THE ROAD SAFETY TOTAL LEARNING RESOURCE (YEARS 9-10)

Car safety

The physics of staying safe on the road

ABOUT | BACKGROUNDER | PROFILES | ENGAGE
EXPLORE | EXPLAIN | ELABORATE | EVALUATE

The National Roads & Motorists' Association

REFRACTION MEDIA

INTRODUCTION TO THE GUIDE

The *Road Safety Total Learning Resource* is designed to assist high school teachers (Years 9–10) to engage and involve their students in the physics, health and essential maths of road safety.

This teaching resource looks at car safety features and their capacity to reduce injury via content links to the Years 9 and 10 Physics and Chemistry curriculums. It also covers improved safety features of new cars compared to older cars as well as ecological issues such as fuel emissions and hybrid vehicles. General capabilities addressed include literacy, numeracy, ethics and creative thinking.

See the NRMA website for further details and information relevant to road safety.

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HOW TO USE THE GUIDE

The notes in this study guide offer both variety and flexibility of use for the differentiated classroom. You and your students can choose to use all or any of the five sections – although it is recommended to use them in sequence, along with all or a few of the activities within each section.

THE 'FIVE ES' MODEL

This guide employs the 'Five Es' instructional model designed by Biological Sciences Curriculum Study, an educational research group in Colorado. It has been found to be extremely effective in engaging students in learning science and technology.
It follows a constructivist or inquiry-based approach to learning, in which students build new ideas on top of the information they have acquired through previous experience.

Its components are:

Engage
Students are asked to make connections between past and present learning experiences and become fully engaged in the topic to be learned.
Explore
Students actively explore the concept or topic being taught. It is an informal process where the students should have fun manipulating ideas or equipment and discovering things about the topic.
Explain
This is a more formal phase where the theory behind the concept is taught. Terms are defined and explanations are given about the models and theories.
Elaborate
Students have the opportunity to develop a deeper understanding of sections of the topic.
Evaluate
Both the teacher and the students evaluate what they have learned in each section.

MESSAGE FOR TEACHERS FROM NRMA

NRMA is working to create a wide range of free education resources for schools that will include teacher and student resources, Road Safety presentations in schools delivered by NRMA staff and school/student competitions.

All information on these resources can be viewed on **www.mynrma.com.au/youngdrivers**. Your help and feedback in creating and refining these new programs will be greatly appreciated, so please keep in touch.

Motoring Education Team
National Roads & Motorists' Association

Register for an email alert: **https://www.research.net/s/HSAlert**
Email: **education@mynrma.com.au**
Web: **www.mynrma.com.au/youngdrivers**

THE PHYSICS OF CAR CRASHES

Physics can tell you how long it takes for a car to stop once you hit the brake, why you might lose control rounding a curve and why some car collisions result in more damage than others.

> **IT IS EASY TO IMAGINE THAT A HEAVY VEHICLE MOVING VERY FAST IS HARDER TO STOP THAN A LIGHTER VEHICLE MOVING MORE SLOWLY. THESE FACTORS ARE CONTROLLED BY THE PHYSICAL LAWS OF MOTION AND ENERGY.**

Newton's Three Laws of Motion

In the 1700's, while trying to identify a single rule by which the motion of all bodies could be calculated, English mathematician and theoretical physicist Isaac Newton developed the Three Laws of Motion – and changed the way we think about the world. They were published in 1686 in a work commonly known as *Principia*, which has often been considered by some to be the most significant scientific publication in history and the foundation on which much of modern physics was built. We can use Newton's Three Laws of Motion to help us understand the physics of car crashes.

The Law of Inertia

Every object in a state of uniform motion tends to remain in that state of motion unless an external force is applied to it.

The First Law of Motion means that objects that have greater momentum also have greater inertia.

A stationary object will require a push or a pull to set it in motion. When the net force on an object is zero, its speed and direction of motion will remain unchanged. This is true for both stationary objects as well as those already in motion.

An object that is in motion, and has no other force acting upon it, such as the force of friction, will remain in constant motion. The planets in space revolving around the Sun are one example of objects staying in constant motion.

A person travelling in a car at 60 km/h will keep moving at the same speed if the car stops suddenly. This means that they will be flung forward and can injure themselves hitting the steering wheel or windscreen. We use seatbelts to strap ourselves to the moving car to combat the Law of Inertia. The seatbelt allows us to become one with the body of the car, so that when it slows down we slow down with it.

The Law of Inertia also shows us that loose objects in a car, such as luggage, sharp tools or pets can also be hazardous when a vehicle has to stop suddenly.

When a stationary car is hit from behind it can be suddenly pushed forward. Inertia causes the car to move forward while the passengers' head remains stationary, causing whiplash. Fitted head rests are now compulsory in cars in order to reduce injury by whiplash after rear end collisions.

F = ma

F = force, m = mass and a = acceleration.

Newton's second law supports our awareness of road safety by showing us that the magnitude of the net force on a vehicle is the product of its mass and acceleration.

If you push an empty box it will move, or accelerate, forward. When there is an overall force on an object that is not balanced, the object accelerates in the direction of the overall net force. Acceleration can be negative, for example when a driver hits the brakes and increases the force of friction to slow the car down. Here, a rapid increase in force results in a rapid negative acceleration.

