source?* Graph: Lives Lost by Year (data from the TAC) 
I	Interpretation	*What do we notice in the data? What patterns, trends, outliers or information stand out?* · The highest lives-lost was in 2016/2025 at 290 · The lowest lives-lost was 2020 at 211, closely followed by 2018 at 213 · There is not a particularly clear trend of increasing or decreasing
A	Analysis	*What might the data suggest about what is happening? What conclusions, inferences, arguments, predictions or hypotheses might we make based on the data?* · The data is relatively stable over time · The last three years have been amongst the highest · The years 2020 to 2022 were understandably lower due to less road use due to covid-19
L	Limitations	*What limitations are there in the data? How might this impact our analysis? What more might we need to have greater confidence?* · This data does not include injuries, so shows only some of the impact of road accidents · This data is not scaled against volume of road use, or population · More detailed data, breaking it down into different categories or similar may help to identify any more definite trends (and possible underlying causes)

DATASET 2 - NUMBER OF CRASHES BY YEAR AND SEVERITY

D	Data	*What is the raw information and what is its source?* <u>Graph: Crashes by Year and Severity (Department of Transport and Planning)</u> 
I	Interpretation	*What do we notice in the data? What patterns, trends, outliers or information stand out?* .
A	Analysis	*What might the data suggest about what is happening? What conclusions, inferences, arguments, predictions or hypotheses might we make based on the data?* .
L	Limitations	*What limitations are there in the data? How might this impact our analysis? What more might we need to have greater confidence?* .

ROAD SAFETY EDUCATION VICTORIA

DATASET 3 – LIVES LOST BY VEHICLE AGE GROUP

D	Data	*What is the raw information and what is its source?* Graphic: Lives Lost by Vehicle Age Group (data from the TAC) 
I	Interpretation	*What do we notice in the data? What patterns, trends, outliers or information stand out?* ·
A	Analysis	*What might the data suggest about what is happening? What conclusions, inferences, arguments, predictions or hypotheses might we make based on the data?* ·
L	Limitations	*What limitations are there in the data? How might this impact our analysis? What more might we need to have greater confidence?* ·

DATASET 4 – LIVES LOST BY ROAD USER

D	Data	*What is the raw information and what is its source?*
I	Interpretation	*What do we notice in the data? What patterns, trends, outliers or information stand out?* .
A	Analysis	*What might the data suggest about what is happening? What conclusions, inferences, arguments, predictions or hypotheses might we make based on the data?* .
L	Limitations	*What limitations are there in the data? How might this impact our analysis? What more might we need to have greater confidence?* .

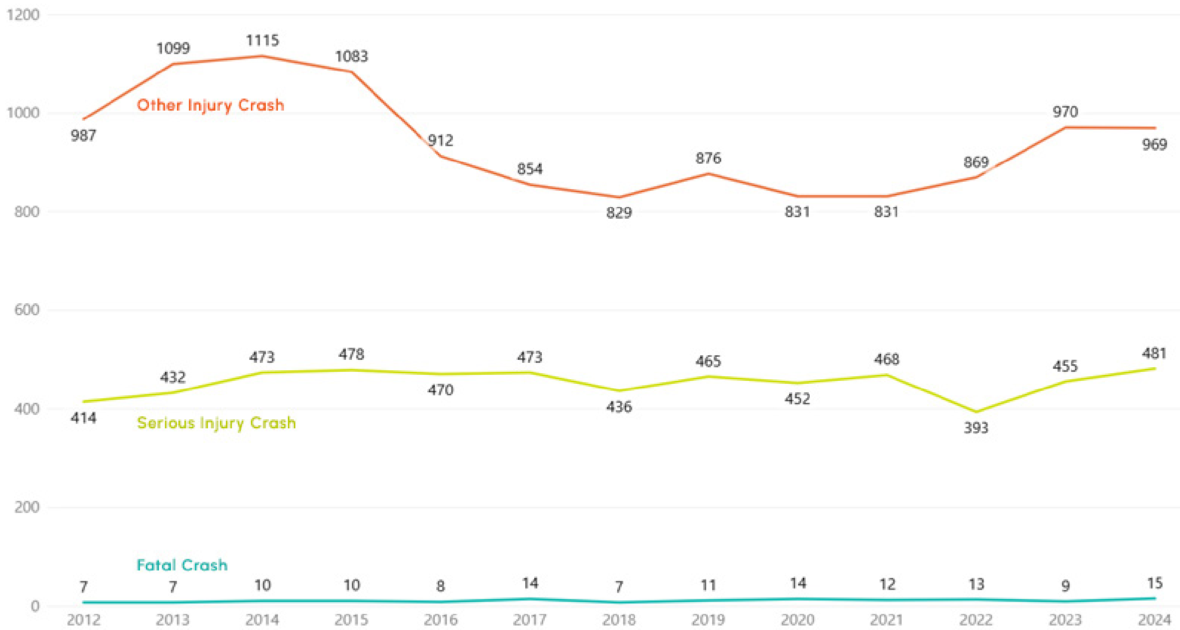
<u>Table: Lives Lost by Road User (data from the TAC)</u>

	Year				
User Type	**2022**	**2023**	**2024**	**2025**	**2026**
Bicyclist	6	6	5	3	5
Driver	53	70	60	67	53
E-Scooter Rider	1	1	2	1	1
Motorcyclist	27	19	34	40	20
Passenger	15	40	19	24	26
Pedestrian	23	16	25	30	25
Total	**125**	**152**	**145**	**165**	**130**

DATASET 5 – NUMBER OF CRASHES BY YEAR AND SEVERITY (BICYCLE)

<table>
<tr><td>D</td><td>Data</td><td>What is the raw information and what is its source?

<u>Graph: Number of Crashes involving a Bicycle by Year and Severity (Department of Transport and Planning)</u>


</td></tr>
<tr><td>I</td><td>Interpretation</td><td>What do we notice in the data? What patterns, trends, outliers or information stand out?
.</td></tr>
<tr><td>A</td><td>Analysis</td><td>What might the data suggest about what is happening? What conclusions, inferences, arguments, predictions or hypotheses might we make based on the data?
.</td></tr>
<tr><td>L</td><td>Limitations</td><td>What limitations are there in the data? How might this impact our analysis? What more might we need to have greater confidence?
.</td></tr>
</table>

DATASET 6 – LIVES LOST BY LOCATION

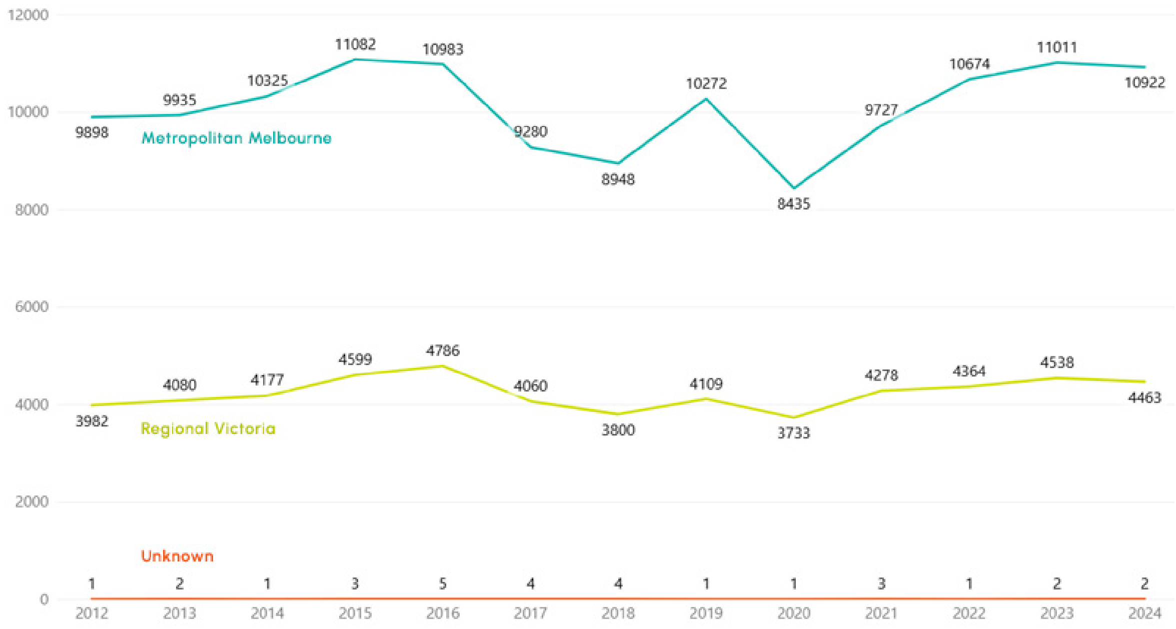
<table>
<tr><td>D</td><td>Data</td><td>What is the raw information and what is its source?

<u>Table: Lives Lost by Location (data from the TAC)</u>
<table>
<tr><th></th><th colspan="3">Year</th></tr>
<tr><th>Level of Urbanisation</th><th>2023</th><th>2024</th><th>2025</th></tr>
<tr><td>Provincial Cities/Towns</td><td>33</td><td>29</td><td>25</td></tr>
<tr><td>Rural Roads</td><td>158</td><td>145</td><td>154</td></tr>
<tr><td>Small Towns/Hamlets</td><td>0</td><td>2</td><td>0</td></tr>
<tr><td>Urban Melbourne</td><td>103</td><td>107</td><td>111</td></tr>
</table>
</td></tr>
<tr><td>I</td><td>Interpretation</td><td>What do we notice in the data? What patterns, trends, outliers or information stand out?</td></tr>
<tr><td>A</td><td>Analysis</td><td>What might the data suggest about what is happening? What conclusions, inferences, arguments, predictions or hypotheses might we make based on the data?</td></tr>
<tr><td>L</td><td>Limitations</td><td>What limitations are there in the data? How might this impact our analysis? What more might we need to have greater confidence?</td></tr>
</table>

DATASET 7 – NUMBER OF CRASHES BY YEAR AND LOCATION (METRO AND REGIONAL)

<table>
<tr><td>D</td><td>Data</td><td>What is the raw information and what is its source?

