THE MATHEMATICAL ASSOCIATION OF VICTORIA

TEACHER NOTES

MATHEMATICS IN CAREERS

Investigation - How safe is a vehicle?

Key career focus for this investigation: Engineer and design
Related career areas: Auto mechanics

THINKING ABOUT CAREERS

- Brainstorm information technology professions you can think of where maths is frequently used.
  Use https://joboutlook.gov.au to explore engineering related career pathways that include use of mathematics. *How is maths used in these scenarios? What maths is used in these scenarios?*
- This task focuses on how maths is used in engineering through investigating car safety.
- Explore careers such as mechanical engineering to discover how maths is used in these. For a more extensive list of careers related to this task, with a maths / science focus, refer to the table at the end of the task and explore the maths used in these jobs.

MATHEMATICS IN EVERYDAY LIFE AND CAREERS

Mathematical focus for this investigation

- Represent worded problem with simple linear equations and solve them to answer questions.
- Solving simple equations arising from formulas
- Calculate speed, time, and distance
- Comparing and analysing data to draw conclusions

A formula is a mathematical relationship expressed in variables. Many people use formulas every day to calculate unknown values. Formulas can be used to calculate or convert different values such as Celsius degrees to Fahrenheit or currency exchange rates.

Brainstorm and share scenarios where this mathematics may be used in engineering to solve problems.

MATHEMATICAL INVESTIGATION
HOW SAFE IS A VEHICLE?

TEACHER INFORMATION

LINKS TO VICTORIAN CURRICULUM

Mathematics links to Victorian Curriculum Level 10	Application to work and life
Patterns and algebra Substitute values into formulas to determine an unknown and re-arrange formulas to solve for a particular term. (VCMNA333) **Real numbers** Solve problems involving direct proportion. Explore the relationship between graphs and equations corresponding to simple rate problems. (VCMNA301)	Linear equations use one or more variables where one variable is dependent on the other. Almost any situation where there is an unknown quantity can be represented by a linear equation, like figuring out income over time, calculating mileage rates, or predicting profit. Many people use linear equations every day, even if they do the calculations in their head without drawing a line graph. Scientists model relationships comparing different scenarios. The relationship may be linear other. They graph data and compare the graphs, changing one variable to see the effect on the other to test hypothesis.

PROFICIENCY FOCUS: VICTORIAN CURRICULUM

This investigation focuses on: Fluency, Understanding, Problem Solving

Fluency describes students developing skills in choosing appropriate procedures, carrying out procedures flexibly, accurately, efficiently and appropriately, and recalling factual knowledge and concepts readily.

This investigation focuses on:

- solving simple equations arising from formulas.
- re-arranging expressions to make a specified variable the subject.
- solving problems using the fact that the product of the gradients of perpendicular lines is –1 and conversely that if the product of the gradients of two lines is –1 then they are perpendicular.
- solving linear equations, including those involving one or two simple algebraic fractions, and checking solutions by substitution.
- representing word problems, including those involving fractions, as equations and solving them to answer the question.

Understanding refers to students building a robust knowledge of adaptable and transferable mathematical concepts and structures.

This investigation focuses on:

- describe their mathematical thinking.
- interpret mathematical information.

Problem Solving is the ability of students to make choices, interpret, formulate, model and investigate situation, select and use technological functions and communicate solutions effectively.

This investigation focuses on:

- students applying their existing strategies to seek solutions

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STUDENT INVESTIGATION WITH TEACHER GUIDE

INVESTIGATION BACKGROUND

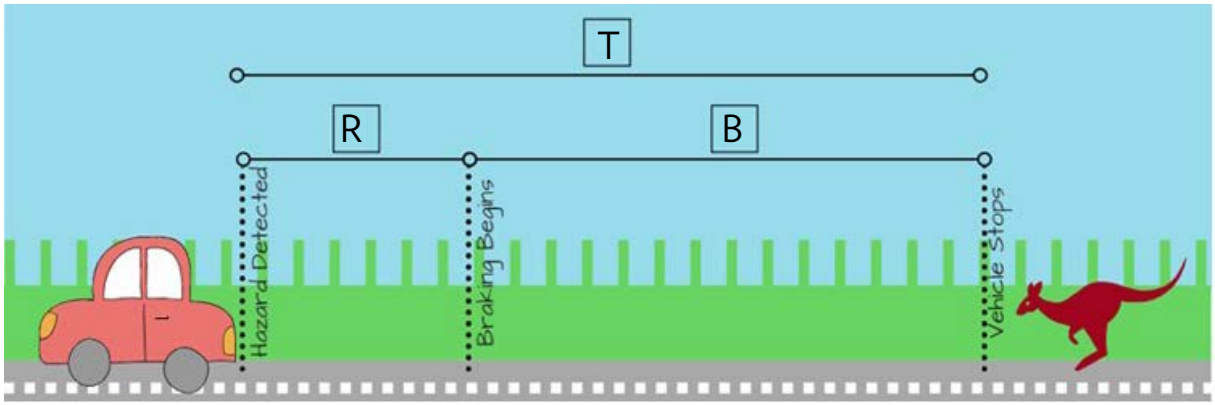
The EuroNCAP is a rating system to help customers understand how safe their vehicles are. The vehicle is rated out of five stars based on four key categories – Adult Occupant, Child Occupant, Safety Assist and Vulnerable Road Users (VRU).

YOUR INVESTIGATION

As Future Ford Driver Assist Technologies (DAT) engineers, your task is to compare 3 vehicles and rank them in terms of their safety for vulnerable road users. You are then to provide a recommendation of what you would do to improve the performance of the vehicle in terms of VRU protection.

PART 1

Label the missing distances on the below diagram:



The missing variables are:
R = Reaction distance in meters
B = Vehicle Braking distance in meters
T = Total stopping distance in meters

PART 2: HOW SAFE IS YOUR VEHICLE?

Refer to Table 1 below for vehicle information

Vehicle 1	Vehicle 2	Vehicle 3
		
Vehicle style: Everyday hatchback Vehicle mass: 1,800 kg Technology: Level 1 DAT	Vehicle style: Sports car Vehicle mass: 2,000 kg Technology: None	Vehicle style: 4 x 4 off-roader Vehicle mass: 2,200 kg Technology: Level 2 DAT

Table 1. Vehicle information.

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For the two tasks below, you will also need to refer to the appendices in the reference section (See appendix 1 for the scenarios and appendix 2 for the cheat sheet).

TASK 1

- Predict the success of each vehicle and use calculations to prove your hypothesis (fill in Table 2). To help with the calculations you will need to refer to the formula in the reference section.
- $R = s \times t$ where R is the reaction distance in metres.

	 Scenario 1 40km/h	 Scenario 2 60km/h	 Scenario 3 80km/h
	Speed is 40km/h but speed is calculated in m/sec 40km in 1 hour 40 000m in 60 mins 40 000m in 3600 secs 400m in 36 secs s = 11.11m/s	Speed is 60km/h but speed is calculated in m/sec 60km in 1 hour 60 000m in 60 mins 60 000m in 3600 secs 600m in 36 secs s = 16.67m/s	Speed is 80km/h but speed is calculated in m/sec 80km in 1 hour 80 000m in 60 mins 80 000m in 3600 secs 800m in 36 secs s = 22.22m/s
Everyday hatchback Tech: DAT Level 1 	Reaction time in secs t = 1.0 sec $R = s \times t$ R = 11.11 x 1 R = 11.11 $T = R + B$ From table provided B = 10m T = 11.11 + 10 T = 21.11m	Reaction time in secs t = 1.0 sec $R = s \times t$ R = 16.67 x 1 R = 16.67 $T = R + B$ From table provided B = 20m T = 16.67 + 20 T = 36.67m	Reaction time in secs t = 1.0 sec $R = s \times t$ R = 22.22 x 1 R = 22.22 $T = R + B$ From table provided B = 35m T = 22.22 + 35 T = 57.22m
Sports car Tech: None 	Reaction time in secs no DAT given so assume human reaction time t = 1.5 sec $R = s \times t$ R = 11.11 x 1.5 R = 16.67 $T = R + B$ From table provided B = 11m T = 16.67 + 11 T = 27.67m	Reaction time in secs no DAT given so assume human reaction time t = 1.5 sec $R = s \times t$ R = 16.67 x 1.5 R = 25 $T = R + B$ From table provided B = 22m T = 25 + 22 T = 47m	Reaction time in secs no DAT given so assume human reaction time t = 1.5 sec $R = s \times t$ R = 22.22 x 1.5 R = 33.33 $T = R + B$ From table provided B = 39m T = 33.33 + 39 T = 72.33m
4 x 4 Off-roader Tech: DAT Level 2 	Reaction time in secs t = 0.8 sec $R = s \times t$ R = 11.11 x 0.8 R = 8.89 m $T = R + B$ From table provided B = 12m T = 8.89 + 12 T = 20.89 m	Reaction time in secs t = 0.8 sec $R = s \times t$ R = 16.67 x 0.8 R = 13.33 $T = R + B$ From table provided B = 24m T = 13.33 + 24 T = 37.33m	Reaction time in secs t = 0.8 sec $R = s \times t$ R = 22.22 x 0.8 R = 17.78 $T = R + B$ From table provided B = 50m T = 17.78 + 50 T = 67.78m