Have you ever wondered why drivers hate to sit behind a huge truck at the traffic lights? A greater force is needed to accelerate an object with a greater mass so trucks take longer to accelerate to the speed limit than cars do. Drivers should be careful never to pull in front of a slowing truck because its mass means it will take longer to negatively accelerate and could need the space in front

If a car crashes at 50 km/h into a brick wall, is the crash identical to one with an oncoming car of the same size travelling at the same speed?

The initial presumption is that the force of the crash involving two vehicles colliding head on would be greater because there is more kinetic energy. As it turns out, however, they are exactly the same. Each individual car carries its own kinetic energy into the collision and, assuming the cars are identical, each of the cars individually absorbs its own kinetic energy. There is twice as much kinetic energy in the system to begin with because there are two cars, but you've also got twice as many cars to spread the energy over.

of it to come to a safe stop. And conversely, that its mass and acceleration is what produces the force a vehicle can transfer onto a pedestrian or tree trunk when the driver loses control of the wheel.

Speed bumps, roundabouts and reduced speed limits (particularly around pedestrian areas) are all designed to prevent drivers from going too fast.

The Law of action and reaction

For every action there is an equal and opposite reaction.
If you push against an immobile object, the object pushes back in equal amounts. Only when the push on the object is greater than the push it can return will it move forward. When two identical vehicles hit each other with equal force the damage to both will be equal. But when one vehicle has a greater mass and a greater acceleration (i.e. is heavier and faster) than the other it will exert a greater force. If you collide a light object with a heavy object it's the lighter object that rebounds more. An everyday example of this is when a ball hits a bat, the ball rebounds while the bat, and the person attached to it, tends not to!

This Third Law of Motion explains why your car moves forward instead of the road moving backward when you step on the accelerator. The force exerted by the tyres on the road is matched by an equal and opposite force exerted by the road on the tyres. If that force is enough to overcome the car's inertia, e.g., on a clean, dry road, the car accelerates forward.

It is easy to imagine that a heavy vehicle moving very fast (and therefore with a high momentum) is harder to stop than a lighter vehicle moving more slowly.

Energy of car collisions

The Law of Conservation of Energy states that energy is neither created or lost but can be transferred or transformed (converted) from one type of energy to another.

Kinetic energy

Kinetic energy is the energy of movement – the force of work needed to accelerate a body of mass from a state of rest to a given velocity. Kinetic energy can be determined

A heavy, fast-moving vehicle takes longer to stop.

Lighter vehicles moving more slowly take less time, and a shorter distance, to come to a halt.

with the following equation: **ke = ½ m X v²** – where **ke** represents kinetic energy in joules, **m** represents mass and **v** represents velocity.

When a car collides with a stationary object, the kinetic energy is converted into energy deforming the bonnet and any other area of the car and the object included in the impact. Heat and sound energy is also released.

If a car is travelling faster or has a greater mass, it will also have more kinetic energy.

The more kinetic energy there is, the more that needs to be displaced when the vehicle collides. When the force acting on a car is friction, the kinetic energy of the car is converted to heat energy, and sound energy if the brakes squeal, due to the friction required to slow it down.

When Formula 1 cars crash their external parts are designed to come to pieces and fly off in all directions while the driver remains strapped to the inner frame of the vehicle. The kinetic energy of the flying parts move a great deal of kinetic energy away from the vehicle so that there is less near the car that can harm the driver.

When two cars travelling at 50 km/h hit each other head on the damage is the same as a car travelling 50 km/h hitting a brick wall. It is easy to imagine the damage would be twice as bad because there is twice as much kinetic energy to convert due to the movement of both vehicles. But the damage is the same because even though there is twice as much kinetic energy, there are two bonnets to absorb the kinetic energy as they crumple.

Elastic energy

Elastic energy is energy stored in a spring or piece of elastic. Although dodgem car collisions are somewhat elastic, where the kinetic energy of the moving car is absorbed by the spongy rubber and then converted back to kinetic energy as the dodgem car bounces away, collisions between metallic cars are not elastic. The kinetic energy of the moving car is converted into the energy required to crumple the bonnet or other panels when the car hits something. A car crash is an example of an inelastic collision, where energy is used up and transferred into another form, e.g. heat or sound. It takes energy to smash and bend steel.

There has been a great deal of research into the crumple effect of the bonnet of a vehicle to allow it to absorb as much of the kinetic energy of a car crash as possible so that the energy is not transferred to the passengers where it can cause major injury.

Friction

Friction is the opposing force of two objects rubbing together and produces heat. If the surfaces are rough there is a great deal of friction and if the surfaces are smooth there is very little friction.

Friction is a force that has an enormous effect on the motion of everyday objects and is very important to road safety. Without friction cars would have difficulty stopping. Anything that reduces friction, such as a wet slippery road or bald tyres, is a hazard to a moving vehicle.

Combustion

In a combustion reaction, oxygen usually combines with another compound, the fuel, to form carbon dioxide and water. Because oxygen is used up, combustion is known as an oxidation reaction. Heat is generated so this is an exothermic reaction.