<u>Graph: Number of Crashes by Year and Location (Department of Transport and Planning)</u>



</td></tr>
<tr><td>I</td><td>Interpretation</td><td>What do we notice in the data? What patterns, trends, outliers or information stand out?
.</td></tr>
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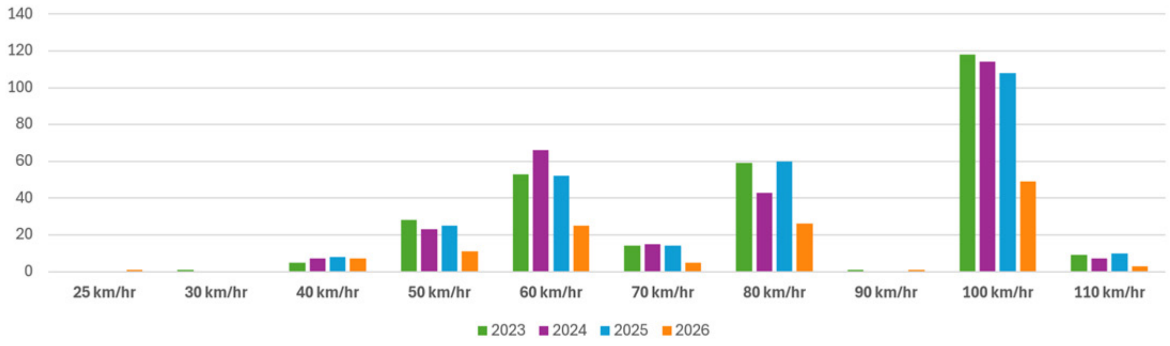
.</td></tr>
<tr><td>L</td><td>Limitations</td><td>What limitations are there in the data? How might this impact our analysis? What more might we need to have greater confidence?
.</td></tr>
</table>

Speed Statistics

DATASET 8 – LIVES LOST BY SPEED ZONE

<table>
<tr><td>D</td><td>Data</td><td>What is the raw information and what is its source?

Graph: Lives Lost by Speed Zone (data from the TAC)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<tr><td>L</td><td>Limitations</td><td>What limitations are there in the data? How might this impact our analysis? What more might we need to have greater confidence?
.</td></tr>
</table>

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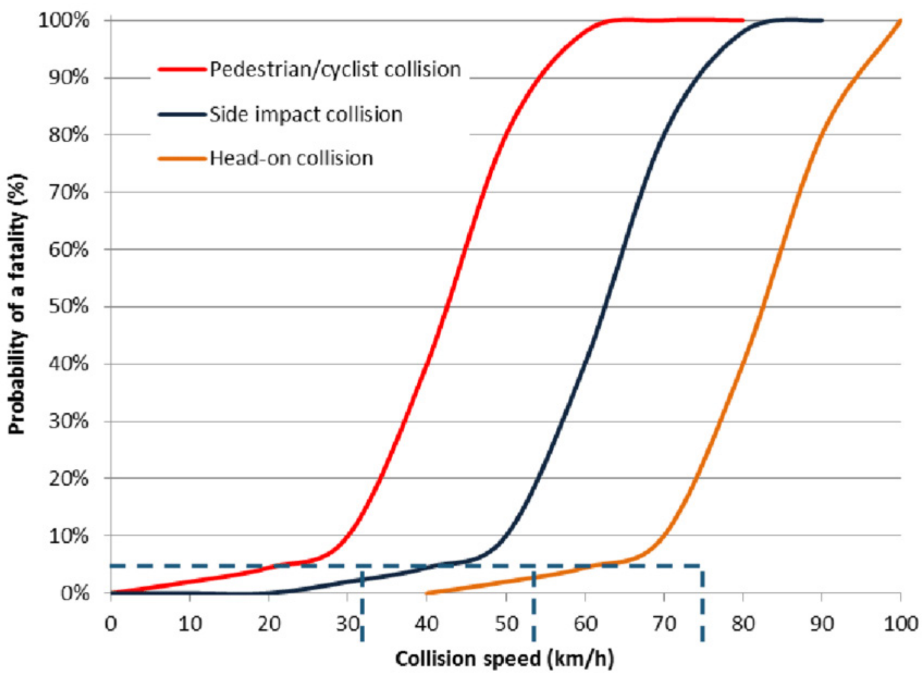
DATASET 9 – IMPACT OF SPEED MODEL FROM RESEARCH

<table>
<tr><td>D</td><td>Data</td><td>

What is the raw information and what is its source?

<u>Graph: Fatality Risk by Impact Speed & Crash Type</u>



Source: Jurewicz, Tofler, Makwasha. (2015). https://www.researchgate.net/figure/Wramborgs-model-for-fatality-probability-vs-vehicle-collision-speeds_fig2_295072998

</td></tr>
<tr><td>I</td><td>Interpretation</td><td>

What do we notice in the data? What patterns, trends, outliers or information stand out?

.

</td></tr>
<tr><td>A</td><td>Analysis</td><td>

What might the data suggest about what is happening? What conclusions, inferences, arguments, predictions or hypotheses might we make based on the data?

.

</td></tr>
<tr><td>L</td><td>Limitations</td><td>

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</td></tr>
</table>

Revisiting Key Energy Concepts

PART 1 – DEFINING ENERGY

Scientists define energy as a measure of capacity to __do work___. More energy means __more___ ability to do work. This means that it can cause change.

PART 2 – TYPES OF ENERGY

There are many different types of energy. We commonly refer to these three types.

Kinetic energy	The energy of objects with __mass__ that are __moving___.	e.g. a car driving along the highway	$E_k = \frac{1}{2} mv^2$
Gravitational potential energy	The energy of an object due to its position within a gravitational field	e.g. lifting ball above your head	$E_g = mg\Delta h$
Elastic potential energy	The energy stored by compressing or stretching elastic materials	e.g. stretching or squashing a spring	$E_s = \frac{1}{2} kx^2$

PART 3 – ENERGY CONSERVATION

Conservation of energy means that it cannot be __created__ or __destroyed__. The total energy is an _isolated__ system will be constant.

PART 4 – ENERGY CHANGES

Energy changes happen when it is transferred or transformed.

Transfer occurs when energy moves to a different __object__ or __place__ . For example, when electrical energy is transferred between devices. The form does not change.

Transformation of energy occurs when it changes __form__ . For example, when the gravitational potential energy of a falling ball is transformed into kinetic energy.

Kinetic energy calculations

PART 1 – KINETIC ENERGY

Calculating kinetic energy – worked example

A compact car of mass 1200 kg is travelling in a school zone at 36 km h^{-1} (10 m s^{-1}). Calculate its kinetic energy.

$$E_k = \frac{1}{2} mv^2$$
$$E_k = \frac{1}{2} (1200)(10)^2$$
$$E_k = \frac{1}{2} (1200)(100)$$
$$E_k = 60\ 000 \text{ J}$$

Calculating kinetic energy – faded example

A van of mass 2700 kg is travelling on a freeway at 90 km h^{-1} (25 m s^{-1}). Calculate its kinetic energy.

$$E_k = \frac{1}{2} mv^2$$
$$E_k = \frac{1}{2} (2700)$$
$$E_k = \frac{1}{2} (2700)(625)$$
$$E_k = 843\ 750 \text{ J}$$

Calculating energy – practice and check understanding (1)

A small truck of mass of 4400 kg is travelling on a road at 72 km h^{-1} (20 m s^{-1}). Calculate its kinetic energy.

$$E_k = \frac{1}{2} mv^2$$
$$E_k = \frac{1}{2} (4400)(20)^2$$
$$E_k = \frac{1}{2} (4400)(400)$$
$$E_k = 880\ 000 \text{ J}$$

Calculating energy – practice and check understanding (2)

A scooter and rider with a combines mass of 190 kg are travelling on a road at 27 km h^{-1} (7.5 m s^{-1}). Calculate their kinetic energy.

$$E_k = \frac{1}{2} mv^2$$
$$E_k = \frac{1}{2} (190)(7.5)^2$$
$$E_k = \frac{1}{2} (190)(56.25)$$
$$E_k = 5\ 343.75 \text{ J}$$

PART 2 – CONVERTING UNITS

Converting km h^{-1} to m s^{-1}

To get from km to m we need to multiply by 1000.

To get from hours to seconds we need to divide by 3600.

Therefore, to get from km h^{-1} to m s^{-1} we multiply by 1000/3600.

Simplifying this, we just need to divide by __3.6__ .

Converting to m s^{-1} – worked example

A cyclist is travelling at 20 km h^{-1}. Calculate their speed in m s^{-1}.

$$20 \text{ km h}^{-1} = \frac{20}{3.6} \text{ m s}^{-1}$$
$$= 5.56 \text{ m s}^{-1}$$

Converting to m s^{-1} – faded example

A mobility scooter is travelling at its top speed of 9 km h^{-1}. Calculate its speed in m s^{-1}.

$$9 \text{ km h}^{-1} = \frac{9}{3.6} \text{ m s}^{-1}$$
$$= 2.5 \text{ m s}^{-1}$$

Converting to m s^{-1} – practice and check understanding (1)

A car is travelling at 45 km h^{-1}. Calculate its speed in m s^{-1}.

$$45 \text{ km h}^{-1} = \frac{45}{3.6} \text{ m s}^{-1}$$
$$= 12.5 \text{ m s}^{-1}$$

Converting to m s^{-1} – practice and check understanding (2)

A car is travelling at 100 km h^{-1}. Calculate its speed in m s^{-1}.

$$100 \text{ km h}^{-1} = \frac{100}{3.6} \text{ m s}^{-1}$$
$$= 27.78 \text{ m s}^{-1}$$

PART 3 – COMBINING ENERGY CALCULATIONS AND UNIT CONVERSIONS

Calculating kinetic energy – practice and check understanding (1)

A car of mass 2100 kg is travelling at 108 km h^{-1}. Calculate its kinetic energy.