Table 2. Comparison table of vehicles and scenarios prediction.

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TASK 2

- Calculate whether each vehicle will stop and safely avoid a collision in each scenario (fill in Table 3).

	 Scenario 1 40km/h	 Scenario 2 60km/h	 Scenario 3 80km/h
Everyday hatchback Tech: DAT Level 1	Yes 25 m	Yes 45 m	Yes 65 m
Sports car Tech: None	No 25 m	No 45 m	No 65 m
4 x 4 Off-roader Tech: DAT Level 2	Yes 25 m	Yes 45 m	No 65 m

PART 3: GROUP DISCUSSION

- Why did some vehicles avoid a collision, and some not?
- Which vehicle is the safest, and why?

PART 4: WHAT COULD YOU CHANGE?

- Provide options to improve the performance of each vehicle to avoid a collision.
- What improvement/safety factor you are trying to achieve? (e.g just in time stop or time/distance before impact; Does your requirement depend on speed?)
- Ensure to define your independent and dependant variables (i.e. what is changing).

	Vehicle 1	Vehicle 2	Vehicle 3
			
Starting assumptions	Vehicle style: Everyday hatchback Vehicle mass: 1,800 kg Technology: Level 1 DAT	Vehicle style: Sports car Vehicle mass: 2,000 kg Technology: None	Vehicle style: 4 x 4 off-roader Vehicle mass: 2,200 kg Technology: Level 2 DAT
Option 1			
Option 2			
Option 3			

Table 4: Vehicle improvements.

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CAREERS RELATED TO THIS INVESTIGATION

Refer to the student investigation, it provides:

- An extensive table of careers related to this investigation
- Further career references

CAREERS ACTIVITIES

Refer to the student investigation, it provides:

- A table of the top 10 rated jobs of 2021. This data comes from careercast.com. Have students investigate the jobs specific to this investigation.

INDUSTRY PARTNER

This project was produced collaboratively between The Mathematical Association of Victoria (MAV) and FORD

Ford Motor Company of Australia Pty Limited is a subsidiary of Ford Motor Company, founded in Geelong, Victoria, in 1925. The company designs, engineers, and imports award-winning and best-selling cars, SUVs and trucks, including Puma, Escape, Everest, Focus, Fiesta ST, Ranger, Ranger Raptor, Mustang, Mustang Mach 1 and Transit commercial vans. Australia is a key product development hub for Ford, with the company investing more than $2.5 billion in research and development in Australia between 2016-20. More than $500 million is expected to be invested in our Australian operations in 2021.

Ford is Australia's largest automotive employer, with a team of over 2,500 engineers, designers, technical, automotive and other specialists working at four locations across Victoria. Australia-based engineers and designers lead the development of award-winning vehicles sold in more than 180 markets globally, such as the Ford Ranger pickup and Ford Everest SUV.

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