The standard format for a combustion reaction is:

Word equation:

Combustible compound + Oxygen →
Carbon dioxide + Water

Chemical equation:

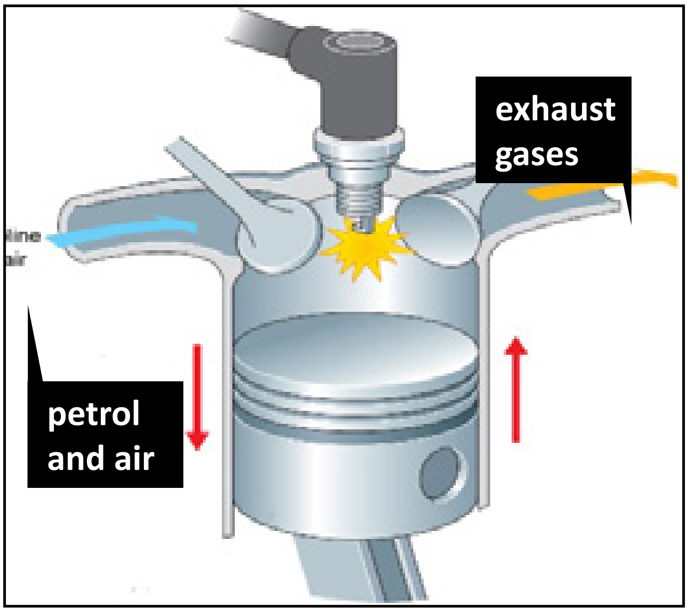
Combustible compound + O_2 → CO_2 + H_2O

An example of a combustion reaction is one between naphthalene and oxygen:

Naphthalene + Oxygen → Carbon dioxide + Water

$$C_{10}H_8 + 12O_2 \rightarrow 10CO_2 + 4H_2O$$

In a combustion engine, sparks are used to ignite fuel vapours (oxidation) that work pistons that drive the engine.



BE AWARE

Taking risks isn't worth it, says Mark Toole.

“ DRIVING IS THE MOST DANGEROUS THING THAT PEOPLE DO.

“DRIVING IS THE MOST dangerous thing that people do, and they do it on a daily basis,” says Mark Toole, a learning and development consultant from NRMA Safer Driving. “There is a lot of potential for harm out on the roads, so people need to focus on getting to their destinations safely.”

As part of his job, Mark identifies risk-taking behaviour and investigates why people take risks. He says drivers should take time before each trip to assess how long it will take and the conditions they'll be driving through, so they eliminate the temptation to speed to make up time. He advises all drivers to be on the lookout for other road users – “we can't predict or control what they'll do but we can ensure that we are driving in a low risk manner so we are better prepared should things change suddenly”.

Mark started working as a driving instructor in 2000. He encourages his students to think about what they're doing on the road, for example getting them to analyse when would be a good time to change lanes. He also uses quizzes and games, such as ‘dog/pram’ where he asks his students to count how many dogs or prams they see, to get them to scan for risks without realising it.

He works very hard at being a calm and lucid driver. “I'm faced with the same temptations and frustrations and motivations to take risks,” he says. “It's about working to learn patience.” – *Laura Boness*

MINIMISING DRIVER DISTRACTION

Dr Kristie Young is making a big impact around the globe with her research into driver distraction.

DR KRISTIE YOUNG'S RESEARCH has highlighted the dangers of texting while driving. She says younger drivers are more likely to take risks such as texting or interacting with their personal music players, and they're also more vulnerable to distractions because their driving skills haven't yet become automatic – making their attention less available for other tasks.

“When young drivers are texting, they spend four times longer than usual with their eyes off the road,” she says.

Kristie was interested in a research career, but wasn't sure which topic to pursue after finishing her Psychology (Honours) degree at Deakin University. She applied for a research assistant position at Monash University's Accident Research Centre and enjoyed it so much she's still there today.

She and her colleagues look at the advantages and disadvantages of introducing new technology, such as speed and collision warnings, into cars.

Some of their research has led to changes being implemented in new cars – for example, Holden's design for a vehicle infotainment system, a system in automobiles that delivers entertainment and information content, is easier to use and minimises driver distractions.

“It's really good when you can actually see the research having an impact and being implemented in the community,” says Kristie.