Convert speed units.

$$108 \text{ km h}^{-1} = \frac{108}{3.6} \text{ m s}^{-1}$$

$$= 30 \text{ m s}^{-1}$$

Calculate kinetic energy.

$$E_k = \frac{1}{2} mv^2$$

$$E_k = \frac{1}{2}(2100)(30)^2$$

$$E_k = \frac{1}{2}(2100)(900)$$

$$E_k = 945\ 000 \text{ J}$$

Calculating kinetic energy – practice and check understanding (2)

A car of mass 1800 kg is travelling at 80 km h^{-1}. Calculate its kinetic energy.

Convert speed units.

$$80 \text{ km h}^{-1} = \frac{80}{3.6} \text{ m s}^{-1}$$

$$= 22.22 \text{ m s}^{-1}$$

Calculate kinetic energy.

$$E_k = \frac{1}{2} mv^2$$

$$E_k = \frac{1}{2}(1800)(22.22)^2$$

$$E_k = \frac{1}{2}(1800)(493.83)$$

$$E_k = 444\ 444 \text{ J}$$

Kinetic energy analysis

PART 1 – KINETIC ENERGY ANALYSIS WORKED EXAMPLE

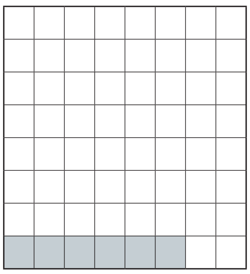
Calculation

This is a complete worked example of the calculation of kinetic energy for a given mass and speed.

	Worked Example
Mass	950 kg
Speed	40 km h^{-1}
Calculation	Convert speed to m s^{-1} $40 \text{ km h}^{-1} = \frac{40}{3.6} \text{ m s}^{-1}$ $= 11.11 \text{ m s}^{-1}$ Calculate the kinetic energy $E_k = \frac{1}{2} mv^2$ $E_k = \frac{1}{2}(950)(11.11)^2$ $E_k = \frac{1}{2}(950)(123.46)$ $E_k = 58\ 630 \text{ J}$
Kinetic Energy in kJ	Round to the nearest 10 kJ Approximately 60 kJ
Squares to shade	Each square represents 10 kJ Shade in 6 squares

Graphical visualisation

Each square represents 10 kJ, shade in 6 starting from the bottom left. This is a visual representation of the amount of energy that we can compare to other calculations.



PART 2 – KINETIC ENERGY ANALYSIS, YOUR TURN

Select vehicle mass (circle one): 1250 kg 1700 kg 2200 kg 2750 kg

Calculate the kinetic energy (show your working) for each of the speeds in the table below. Shade in the graphs to create a visual representation of the energy that you can easily compare.

	A	B	C
Mass			
Speed	70 km h^{-1}	60 km h^{-1}	50 km h^{-1}
Calculation			
Kinetic Energy in kJ			
Squares to shade			
Graphical visualisation			

	D	E	F
Mass			
Speed	40 km h^{-1}	0 km h^{-1}	
Calculation			
Kinetic Energy in kJ			
Squares to shade			
Graphical visualisation			

Recap of describing motion

PART 1 – SPEED

$$\text{speed} = \frac{\text{distance travelled}}{\text{time taken}}$$

$$v = \frac{d}{t}$$

Calculating speed – worked example

A car travels 1200 metres in 40 seconds, calculate its speed in metres per second.

$$v = \frac{d}{t}$$

$$v = \frac{1200}{40}$$

$$v = 30 \text{ m s}^{-1}$$

Calculating speed – practice (1)

A motorbike travels 400 metres in 25 seconds, calculate its speed in metres per second.

$$v = \frac{d}{t}$$

$$v = \frac{400}{25}$$

$$v = 16 \text{ m s}^{-1} 50 \text{ J}$$

Calculating speed – practice (2)

A cyclist travels 150 metres in 36 seconds, calculate its speed in metres per second.

$$v = \frac{d}{t}$$

$$v = \frac{150}{36}$$

$$v = 4.2 \text{ m s}^{-1}$$

PART 2 – DISTANCE

$$\text{speed} = \frac{\text{distance travelled}}{\text{time taken}}$$

Rearranging this relationship to find the distance:

$$\text{distance travelled} = \text{speed} \times \text{time taken}$$

$$d = v \times t$$

$$d = vt$$

Calculating distance – worked example

A car travels at 25 metres per second for 7 seconds, calculate the distance travelled.

$$d = vt$$

$$d = 25 \times 7$$

$$d = 175 \text{ m}$$

Calculating distance – practice (1)

A cyclist travels at 8 metres per second for 4 seconds, calculate the distance travelled.

$$d = vt$$

$$d = 8 \times 4$$

$$d = 32 \text{ m}$$

Calculating distance – practice (2)

A motorbike travels at 18 metres per second for 1.5 seconds, calculate the distance travelled.

$$d = vt$$

$$d = 18 \times 1.5$$

$$d = 27 \text{ m}$$

CONVERTING UNITS – WORKED EXAMPLE

Quantity	From	To	Conversion	Example
Distance	Kilometres (km)	Metres (m)	Multiply by 1000	$12 \text{ km} = 12 \times 1000 = 12\,000 \text{ m}$
Distance	Metres (m)	Kilometres (km)	Divide by 1000	$7500 \text{ m} = \frac{7500}{1000} = 7.5 \text{ km}$
Time	Minutes	Seconds (s)	Multiply by 60	$3 \text{ minutes} = 3 \times 60 = 180 \text{ s}$
Time	Seconds (s)	Minutes	Divide by 60	$720 \text{ s} = \frac{720}{60} = 12 \text{ minutes}$
Time	Hours	Seconds (s)	Multiply by 3600	$2.5 \text{ hours} = 2.5 \times 3600 = 9000 \text{ s}$
Time	Seconds (s)	Hours	Divide by 3600	$1800 \text{ s} = \frac{1800}{3600} = 0.5 \text{ hours}$
Speed	Kilometres per hour (km/h)	Metres per second (m/s)	Divide by 3.6	$40 \text{ km h}^{-1} = 40/3.6 = 11.11 \text{ m s}^{-1}$
Speed	Metres per second (m/s)	Kilometres per hour (km/h)	Multiply by 3.6	$18 \text{ m s}^{-1} = 18 \times 3.6 = 64.8 \text{ km h}^{-1}$

CONVERTING UNITS – PRACTICE

Quantity	From	To	Conversion	Your Turn
Distance	Kilometres (km)	Metres (m)	Multiply by 1000	$4 \text{ km} = 4 \times 1000 = 4000 \text{ m}$
Distance	Metres (m)	Kilometres (km)	Divide by 1000	$2750 \text{ m} = \frac{2750}{1000} = 2.75 \text{ km}$
Time	Minutes	Seconds (s)	Multiply by 60	$2 \text{ minutes} = 2 \times 60 = 120 \text{ s}$
Time	Seconds (s)	Minutes	Divide by 60	$450 \text{ s} = \frac{450}{60} = 7.5 \text{ minutes}$
Time	Hours	Seconds (s)	Multiply by 3600	$1.5 \text{ hours} = 1.5 \times 3600 = 5400 \text{ s}$
Time	Seconds (s)	Hours	Divide by 3600	$1200 \text{ s} = \frac{1200}{3600} = 0.33 \text{ hours}$
Speed	Kilometres per hour (km/h)	Metres per second (m/s)	Divide by 3.6	$70 \text{ km h}^{-1} = \frac{70}{3.6} = 19.44 \text{ m s}^{-1}$
Speed	Metres per second (m/s)	Kilometres per hour (km/h)	Multiply by 3.6	$15 \text{ m s}^{-1} = 15 \times 3.6 = 54 \text{ km h}^{-1}$

Calculating stopping distance

Stopping distance = reaction distance + braking distance

PART 1 – REACTION DISTANCE

Reaction distance while travelling at a constant speed:

$$\text{reaction distance} = \text{speed} \times \text{reaction time}$$

$$d_r = v \times t_r$$

Reaction distance – worked example (1)

The driver of a car travelling at 15 m s^{-1} sees a kangaroo on the road ahead. It takes them 2 seconds to react and respond by applying the brakes. Calculate their reaction distance.

$$d_r = v \times t_r$$

$$d_r = 15 \times 2$$

$$d_r = 30 \text{ m}$$

Reaction distance – worked example (2)

The driver of a truck travelling at 50 km h^{-1} sees a vehicle braking suddenly on the road ahead. It takes them 2.5 seconds to react and respond by applying the brakes. Calculate their reaction distance.

Convert the speed to m s^{-1}.

$$50 \text{ km h}^{-1} = \frac{50}{3.6} = 13.89 \text{ m s}^{-1}$$

Calculate the reaction distance.

$$d_r = v \times t_r$$

$$d_r = 13.89 \times 2.5$$

$$d_r = 34.73 \text{ m}$$

Reaction distance – practice (1)

The driver of a car travelling at 25 m s^{-1} sees an obstacle on the road ahead. It takes them 3 seconds to react and respond by applying the brakes. Calculate their reaction distance.

$$d_r = v \times t_r$$

$$d_r = 25 \times 3$$

$$d_r = 75 \text{ m}$$

Reaction distance – practice (2)

The driver of a bus travelling at 80 km h^{-1} sees an amber traffic light ahead. It takes them 1.9 seconds to react and respond by applying the brakes. Calculate their reaction distance.

Convert the speed to m s^{-1}.

$$80 \text{ km h}^{-1} = \frac{80}{3.6} = 22.22 \text{ m s}^{-1}$$

Calculate the reaction distance.

$$d_r = v \times t_r$$

$$d_r = 22.22 \times 1.9$$

$$d_r = 42.22 \text{ m}$$

PART 2 – BRAKING DISTANCE

Braking distance for a constant acceleration of a m s^{-2}:

$$d_b = \frac{v^2}{2a}$$

Note that this formula has been specifically derived and simplified for braking distance scenarios and takes in the magnitude of the initial speed and acceleration.