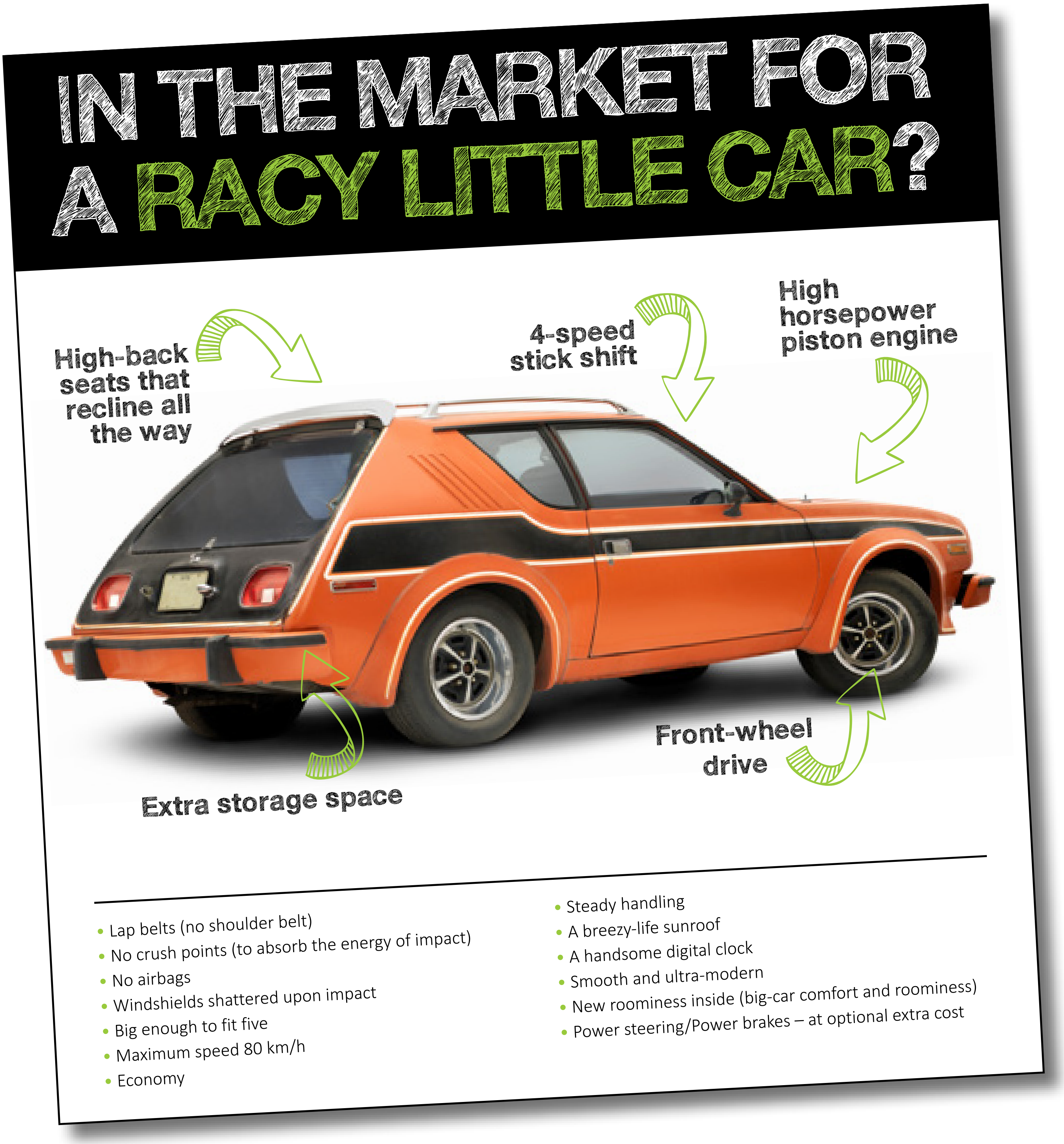
Her research has also made a difference to road safety in Sweden. During the construction of a 17-kilometre tunnel to bypass Stockholm, the Swedish National Road and Transport Research Institute was designing a system to warn drivers of traffic changes and hazards in the tunnel. They considered text message alerts as one option, but because of Kristie's research indicating this would take drivers' attention off the roads, decided against it. – *Laura Boness*

“ YOUNG DRIVERS ARE MORE VULNERABLE TO DISTRACTIONS BECAUSE THEIR DRIVING SKILLS HAVEN'T YET BECOME AUTOMATIC.

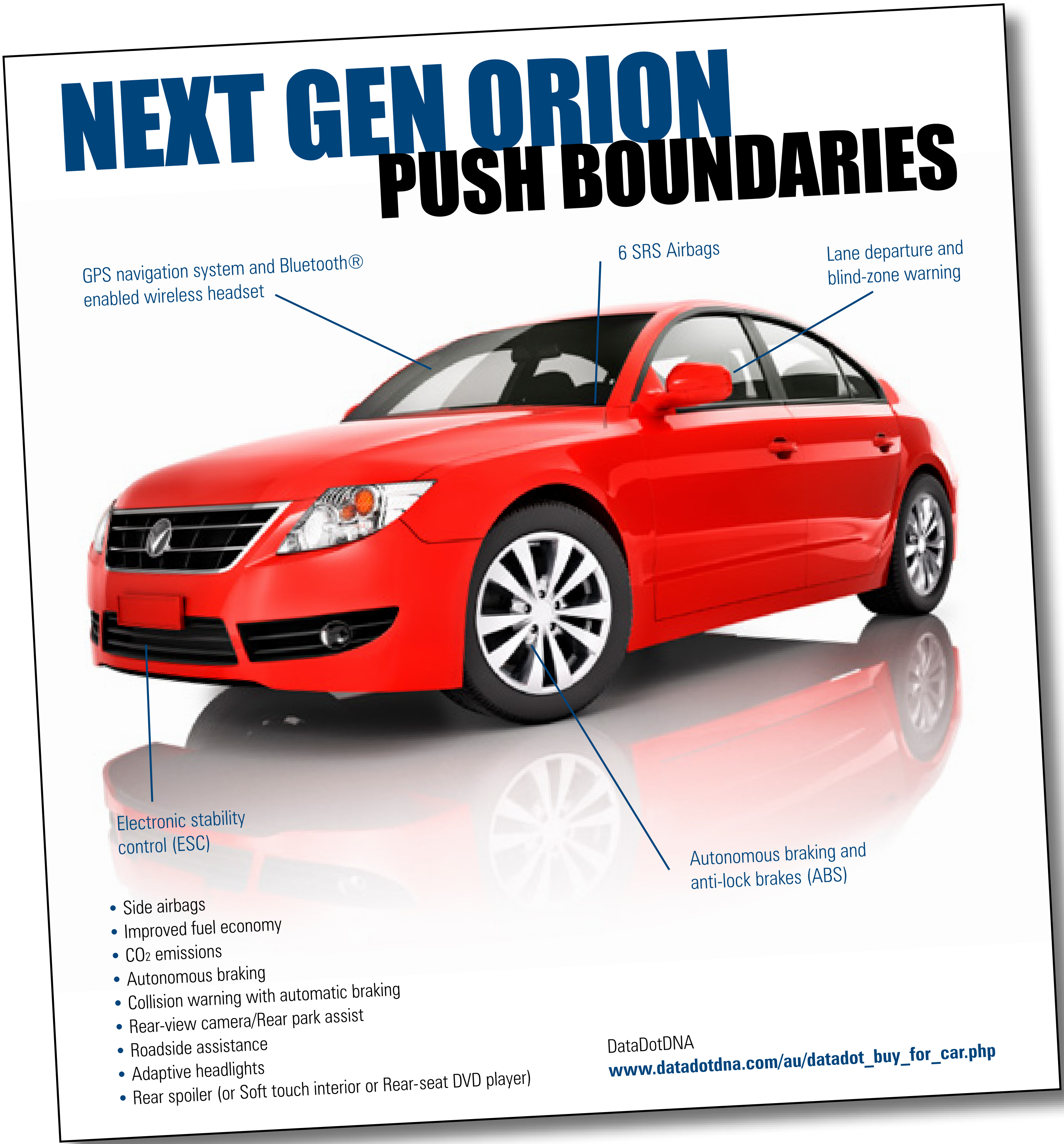
COMPARE THE CARS

Look at the cars in the two advertisements (A and B).

A. OLD CAR



B. NEW CAR


NEXT GEN ORION
PUSH BOUNDARIES
GPS navigation system and Bluetooth® enabled wireless headset
6 SRS Airbags
Lane departure and blind-zone warning
Electronic stability control (ESC)
Autonomous braking and anti-lock brakes (ABS)
• Side airbags
• Improved fuel economy
• CO_2 emissions
• Autonomous braking
• Collision warning with automatic braking
• Rear-view camera/Rear park assist
• Roadside assistance
• Adaptive headlights
• Rear spoiler (or Soft touch interior or Rear-seat DVD player)
DataDotDNA
www.datadotdna.com/au/datadot_buy_for_car.php

1. What are the main marketing messages for the car in Advert A? Tick the most appropriate choices.

- [ ] **a)** comfort
- [ ] **b)** speed
- [ ] **c)** space
- [ ] **d)** safety
- [ ] **e)** other: (specify) ____________________________

2. What are the main marketing messages for the car in Advert B? Tick the most appropriate choices.

- [ ] **a)** comfort
- [ ] **b)** speed
- [ ] **c)** space
- [ ] **d)** safety
- [ ] **e)** other: (specify) ____________________________

3. What are the differences between the features in the old car in Advert A and the new car in Advert B? What has changed in people's thinking towards cars now, compared to a couple of decades ago?

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4. Which car would you prefer to buy? Why?

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5. Imagine you are a student with little money in the bank and a part time job to support you while you study. Which of the cars above would you buy? Give reasons for your response.

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6. How might an inexperienced driver with an old car compensate for fewer safety features compared to how they would compensate if they drove a newer car?

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7. Do you think it is fair that, generally, the least experienced drivers drive the least safe cars? Give reasons for your response.

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8. Imagine you have a budget of between $5000–$10,000 to buy a safe used car. Go to the Used Car Safety Ratings Buyers' Guide at **http://www.mynrma.com.au/motoring-services/reviews/safety.htm** and find used cars that are recommended highly for safety. Do research on car buying guides to see cars fit best into your budget. Record your findings here.

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TEACHER'S NOTES

The aim of the Explore section is for students to investigate some of the dangers and safety issues around cars and driving, and ponder the possible impacts on drivers and passengers. It is intended that students make their own discoveries as they work around the stations.

The following table lists the equipment and preparation required. The stations can be completed in any order.