Braking distance – worked example (1)

The driver of a car travelling at 11 m s^{-1} reacts and brakes when a car pulls out in front of them from a side road. The braking force applied by the road on the tyres causes an acceleration of 6 m s^{-2}. Calculate the braking distance.

$$d_b = \frac{v^2}{2a}$$

$$d_b = \frac{11^2}{2 \times 6}$$

$$d_b = 10.08 \text{ m}$$

Braking distance – worked example (2)

The driver of a small truck travelling at 65 km h^{-1} reacts and brakes when they see an obstacle on the road ahead. The road is wet, so the braking force applied by the road on the tyres causes an acceleration of 4 m s^{-2}. Calculate the braking distance.

Convert the speed to m s^{-1}.

$$65 \text{ km h}^{-1} = \frac{65}{3.6} = 18.06 \text{ m s}^{-1}$$

Calculate the braking distance.

$$d_b = \frac{v^2}{2a}$$

$$d_b = \frac{(18.06)^2}{2 \times 4}$$

$$d_b = 40.75 \text{ m}$$

Braking distance – practice (1)

The driver of a bus travelling at 25 m s^{-1} reacts and brakes. The braking force applied by the road on the tyres causes an acceleration of 5.5 m s^{-2}. Calculate the braking distance.

$$d_b = \frac{v^2}{2a}$$

$$d_b = \frac{25^2}{2 \times 5.5}$$

$$d_b = 56.82 \text{ m}$$

Braking distance – practice (2)

The driver of a car travelling at 95 km h^{-1} reacts and brakes. The road is wet, so the braking force applied by the road on the tyres causes an acceleration of 4.5 m s^{-2}. Calculate the braking distance.

Convert the speed to m s^{-1}.

$$95 \text{ km h}^{-1} = \frac{95}{3.6} = 26.39 \text{ m s}^{-1}$$

Calculate the braking distance.

$$d_b = \frac{v^2}{2a}$$

$$d_b = \frac{(26.39)^2}{2 \times 4.5}$$

$$d_b = 77.37 \text{ m}$$

PART 3 – STOPPING DISTANCE

Stopping distance = reaction distance + braking distance

$$d_s = d_r + d_b$$

$$d_s = v \times t_r + \frac{v^2}{2a}$$

Stopping distance – worked example (1)

A dog appears on the road ahead of a truck travelling at 14 m s^{-1}. The driver takes 1.8 seconds to react before they apply the brakes. The braking force applied by the dry road surface on the tyres causes an acceleration of 5 m s^{-2}. Calculate the stopping distance.

$$d_s = v \times t_r + \frac{v^2}{2a}$$

$$d_s = 14 \times 1.8 + \frac{14^2}{2 \times 5}$$

$$d_s = 25.2 + 19.6$$

$$d_s = 44.8 \text{ m}$$

Stopping distance – worked example (2)

A hazard appears on the road ahead of a car travelling at 60 km h^{-1}. The driver takes 2.1 seconds to react before they apply the brakes. The braking force applied by the dry road surface on the tyres causes an acceleration of 5.9 m s^{-2}. Calculate the stopping distance.

Convert the speed to m s^{-1}.

$$60 \text{ km h}^{-1} = \frac{60}{3.6} = 16.67 \text{ m s}^{-1}$$

Calculate the stopping distance.

$$d_s = v \times t_r + \frac{v^2}{2a}$$

$$d_s = 16.67 \times 2.1 + \frac{(16.67)^2}{2 \times 5.9}$$

$$d_s = 35.00 + 23.54$$

$$d_s = 58.54 \text{ m}$$

Stopping distance – practice (1)

A driver notices a fallen tree on the road ahead of a car travelling at 27 m s^{-1}. The driver takes 1.7 seconds to react before they apply the brakes. The braking force applied by the dry road surface on the tyres causes an acceleration of 5.5 m s^{-2}. Calculate the stopping distance.

$$d_s = v \times t_r + \frac{v^2}{2a}$$

$$d_s = 27 \times 1.7 + \frac{27^2}{2 \times 5.5}$$

$$d_s = 45.90 + 66.27$$

$$d_s = 112.17 \text{ m}$$

Stopping distance – practice (2)

A hazard appears on the road ahead of a bus travelling at 30 km h^{-1}. The driver takes 1.6 seconds to react before they apply the brakes. The braking force applied by the dry road surface on the tyres causes an acceleration of 5.2 m s^{-2}. Calculate the stopping distance.

Convert the speed to m s^{-1}.

$$30 \text{ km h}^{-1} = \frac{30}{3.6} = 8.33 \text{ m s}^{-1}$$

Calculate the stopping distance.

$$d_s = v \times t_r + \frac{v^2}{2a}$$

$$d_s = 8.33 \times 1.6 + \frac{(8.33)^2}{2 \times 5.2}$$

$$d_s = 13.28 + 6.67$$

$$d_s = 19.95 \text{ m}$$

Analysing stopping distance

PART 1 – STOPPING DISTANCE ANALYSIS WORKED EXAMPLE

If we make some assumptions, we can calculate and compare stopping distances in different scenarios.

In all these calculations we will assume a reaction time of 1.5 seconds.

$$t_r = 1.5\ \text{s}$$

The braking acceleration depends on the road conditions and tyres. We will assume two different scenarios for comparison:

Wet: $a = 4.5\ \text{m s}^{-1}$

Dry: $a = 6.0\ \text{m s}^{-1}$

Using these assumptions, we can calculate and compare the wet and dry stopping distances at different speeds. For example.

45 km h^{-1} stopping distance comparison

Speed conversion (km h^{-1} to m s^{-1}):

$$45\ \text{km h}^{-1} = \frac{45}{3.6} = 12.50\ \text{m s}^{-1}$$

Dry stopping distance calculation:

$$d_s = v \times t_r + \frac{v^2}{2a}$$
$$d_s = 12.5 \times 1.5 + \frac{(12.5)^2}{2 \times 6}$$
$$d_s = 18.75 + 13.02$$
$$d_s = 31.77\ \text{m}$$

Wet stopping distance calculation:

$$d_s = v \times t_r + \frac{v^2}{2a}$$
$$d_s = 12.5 \times 1.5 + \frac{(12.5)^2}{2 \times 4.5}$$
$$d_s = 18.75 + 17.36$$
$$d_s = 36.11\ \text{m}$$

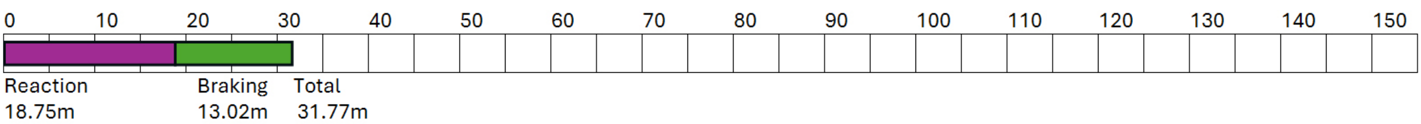
Summary table:

e.g.	Speed = 12.5 m s^{-1}	**Reaction distance (m)**	**Braking distance (m)**	**Stopping distance (m)**
45 km h^{-1}	**Dry**	18.75	13.02	31.77
	Wet	18.75	17.36	36.11

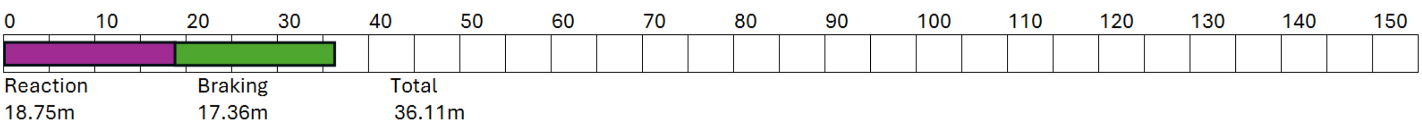
Stopping distance visualisation:

- Each square represents 5 metres
- Shade and label the reaction distance, braking distance and total stopping distance

Dry



Wet



ROAD SAFETY EDUCATION VICTORIA

PART 2 – STOPPING DISTANCE ANALYSIS, YOUR TURN

Assumptions

Reaction time: $t_r = 1.5 \text{ s}$

Acceleration, wet: $a = 4.5 \text{ m s}^{-1}$

Acceleration, dry: $a = 6.0 \text{ m s}^{-1}$

Calculations and summary

Calculate the stopping distances for each of the scenarios below to complete the table. Use the space below for your working.

A 40 km h^{-1}	Speed = m s^{-1}	**Reaction distance (m)**	**Braking distance (m)**	**Stopping distance (m)**
	Dry			
	Wet			

B 60 km h^{-1}	Speed = m s^{-1}	**Reaction distance (m)**	**Braking distance (m)**	**Stopping distance (m)**
	Dry			
	Wet			

C 80 km h^{-1}	Speed = m s^{-1}	**Reaction distance (m)**	**Braking distance (m)**	**Stopping distance (m)**
	Dry			
	Wet			

D 100 km h^{-1}	Speed = m s^{-1}	**Reaction distance (m)**	**Braking distance (m)**	**Stopping distance (m)**
	Dry			
	Wet			

Visualisation

Each square represents 5 metres. Shade and label the reaction distance, braking distance and total stopping distance.

A

$40\ \text{km h}^{-1}$

Dry

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150

Wet

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150

B

$60\ \text{km h}^{-1}$

Dry

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150

Wet

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150

C

$80\ \text{km h}^{-1}$

Dry

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150

Wet

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150

D

$100\ \text{km h}^{-1}$

Dry

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150

Wet

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150

Reaction Times Experiment

BACKGROUND

Reaction time is one of the factors that effects stopping distance. Understanding more about reaction times, and what can affect them, can help us to understand what can be done to reduce stopping distances and make road use safer.

$$d_s = v \times t_r + \frac{v^2}{2a}$$

AIMS

1. To determine our average reaction time
2. To investigate the effects of field of vision and distractions on reaction time

EQUIPMENT

- Ruler (at least 30 cm, 1 m recommended)
- Writing materials
- Experiment worksheet

THEORY

Reacting

For a human to react to a stimulus (visual, auditory, touch) we need to first detect it, transmit that information in a signal to the brain, then our brain must process it, and then transmit another signal to act in response. Different factors in the environment can affect different parts of this process, impacting our reaction time. A typical reaction time is around 250 milliseconds (or 0.25 seconds).