Equipment and preparation table for the Explore circuit

Station no. and activity	Materials list
1. Crash test dummies with and without seat belts	Computer to access the following video: **www.youtube.com/watch?v=d7iYZPp2zYY**
2. Crumple zones	Computer to access the following videos: **www.youtube.com/watch?v=zS_Gk7vjmOg** and **www.youtube.com/watch?v=N11_BWe9hYU**
3. Mass and impact	Plastecine, small marble, large marble
4. Combustion	Crucible with lid, clay triangle, tripod, Bunsen burner, 7–8 (1 cm) lengths of magnesium ribbon, metal tongs, matches, weighing scale, computer with internet access
5. Mobile phone use and reaction time	Ruler
6. Stopping distance and speed	Ruler, two toy cars, x1 A5 sheet of paper with a 1 cm^2 grid drawn on the surface, pack of dominos
7. Stopping distance and friction	Two toy cars, Vaseline, oil, ramp, smooth plastic sheet, glad wrap
8. Reaction time	Computer to access the following game: **www.getinlane.co.uk/activities/games-section/reaction-tester/**

STATION 1
CRASH TEST DUMMIES WITH AND WITHOUT SEATBELTS

1. Watch the following video: **www.youtube.com/watch?v=d7iYZPp2zYY**.

2. Make a list of all the possible injuries to a person during a collision without a seatbelt and with a seatbelt.

Possible injuries during a collision	
Without a seatbelt	**With a seatbelt**

3. From what you have learnt in the video, write a general statement that could be used in an advertising campaign to encourage people to wear seatbelts.

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STATION 2
CRUMPLE ZONES

1. Watch this video about the well-designed crumple zone in a Volvo:
www.youtube.com/watch?v=zS_Gk7vjmOg.

2. Now watch this video of a poorly designed crumple zone in a crash:
www.youtube.com/watch?v=N11_BWe9hYU.

3. Compare the possible damage to the whole car and to the driver in the well-designed and poorly-designed crumple zones.

	Well-designed crumple zone	Poorly-designed crumple zone
Possible damage to a car		
Possible injury to a person		

4. From watching the videos, what do you think a crumple zone is?

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5. Where does the kinetic energy of the impact of the collision go after the impact? Complete the following energy flow chart:

Kinetic energy of a moving car

a. Energy is in the moving car → **b.** ______________ → **c.** ______________ → **d.** ______________

6. From what you have seen in the videos, write a general statement that could be used in a car advertising campaign to promote a car with a well-designed crumple zone.

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STATION 3
MASS AND IMPACT

1. Make a 10 x 10 cm square out of the plastecine that is 1 cm thick.

2. Drop a small marble from 40 cm height into the plactecine. Note the depth of the impact it makes in the plastecine.

3. Drop a larger, heavier marble from 40 cm height into the plactecine. Note the depth of the impact it makes in the plastecine.

4. Draw your results in the space below.

5. Predict the effect of size (mass) of a vehicle on its force during a head-on collision.

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STATION 4
COMBUSTION

1. Place several pieces of magnesium in a clean crucible.

2. Weigh the magnesium and the crucible. Write the weight here: _________________

3. Put the lid on the crucible and place it in a clay triangle over a tripod.

4. Place the tripod over the hot flame of a Bunsen burner to heat the metal in the crucible.

5. Occasionally, and very carefully and slowly, lift the lid off the crucible with the metal tongs to observe the magnesium. DO NOT LOOK DIRECTLY AT THE MAGNESIUM FOR EXTENDED PERIODS OF TIME.

6. When the magnesium has turned to ash, turn off the Bunsen burner and wait for the crucible to cool.

7. Weigh the crucible with the magnesium ash. Write the weight here: _________________

8. What is the increase in mass of the magnesium and crucible? _________________

9. Combustion requires the presence of three things to take place: heat, fuel and oxygen. (It is the oxygen that you have measured as the magnesium turned to magnesium oxide.) What is the fuel in this experiment?

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10. Combustion occurs in the engine of cars. Research combustion in car engines and describe how it works. Write your answer here. Include the type of fuel used and how it is used to create motion.

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STATION 5
MOBILE PHONE USE AND REACTION TIME

1. Place the 0 cm mark on the ruler between the thumb and pointer finger of your partner. Agree on a distance the thumb and pointer finger should be apart. Catching the ruler when dropped will simulate the concentration needed to react when driving.

2. Ask your partner some simple mathematical problems (see examples in the box below).

3. At a random point during the question asking, drop the ruler and record the distance they caught the ruler. This is their reaction time when being distracted.

4. Repeat Steps 2 and 3 twice.

5. Repeat Steps 2–4 without distracting your partner.

Trial number	Reaction while being distracted (cm)	Reaction while not being distracted (cm)
1		
2		
3		
Average		

Simple mathematical problems to distract your partner with...

5+3(8), 19+2(21), 17-6(11), 5x3(15), 13+5(18), 27-3(24), 20÷4(5), 2x7(14), 6+7(13), 8÷2(4), 7+9(16), 11x3(33), 28÷7(4), 12÷3(4), 9x3(27), 12-4(8), 8+5(13), 6+5(11), 12x3(36), 19-5(14), 4x8(32), 2+27(29), 11-7(4), 32÷2(16), 9÷3(3), 14+4(18), 23+23(46), 37-12(25), 9+12(21), 8x8(64), 16+3(19), 16-3(13).