Eye sees ruler move → Eye sends message to brain → Brain processes message → Brain sends message to hand → Fingers close to stop ruler

The Falling Ruler

A really simple way to estimate reaction time is using a falling ruler. The ruler starts at zero velocity and accelerates downwards at a predictable rate due to the gravitational force acting on it.

Using the relationships for speed, distance, time and acceleration we can derive the following formula for the time that the ruler is falling for (this is something that you learn to do in VCE Physics).

$$t = \sqrt{\frac{2y}{a}}$$

Where: t is the time the ruler dropped for
y is the vertical distance that the ruler fell in m
a is the acceleration due to gravity, 9.81 m s^{-1}

As the acceleration due to gravity can be assumed to be constant for this experiment, we can substitute its value into the formula and simplify to get a formula for reaction time.

$$t_r = \sqrt{\frac{y}{4.905}}$$

For example, if the ruler fell 30cm, the reaction time calculation would be:

$$t_r = \sqrt{\frac{y}{4.905}}$$

$$t_r = \sqrt{\frac{0.3}{4.905}}$$

$$t_r = \sqrt{0.06116}$$

$$t_r = 0.247 \text{ s or } 247 \text{ ms}$$

Check that you can do this calculation accurately. Calculate the reaction time for a 15cm drop.

$$t_r = \sqrt{\frac{y}{4.905}}$$

$$t_r = \sqrt{\frac{0.15}{4.905}}$$

$$t_r = \sqrt{0.03058}$$

$$t_r = 0.175 \text{ s or } 175 \text{ ms}$$

ROAD SAFETY EDUCATION VICTORIA

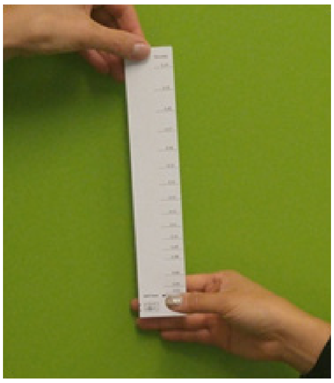
METHOD

1. Work in pairs. Decide who is partner A and B. If you need help deciding, just use alphabetical order by your first name.
2. Get the materials you need (ruler, writing materials, this worksheet).

Part 1 – Reaction time

3. A is going to drop the ruler; B is going to react and catch.
4. A, hold the ruler in front of B so that the bottom is near their eye level.
5. B, put your dominant (preferred) hand around the bottom of the ruler, ready to grab it but not touching it. Line up the zero on the ruler with the top of your thumb.
6. Confirm that you are both ready to go.
7. Within approximately 5 seconds, A drops the ruler, B catches it by 'closing' their grip in it
8. Read the measurement off the ruler from the top of B's thumb and record it.
9. Repeat a total of 5 times.
10. Swap roles and repeat steps 4 – 9.

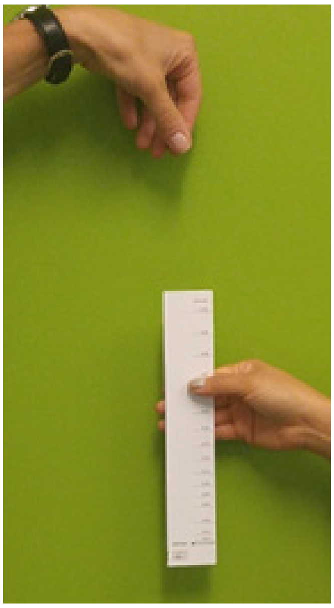
Ready to go (step 6)



Part 2 – Effect of distraction

11. Keep the setup the same. Make sure A can see the list of times tables problems). Once you are ready to go, A should start to ask B questions from the times tables sheet (at the end of this handout). Whilst B is answering these, A should drop the ruler.
12. Repeat steps 4 to 10 with this change to the process.

Caught and ready to read and record the result (steps 7-8)



Part 3 – Effect of field of view

13. Change the set up so that the ruler is to the side of B's field of vision. Place it at 45 degrees (halfway between 'directly in front' of them and 'completely beside their shoulders'). B must look straight ahead focussing on something in front of them (not 'eyes sideways').
14. Repeat steps 4 to 10 with this different setup.

Part 4 – Testing additional variables (optional)

15. Consider testing another variable and its impact (e.g. auditory response by closing eyes and saying 'go'; listening to music; watching a video; non-dominant hand)
16. Repeat steps 4 to 10 with this different variable.

Suggestions for ensuring a repeatable method

- Use a longer rule if needed. A 1 metre ruler may be needed for part 2 and 3.
- Be sure to record your results in metres, to 3 decimal places (28.3 cm = 0.283m).
- Ensure the ruler and catching hand are in a consistent location for each test.
- Try to keep any other distractions constant across all tests.

RESULTS

Trial #	Example	Distance that the ruler dropped (in m)							
		Part 1 Reaction time		Part 2 Effect of distraction		Part 3 Effect of field of view		Part 4 (optional) Effect of ________.	
		A	B	A	B	A	B	A	B
1	0.283								
2	0.272								
3	0.293								
4	0.280								
5	0.277								
Average	0.281								
Reaction time	0.239 s								

DATA COLLATION

Use the table below to collate the results for the class. Use a cross or other symbol to represent each result in a particular range. This will produce a visual representation of the distribution of results.

Result range	Part 1 Reaction time	Part 2 Effect of distraction	Part 3 Effect of field of view	Part 4 (optional) Effect of ________.
Less than 0.125				
0.125 to 0.149				
0.150 to 0.174				
0.175 to 0.199				
0.200 to 0.224				
0.225 to 0.249				
0.250 to 0.274				
0.275 to 0.299				
0.300 to 0.324				
0.325 to 0.350				
0.350 to 0.374				
0.375 to 0.399				
More than 0.400				

ANALYSIS AND REFLECTION

Use the available data to complete the following statements as part of your analysis of the results.

Method and conducting the experiment

Things we did to ensure we were consistent in our method included: ______________________________

____

The main challenges we faced in controlling the variables were: ______________________________

____

Part 1 (Reaction time)

The most common range of reaction times in the class was ____________

The spread of reaction times in the class ranged from (minimum) ____________ to (maximum) ____________.

There were (how many) ____________ results that might be considered an outlier.

Outlier values were ____________.

Part 2 (Effect of distraction)

The results for the effect of distraction produced a (circle) higher / lower / similar reaction time than Part 1.

The results for the effect of distraction were spread out more / less / the same than Part 1.

Part 3 (Effect of field of view)

The results for the effect of field of view produced a (circle) higher / lower / similar reaction time than Part 1.

The results for the effect of field of view were spread out more / less / the same than Part 1.

DISCUSSION

Did this experiment produce a fair test of reaction times? Explain your reasons. ______________________________

____

How would you improve this experiment if you ran it again? ______________________________

____

What did this experiment suggest about the variation in reaction times between different people? ______________________________

____

What conclusions can you draw about the effect of distraction and field of view (and another variable if you tested it) on reaction time?

____

____

TIMES TABLES PROBLEMS (FOR DISTRACTION)

12 x 2 =

5 x 5 =

11 x 9 =

8 x 5 =

4 x 12 =

12 x 5 =

10 x 6 =

2 x 7 =

6 x 8 =

7 x 11 =

2 x 3 =

8 x 8 =

2 x 10 =

8 x 9 =

3 x 11 =

2 x 3 =

8 x 7 =

4 x 3 =

11 x 8 =

11 x 8 =

5 x 7 =

4 x 8 =

6 x 3 =

3 x 12 =

5 x 2 =

9 x 7 =

2 x 7 =

5 x 9 =

5 x 10 =

4 x 12 =

9 x 9 =

5 x 7 =

6 x 4 =

3 x 12 =

8 x 6 =

3 x 11 =

3 x 2 =

6 x 4 =

5 x 5 =

2 x 11 =

6 x 2 =

3 x 12 =

10 x 6 =

4 x 8 =

3 x 9 =

7 x 7 =

Advanced Driver Assistance Systems Jigsaw

PART 1 – INTRODUCING ADVANCED DRIVER ASSISTANCE SYSTEMS (ADAS)

Advanced Driver Assistance Systems (ADAS) are technologies that help to improve safety by providing assistance to drivers. These are mostly active safety systems, although sometimes you may see passive systems included in examples.

They are not autonomous; they are different from self-driving vehicles.

There are many of these systems that you may have heard of, including:

- Electronic Stability Control (ESC)
- Lane Keep Assist
- Driver Attention Detection
- Automatic Emergency Braking (AEB)
- Intelligent Speed Assistance
- Reversing Camera
- Vulnerable Road User Auto Emergency Braking
- Blind Spot Warning

PART 2 – JIGSAW: GATHERING INFORMATION (SOLO THINKING)

- Use the resources provided.
- Summarise the key information about the safety feature you are focussed on in the table below.

What is it called:	
What does it do:	
How does that improve safety:	
Further important information about this feature:	

PART 3 – JIGSAW: SHARING AND REFINING (AWAY JIGSAW MATCHES)

- Share what you wrote with other(s) who had the same feature.
- Add to and refine your summary as you hear from others.

PART 4 – JIGSAW: SUMMARISING (HOME GROUP)

- Return to your groups.
- Take turns in sharing the most important information about your safety feature.
- Summarise what others have shared in the table below.