STATION 6
STOPPING DISTANCE AND SPEED

1. Stand the dominoes up on the A5 sheet of paper so that they are evenly spaced.

2. Each 1 cm square on the grid on the A5 sheet represents 1 m.

3. Imagine that the dominoes are people and the A5 sheet of paper is the town square.

4. Two cars drive onto a town square from opposite directions. Car A is travelling at 50 km/h and has a braking distance of 9.6 m. The same model car, Car B, is travelling at 55 km/h and has a braking distance of 11.7 m.

5. Describe how you used the equipment to show how an extra two metres stopping distance has a higher chance of injuring someone if the cars have to stop suddenly.

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STATION 7
STOPPING DISTANCE AND FRICTION

1. Use the materials provided to design and conduct a simple investigation to find out if a slippery road affects stopping distance.

2. What method did you use to attempt to find out if slippery surfaces affect stopping distance?

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3. What is your conclusion?

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4. If you are unsure whether or not you managed to conduct a fair and reliable experiment in order to answer the question, why do you think this is? What else could you do to test it?

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5. What kinds of tests would engineers with real cars conduct to test whether stopping distance is affected by friction?

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STATION 8
REACTION TIME

1. Go to: **www.getinlane.co.uk/activities/games-section/reaction-tester/** and play the reaction game to see how fast you can respond to the traffic lights going red.

2. What is your best score? ______________________________

3. What percentage of accidents do they estimate is caused by fatigued drivers? ______________________________

4. What does the game recommend drivers do if they are tired?

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TEACHER'S NOTES

In this section, we discuss and analyse car safety and consider how future cars will improve their safety features to help keep us safe on the road.

Three articles are provided for students to read. Each article is accompanied by a range of literacy activities, including:

- Brainstorming
- Glossary
- Comprehension and summary
- Questioning toolkit

The three articles are:

Article 1 – Cross-section of a car crash

This articles looks at the reasons driving cars is dangerous and some of the safety features that can help reduce these dangers.

Article 2 – Attentiveness and mobile phone use

This article examines mobile phone use while driving as a common reason for car crashes, and why young people are particularly vulnerable.

Article 3 – Cars of the future

This article discusses some of the improved safety features being built into new cars to help improve safety on the roads.

CROSS-SECTION OF A CAR CRASH

Over the years, clever engineering has reduced injuries and deaths, by developing car safety features that absorb the energy of car crashes in a controlled way, explains Jude Dineley.

BECAUSE WE USE VEHICLES every day, it can be easy to forget that they are dangerous machines when handled incorrectly. In 2013, nearly 1200 people died on Australian roads.

The danger vehicles pose comes down to physics. Cars are heavy objects travelling at speed; they have large amounts of kinetic energy that can have catastrophic results when unleashed during a crash. This energy cannot be destroyed – it can only be converted into other forms of energy. So when a car crashes and stops, the car and anything it collides with absorbs the energy. This transformation of energy crushes and deforms the car.

Injuries can happen as the car is crushed, for example if the footwell collapses backwards into passengers' legs. Passengers can also be injured when they are thrown forward against the inside of the car or outside of the car. This is a result of Newton's First Law, the Law of Inertia, which states:

An object at rest stays at rest and an object in motion stays in motion with the same speed and in the same direction unless acted upon by an unbalanced force.

This means that as the car stops, the passengers in the car keep moving forward at speed. Deceleration (decrease in velocity) in itself can also be dangerous. Newton's Second Law of Motion states that force (F) is equal to mass (M) times acceleration (a): F = Ma.

When cars experience a force when they accelerate or decelerate, the more quickly the speed changes, the larger the force will be. Normally a car takes several seconds to stop, and the deceleration forces are small. During a collision a car can stop within tens of milliseconds, making the forces very large. In bad accidents, these forces can be big enough to cause serious injury.

> **CAR ACCIDENTS BECOME MORE LIKELY AS SPEED INCREASES BECAUSE IT TAKES LONGER – AND CONSEQUENTLY FURTHER – TO STOP.**

Stopping distances and reaction times

Accidents become more likely as speed increases because it takes longer – and consequently further – to stop. After spotting a hazard on the road, a driver typically takes 1.5 seconds to react and hit the brakes. It then takes time for the brakes to stop the car. For example, a car travelling at 60 km/h will travel approximately 56 metres before stopping. In some cases this isn't quick enough to avoid crashing with another car or pedestrian.

The kinetic energy that must be absorbed in a crash to avoid harm increases with velocity. Mathematically, kinetic energy (K_e) equals half the mass of the car (m) times the square of its velocity (V^2), so the severity of any accident steadily increases according to how fast the car is travelling.

WORK IT OUT!

You can use maths to work out the distance (D) that you would cover in order to stop depending on the speed you are travelling.

So you start with:

D = 1.5/3600 x V

Where D = distance per km and V = velocity (speed in km/h)

Note: 1.5 seconds = 1.5/3600 hrs

Then you have to add the braking distance (b).