<table>
<tr><th colspan="2">Example</th></tr>
<tr><td colspan="2">Electronic Stability Control (ESC)
Electronic Stability Control monitors the motion of the car.
If a hard steering manoeuvre is detected it will automatically apply the brakes to specific wheels to help the car remain on track and to help the driver keep control of the vehicle.
It is now mandatory on new cars in Australia.</td></tr>
<tr><th colspan="2">Your Turn</th></tr>
<tr><td>A. Lane Keep Assist</td><td>B. Driver Attention Detection</td></tr>
<tr><td>C. Automatic Emergency Braking (AEB)</td><td>D. Intelligent Speed Assistance</td></tr>
<tr><td>E. Reversing Camera or Warning</td><td>F. Blind Spot Warning</td></tr>
</table>

RESOURCES

Resource Set A - Lane Keep Assist

Source B1 – Department of Planning and Transport

Lane keeping technologies are designed to prevent you from leaving your lane of travel.

Lane keep assist systems use sensors to recognise lane markings. It:
- senses if the car is unintentionally leaving its lane
- notifies the driver through a noise, or a symbol on the dashboard
- gently steers the vehicle back into its original lane
- doesn't activate if the driver is using their indicator
- doesn't activate at lower speeds.

Some LKA systems centre the vehicle in its lane.

The driver can override the system, if needed, by firmly holding the steering wheel.

Always be careful when driving. You cannot rely on LKA to control your vehicle or avoid crashes.

Source: https://transport.vic.gov.au/road-and-active-transport/road-rules-and-safety/vehicle-safety-features

Source B2 - How Safe is Your Car

Active safety features can help to prevent or reduce the severity of a crash.

What is Lane Departure Warning?

Lane Departure Warning systems use cameras to detect line markings and warn you if you're drifting out of lane. It will alert you via a sound, visual display or vibration that your car is about to veer out of your lane.

These systems are only a warning and you are still required to take action and steer back into the driving lane.

What is Lane Keep Assist?

Lane Keep Assist uses the same technology as Lane Departure Warning, with an added feature. If you don't take action the feature will gently steer you back into your lane. The system will disengage when the indicator is in use to enable you to intentionally change lanes.

Why is Lane Keep Assist important?

Lane Keep Assist is estimated to reduce run off road and head on crashes resulting in fatality or serious injury by 22%.

Source: https://howsafeisyourcar.com.au/safety-features/lane-keep-assist

Source B3 – ADAS Assist website

Lane Keeping Assistance returns your vehicle to its lane if you drift out without you indicating, helping you avoid potential collisions.

If the driver does not react to an alert when the system detects lane drift, the function may gently steer you back into your lane or, in the case of Lane Centring Assistance, back to the centre of your lane. ADAS technologies that help you stay in your lane and avoid potential collisions can only operate where road markings are clear.

Source: https://www.adasassist.com.au/adas-functions/lane-keeping-centering-assistance

Source B4 – ADAS Assist fact sheet

Printable PDF https://cdn.prod.website-files.com/673400e12224c02ba668fde6/681da41477e490fee26e7007_Lane-Keeping-Centering-Assistance_3.00.pdf

Further resources
- ADAS Assist video (on Vimeo) https://vimeo.com/1075152805/50cfd3f4df
- How Safe is Your Car Video (embedded in web page, downloadable) https://howsafeisyourcar.com.au/safety-features/lane-keep-assist

RESOURCES

Resource Set B - Driver Attention Detection

Source C1 - How Safe is Your Car

Active safety features can help to prevent or reduce the severity of a crash.

Driver Attention Detection, sometimes known as fatigue detection warns drivers if signs of drowsiness are detected.

How does Driver Attention Detection work?

Driver Attention Detection uses different types of information to detect drowsiness, including steering wheel movements and length of time driving. It will alert the driver to take a break via an alert on the dashboard and a sound. More advanced versions of the technology use a camera near the steering wheel to monitor the driver's eyes and head movements to detect drowsiness.

Why is Driver Attention Detection important?

Driver attention detection systems are designed to warn you that you are fatigued or are at risk of becoming drowsy. Fatigue is a major cause of crashes in Victoria resulting in approximately 50 deaths and 300 serious injuries each year.

If you are feeling fatigued, it is best to avoid driving entirely rather than relying on technology.

Source: https://howsafeisyourcar.com.au/safety-features/driver-attention-detection

Source C2– ADAS Assist website

Fatigue Warning can identify signs that a driver may be getting tired and alert you to stay awake or to take a break from driving.

Indirect systems 'look' for signs of fatigue or inattention, such as repeated lane drift, sudden use of brakes and fluctuations in speed, while newer systems use driver-facing cameras to track head movements and blinking.

Source: https://www.adasassist.com.au/adas-functions/fatigue-warning

Source C3 – ADAS Assist fact sheet

Printable PDF https://cdn.prod.website-files.com/673400e12224c02ba668fde6/681da3838701c0c8ffd64444_Fatigue-Warning_4.00.pdf

Further resources

- ADAS Assist video (on Vimeo) https://vimeo.com/1075099893/03b80f7fb2
- How Safe is Your Car Video (embedded in web page, downloadable) https://howsafeisyourcar.com.au/safety-features/driver-attention-detection
- See also Driver Distraction Warning https://www.adasassist.com.au/adas-functions/distraction-warning

RESOURCES

Resource Set C - Automatic Emergency Braking (AEB)

Source D1 – Department of Planning and Transport

Autonomous emergency braking systems use sensors to monitor the area in front of the vehicle. If a crash is likely to occur, it will warn the driver and, if needed, automatically apply the brakes to avoid or reduce the impact of a crash.

AEB systems are designed to support the driver in an emergency. They are not a substitute for attentive driving. The driver always remains responsible for controlling the vehicle at all times.

Different types of AEB are designed to operate in various scenarios such as:

- low speeds
- high speeds
- detecting pedestrians and cyclists
- reversing.

Source: https://transport.vic.gov.au/road-and-active-transport/road-rules-and-safety/vehicle-safety-features

Source D2 - How Safe is Your Car

Active safety features can help to prevent or reduce the severity of a crash.

AEB is technology designed to apply your car's brakes when you can't to help avoid or reduce the severity of a crash in low and higher speed zones.

How does AEB work?

Auto Emergency Braking technologies are designed to detect objects in your vehicle's path and brake automatically when you can't. The technology can potentially help lessen the impact of a crash and in some circumstances even prevent the crash from happening. There are several different AEB systems that have been designed to deal with different crash situations: AEB car to car targets a range of driving situations and helps avoid crashes in low and higher speed zones (exceeding 50km/h).

Why is AEB important?

AEB has been estimated to reduce rear end crashes resulting in fatal and serious injuries by 27%.

Source: https://howsafeisyourcar.com.au/safety-features/auto-emergency-braking

Source D3 – ADAS Assist website

Advanced emergency braking systems, also referred to as Automatic or Automated Emergency Braking (AEB), work to slow or stop your vehicle when approaching a stopped or slowed object.

Some vehicles may also be fitted with this technology to work in reverse.

Source: https://www.adasassist.com.au/adas-functions/automatic-emergency-braking

Source D4 – ADAS Assist fact sheet

Printable PDF https://cdn.prod.website-files.com/673400e12224c02ba668fde6/681da303a70cffec6a40040f_Automatic-Emergency-Braking_3.00.pdf

Further resources

- ADAS Assist video (on Vimeo) https://vimeo.com/1075097520/8a51b40f70
- How Safe is Your Car Video (embedded in web page, downloadable) https://howsafeisyourcar.com.au/safety-features/auto-emergency-braking
- See also Vulnerable Road User AEB https://howsafeisyourcar.com.au/safety-features/vulnerable-road-user-auto-emergency-braking

RESOURCES

Resource Set D - Intelligent Speed Assistance

Source E1 – Department of Planning and Transport

Speed assist systems, such as Intelligent Speed Assist (ISA), tell the driver when they are over the speed limit. Advanced ISA systems reduce the vehicle's speed if the driver is going above the limit.

Some ISAs rely on GPS data and maps, while others use built-in cameras to read speed signs on the road.

Always check the speed limit yourself. You cannot rely on an ISA to do that for you in all circumstances.

Source: https://transport.vic.gov.au/road-and-active-transport/road-rules-and-safety/vehicle-safety-features

Source E2 - How Safe is Your Car

Active safety features can help to prevent or reduce the severity of a crash.

The vehicle detects the current speed limit and notifies the driver.

How does ISA work?

The car has the ability to read speed signs or obtain this information from the cloud. ISA can be advisory or limiting in nature, as such, the vehicle provides visual or audible warning to the driver if the set speed limit is exceeded (advisory) or the car's speed is adjusted to match the posted speed (limiting).

Why is ISA important?

Speeding is a significant contributor to road trauma. Every km/h over matters: exceeding the speed limit by 3km/h is associated with a 25 percent increase in crash risk.

Source: https://howsafeisyourcar.com.au/safety-features/intelligent-speed-assistance

Source E3 – ADAS Assist website

Passive Intelligent Speed Assistance helps drivers drive within the posted speed limit.

It uses GPS map data and, in some cases, camera technology to read roadside signs and show the speed limit and changes to the limit, warning the driver via sound or flashing symbols if you are exceeding it.

Source: https://www.adasassist.com.au/adas-functions/intelligent-speed-assist-passive

Source E4 – ADAS Assist fact sheet

Printable PDF https://cdn.prod.website-files.com/673400e12224c02ba668fde6/681da3fd0b69c5607984bc36_Intelligent-Speed-Assist-Passive_3.00.pdf

Further resources

- ADAS Assist video (on Vimeo) https://vimeo.com/1075101959/f2e756c0e9
- How Safe is Your Car Video (embedded in web page, downloadable) https://howsafeisyourcar.com.au/safety-features/intelligent-speed-assistance

RESOURCES

Resource Set E - Reversing Camera or Warning

Source F1 – Department of Planning and Transport

Reverse collision avoidance systems aim to stop you hitting objects or other road users when you reverse. Some systems use sensors to warn you when an object is behind your vehicle. Other systems use cameras and a display screen. More advanced systems will automatically apply the brakes.

Source: https://transport.vic.gov.au/road-and-active-transport/road-rules-and-safety/vehicle-safety-features

Source F2 - How Safe is Your Car

The design of a car and its safety features can help reduce the severity of or even avoid a crash with others, including vulnerable road users.

Reversing Camera technology is used to provide you with visibility behind your vehicle.

How does a Reversing Camera work?

A Reversing Camera is made up of a camera and a display monitor. When your car is in reverse, the camera located at the rear of the vehicle activates to show what is behind your car on the monitor. These cameras can help to view objects that may not be visible through head checks and using your reversing mirror.

Why is a Reversing Camera important?

Reversing technologies such as cameras or sensors have been shown to reduce pedestrian crashes by between 31% and 41%.

- They increase rear visibility by enhancing your vision from the rear of your vehicle.
- They provide assistance for tight manoeuvring so you know exactly how far you have until it hits something.
- They provide an extra way to check before reversing to prevent accidents.
- They help you to see objects that might be below your eye line in your vehicle such as small children.

Reversing Cameras are not designed to replace checking behind your car and being aware of the location of children, animals and objects before reversing.

Source: https://howsafeisyourcar.com.au/safety-features/reversing-camera

Source F3 – ADAS Assist website

Activated when you put your vehicle in reverse, Reverse Collision Warning scans for obstacles behind the vehicle.

It alerts the driver to help you avoid colliding with people walking or riding or objects behind you. Sometimes called Rear Collision Warning, it will not take control of the vehicle.

Source: https://www.adasassist.com.au/adas-functions/reverse-collision-warning

Source F4 – ADAS Assist fact sheet

Printable PDF https://cdn.prod.website-files.com/673400e12224c02ba668fde6/681da483e38abea81b661549_Reverse-Collision-Warning_4.00.pdf

Further resources

- ADAS Assist video (on Vimeo) https://vimeo.com/1075152055/5710bbafa4
- How Safe is Your Car Video (embedded in web page, downloadable) https://howsafeisyourcar.com.au/safety-features/reversing-camera

RESOURCES

Resource Set F - Blind Spot Warning

Source H1 – Department of Planning and Transport

'Blind spots' are areas around your car that aren't visible through the windscreen or mirrors.

Blind spot monitoring systems detect if a vehicle is in your blind spot and warns you, using:

- a sound or
- a visual warning (a light or symbol) on your dashboard or side mirror.

You must still do head checks. Physically turn your head to check your blind spots before changing lanes.

Source: https://transport.vic.gov.au/road-and-active-transport/road-rules-and-safety/vehicle-safety-features

Source H2 - How Safe is Your Car

The design of a car and its safety features can help reduce the severity of or even avoid a crash with others, including vulnerable road users.

Detects vehicles you can't see that are next to or behind your car and warns you when they are in your blind spots.

What is Blind Spot Warning?

Blind Spot Warning technology uses sensors to monitor the side of your car, when there is an object in your blind spot. The feature provides a visual warning via your side view mirror or in the windshield frame. In more advanced versions if you indicate to change lanes when there is an object in your blind spot an audible or tactile warning will sound.

Why is Blind Spot Warning important?

Blind Spot Warning systems have been estimated to reduce lane change crashes by 14%.

Source: https://howsafeisyourcar.com.au/safety-features/blind-spot-warning

Source H3 – ADAS Assist website

Blind Spot Warning alerts you if other vehicles are driving in your vehicle's blind spots.

Some systems provide an extra layer of safety by providing a warning if you use your indicator when there are vehicles in the next lane.

Source: https://www.adasassist.com.au/adas-functions/blind-spot-warning

Source H4 – ADAS Assist fact sheet

Printable PDF https://cdn.prod.website-files.com/673400e12224c02ba668fde6/681da333c89720c45e90a894_Blind-Spot-Warning_3.00.pdf

Further resources

- ADAS Assist video (on Vimeo) https://vimeo.com/1075098606/101e83f040
- How Safe is Your Car Video (embedded in web page, downloadable) https://howsafeisyourcar.com.au/safety-features/blind-spot-warning

ADDITIONAL RESOURCES

ADAS Assist – Full list of ADAS features included

Source: https://www.adasassist.com.au/adas-functions

Braking and vehicle control	Active Driving Assistance
	Automatic Emergency Braking
	Automatic Emergency Steering
	Collision Mitigation Support
	Electronic Stability Control
	Hill Descent Assist
	Hill Start Assist
	Lane Keeping and Centring Assistance
	Traction Control
Collision Warning and Avoidance	Active Driving Assistance
	Active Parking Assistance
	Automatic Emergency Braking
	Automatic Emergency Steering
	Blind Spot Warning
	Collision Mitigation Support
	Cross Traffic Warning
	Forward Collision Warning
	Headway Warning
	Lane Departure Warning
	Pedestrian, Cyclist and Obstacle Warning
	Reverse Collision Warning
	Safe Exit Warning
Managing Speed and Safe Following Distance	Active Driving Assistance
	Headway Warning
	Intelligent Speed Assist Active
	Intelligent Speed Assist Passive
	Lane Keeping and Centring Assistance
	Speed Curve Warning
	Traditional and Adaptive Cruise Control
Parking Assistance	Active Parking Assistance
	Parking Warning
	Remote Car Operation
	Reverse Collision Warning
Vehicle Occupant Safety and Convenience	Child Presence Detection
	Distraction Warning
	Fatigue Warning
	Remote Car Operation
	SRS Airbags
	Safe Exit Warning
	Tyre Pressure Monitor
Visibility and Safe Surroundings	Active Parking Assistance
	Adaptive Lighting Systems
	Advanced Lighting
	Automatic Windscreen Wiper Activation
	Blind Spot Warning
	Cross Traffic Warning
	Low Temperature Warning
	Night Vision
	Parking Warning
	Pedestrian, Cyclist and Obstacle Warning

Physics of passive safety systems

PART 1 – WORK AND ENERGY

Recall that when work is done on an object energy is transferred. Work can be done by moving an object in the direction of the applied force. It can also be done when a force causes an object to change shape.

A higher energy collision can lead to greater injury to passengers.

If we want to transfer that energy, we want to ______________________ the work done when parts of the car absorb energy by changing shape.

Crumple zones in vehicles are designed to absorb as much energy as possible.

PART 2 – INERTIA

Recall from Newton's Laws the concept of inertia.

Objects will continue in their state of motion unless acted upon by an unbalanced external force.

A moving object, such as a car and its occupants, will only slow down or stop when there is an unbalanced external ______________________ acting.

Vehicle restraint systems (seatbelts, airbags) are designed to apply forces to occupants in accidents to ensure that they change motion as safely as possible.

PART 3 – NET FORCE AND ACCELERATION

Recall the relationship between force and acceleration from Newton's Laws.

$$F_{net} = ma$$

This shows that the net force acting on an object (of a specific mass) is directly proportional to the acceleration of the object.

A larger **acceleration** requires a larger net force.
A smaller acceleration requires a ____________________ net force.

A larger **net force** produces a larger acceleration.
A smaller net force produces a ____________________ acceleration.

> Larger forces acting on humans in collisions result in worse injuries.
>
> If we want to reduce the force acting on someone in a collision, we want to __________________ the acceleration they experience.

Recall the definition for acceleration. Acceleration is the rate of change of velocity (how fast the velocity is changing). This is calculated as the change in velocity divided by the change in time (or time taken).

$$a = \frac{\Delta v}{\Delta t}$$

This shows that the acceleration on an object is directly proportional to its change in velocity and inversely proportional to the change in time (time taken).

A larger change in **velocity** produces a larger acceleration.
A smaller change in velocity produces a ____________________ acceleration.

A larger change in **time** produces a smaller acceleration.
A smaller change in time produces a ____________________ acceleration..

> To reduce injuries, we want to reduce the force acting on the people involved. This can be achieved by decreasing the acceleration they experience.
>
> If we want to reduce the acceleration of someone in a collision, we want to __________________ their initial speed or ____________________ the time taken (collision duration).
>
> **Active safety systems can reduce the initial speed.**
>
> **Airbags increase the duration that a force is applied to an occupant, resulting in a lower peak force and reduced chance of injury.**

Egg Crash: Design, Build, Test

PART 1 - DESIGN

Design Brief

Purpose:

To design a 'mini vehicle' that does the best possible job of protecting its 'occupant' (an egg) during a collision with a solid barrier. A successful design will:

1. Keep the egg in place after the crash
2. Protect the egg from cracking or breaking

The most successful designs will be able to do this at higher collision speeds.

Parameters and Constraints:

- The vehicles will be tested by rolling down a ramp and colliding into a solid barrier.
- The vehicle must be able to roll freely down the ramp. There should not be any design features that reduce its speed during testing.
- All vehicles will be tested on the same ramp, at the same angle, and using the same barrier.
- If the egg survives the first test at the lowest angle (no cracks or breaks), the angle of the ramp will be increased and the test repeated. This process will be repeated until the egg is damaged or the maximum angle is reached.
- All eggs will be similar in size and will be hard boiled in advance.
- You may only use the materials provided to construct your vehicle.
- Vehicle maximum dimensions: 8 cm wide and 18 cm long
- Minimum vehicle mass (without egg): 50 grams
- The vehicle should be able to withstand at least three collisions without replacing parts.
- The occupant (egg) must be able to be removed after the crash easily, without dismantling the vehicle. You cannot glue the egg in place.

Permitted materials:

The materials will be provided by your teacher. You may not use other materials.

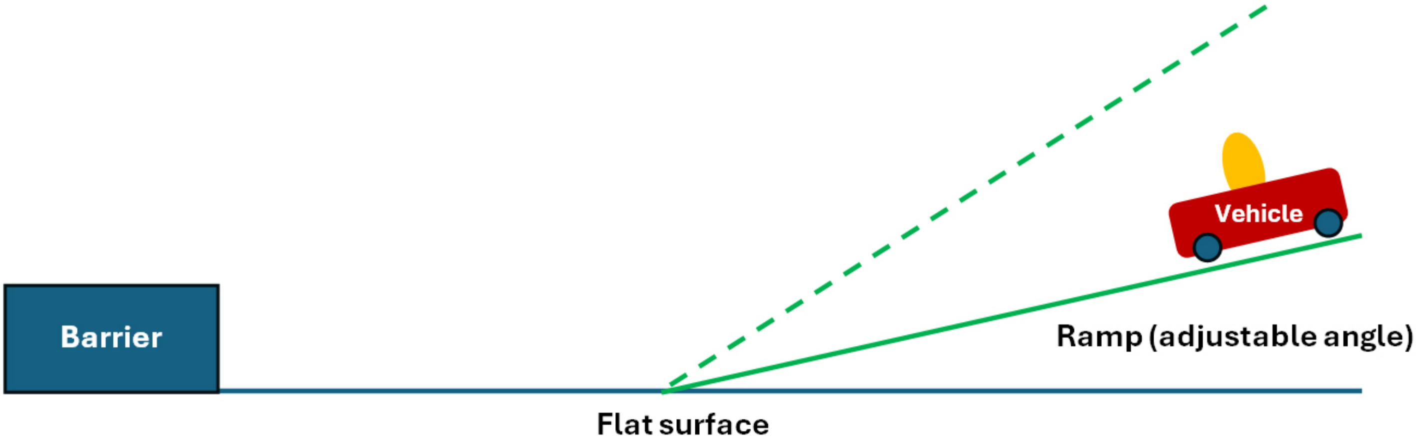
Permitted materials list:

- Hard-boiled egg
- Paper
- Glue
- Bottle caps (wheels)
- Wooden skewers (axles)
- Straws (axle housing)
- A small quantity of tape per group (only to be used for securing the axles in place)

PART 1 - DESIGN

Design Brief

Test setup:



Testing equipment:

Everyone will use the same testing set up comprising of:

- Ramp placed on a flat surface
- Solid barrier for vehicles to collide with (e.g. a concrete block)

Optionally you may use a camera, light gates or sensors to capture additional data such as the vehicle speed immediately before the collision and details of how the vehicle behaves during the collision.

Design Documentation

Design features:

Identify and very briefly explain the main features of your design in the table below.

Consider how your design will:

- roll freely down the ramp
- hold the egg in place
- protect the egg during the collision

Design feature *What it is*	**Purpose** *Why it is needed*	**Function** *How it works*

Design sketch:

Sketch your planned design in the space below. Label key features.

PART 2 - BUILD

Use the time allocated to build your design. Record any changes that you made to your design during the build, and why, in the table below.

Design change *What you changed*	Rationale *Why you made the change*

PART 3 - TEST

Vehicle Specifications:

Before you start testing your design, record its key specifications in the table below.

Width (cm)		Mass without egg (grams)	
Length (cm)		Mass with egg (grams)	

Vehicle Images:

Include photos of your vehicle below:

Photos before testing	Photos during and after testing

Test Results

Test Number	Ramp angle	Observations				
		Egg stayed in place	Egg removed ok after	Egg cracked or damaged	Egg broken	Further observations
1	Lowest	Y or N	Y or N	Y or N	Y or N	
2		Y or N	Y or N	Y or N	Y or N	
3		Y or N	Y or N	Y or N	Y or N	
4		Y or N	Y or N	Y or N	Y or N	
5		Y or N	Y or N	Y or N	Y or N	
6		Y or N	Y or N	Y or N	Y or N	
7		Y or N	Y or N	Y or N	Y or N	
8		Y or N	Y or N	Y or N	Y or N	
9		Y or N	Y or N	Y or N	Y or N	
10		Y or N	Y or N	Y or N	Y or N	

Record any general observations below:

Record the maximum angle that your vehicle performed successfully at:

Maximum angle	

PART 4 - EVALUATE

Use the following prompts to reflection on and evaluate your vehicle.

1. What challenges did you encounter in designing and building your vehicle? How did you overcome them?

2. How successful was your vehicle? What information from the testing supports your conclusions?

3. Was this a fair test of the performance of the vehicles constructed in your class? What was controlled and what was varied? What contributed to making it more fair or less fair?

4. If you had unlimited resources, what extra data would you collect to improve the testing? How would this information help to understand how the different vehicle designs performed?

5. What design features or construction details can you identify that helped to keep the egg in place (in your vehicle or others)? How do these relate to the safety features in cars? How does this connect to physics that you have learnt in this topic?

6. What design features or construction details can you identify that helped to protect the egg from damage (in your vehicle or others)? How do these relate to the safety features in cars? How does this connect to physics that you have learnt in this topic?

7. How would you improve your design if you were to do this again?

8. How would you improve the testing process if you were to do this again?

Road Safety Explainer Poster

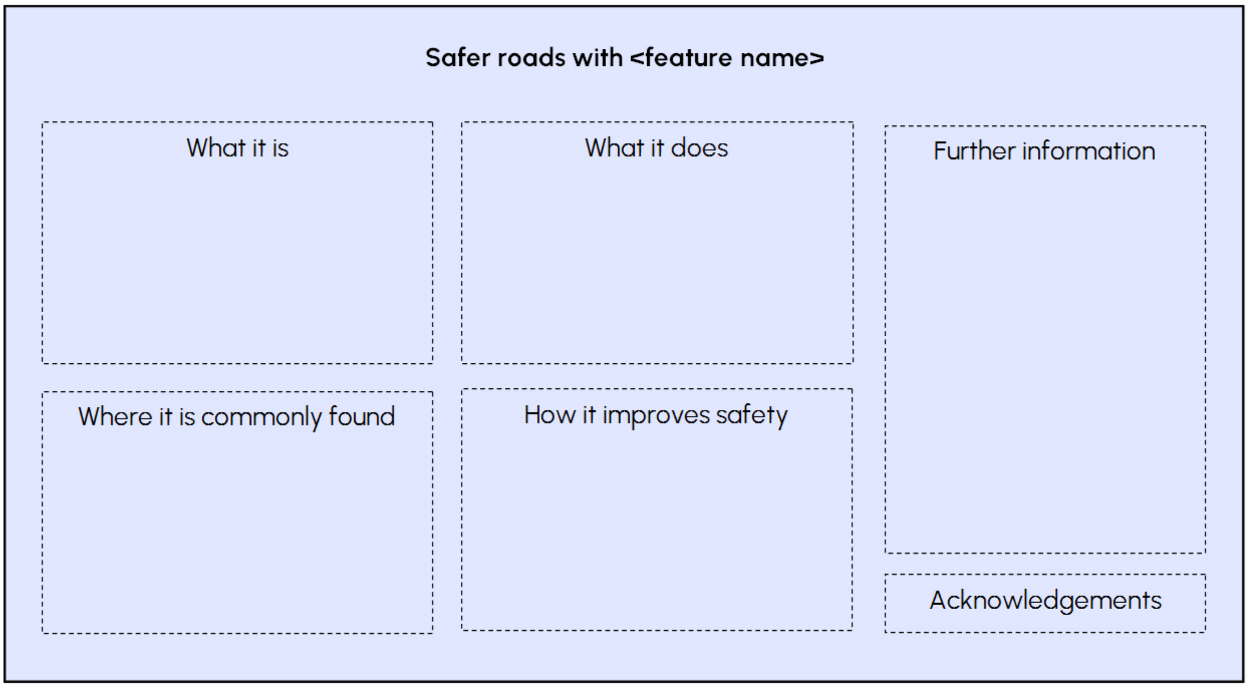
PART 1 - CREATING YOUR POSTER

Purpose:
Communicate the case for a specific road safety feature to a general audience

Topic:
Select one of the features from the list provided (over the page) or another one in agreement with your teacher.

Audience:
Focus on clear communication that someone your age or an adult without any specialist knowledge could understand.

Details:
Produce a poster either on paper or digitally. Use the following template as a guide for what to cover.
Use images or graphics to support your explanation. The focus is on content not formatting.



Checklist:

- ❑ Clear title with any acronyms explained
- ❑ Explanation of what the feature is
- ❑ Explanation of what the feature does
- ❑ Explanation of how it improves safety
- ❑ Making clear connections to the safe system
- ❑ Explanation of where the feature is found
- ❑ Inclusion of further relevant information
- ❑ Use of diagrams to support understanding
- ❑ Language and content suitable for a general audience
- ❑ Sources of information are clearly acknowledged

PART 2 - TESTING AND REFLECTION

Step 1 – Quiet read by peer (5 mins)

- Work with a peer that has chosen a different topic
- Swap posters and read each other's work, making notes for constructive feedback in the space below

What did you learn?	What was clear?	What was the best feature?
Was any critical information missing?	What was unclear?	What one thing would you change to improve it?

Step 2 – Share feedback, give and receive (5 mins each)

- Take turns to share your feedback, ensuring you focus on being constructive
- Take your own notes from the feedback you received in the space below

What was learnt?	What was clear?	What was the best feature?
Was any critical information was missing?	What was unclear?	What could be improved?

Step 3 – Reflect (5 mins)

- Reflect on how your poster could be improved for a further iteration and record your response below. Use the prompting questions to assist you.
- Make sure that you complete the highlight and next step at the end as you will have an opportunity to share these.

What would you add? What would you edit or remove? **Are there opportunities to make the poster clearer for your audience?** **Have you included relevant scientific explanations?** **Have you made connections to the safe system?**
Highlight: What was the strongest feature of your poster?
Next step: What one thing would you improve if you revised your poster?

SUGGESTED TOPICS

- School speed zones
- Variable speed limits
- Speed advisory signs
- P-plate restrictions
- L-plate logbooks
- Driver education programs
- Wearing seatbelts correctly
- Managing driver fatigue
- Airbags (SRS)
- Seatbelts
- Anti-lock
- Electronic Stability Control (ESC)
- Lane Keep Assist (or Lane Departure Warning)
- Driver Attention Detection
- Automatic Emergency Braking (AEB)
- Intelligent Speed Assistance
- Reversing Camera
- Vulnerable Road User Auto Emergency Braking
- Blind Spot Warning
- Vehicle safety ratings
- Roadside safety barriers
- Road rumble strips
- Road reflectors
- Speed humps
- Road lighting