This is proportional to the kinetic energy, so must be in the form of **b x V²**, where b is a constant. So,

D = 1.5/3600 x V + (b x V x V)

We can reduce the first part of the equation to write:

D = V/2400 + (b x V x V)

Substituting this into the information given, we have:

56/1000 = 60/2400 + b x 60 x 60

Which gives **b = 31/3,600,000**

So that:

D = V/2400 + 31 x V x V/3,600,000

Multiplying by 1000, the distance in metres (d) is

d = V/2.4 + 31 x V x V/3600

d = V/2.4 + 31

In this case, our speed was 60 km/h and the stopping distance was 56 m:

56 = 60/2.4 + 31 x 60 x 60/3600

What would the stopping distance be if you were travelling at 70 km/h?

The National Roads & Motorists' Association
REFRACTION MEDIA

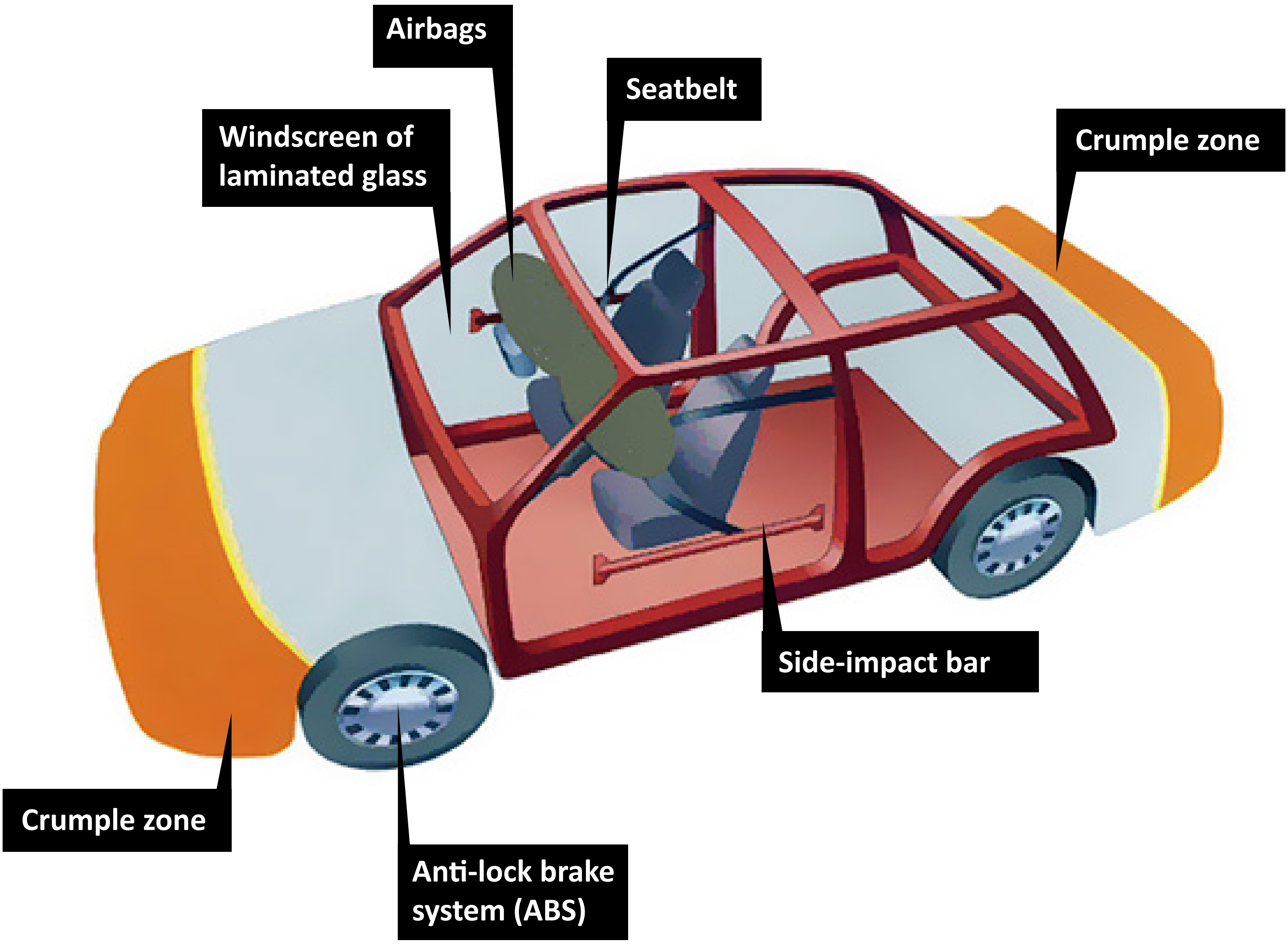
How dangerous is speeding?

Speed (km/h)	Speed increase above 60 km/h speed limit	Increase in kinetic energy	Increased risk of hospitalisation or death
65	+ 8%	+ 17%	X 2
70	+ 17%	+ 36%	X 4
75	+ 25%	+ 56%	X 8

*from Kloeden CN, Ponte G & McLean AJ, Department of Transport and Regional Services Australian Transport Safety Bureau, 2001.

Car safety features

Over the years, clever engineering has dramatically reduced the number of injuries and deaths, by developing safety features that absorb the energy of the crash in a controlled way and decrease the forces acting on the passengers.



Anti-lock brake system (ABS)
This is one of several braking technologies that reduce the chances of a collision happening, as well as the severity of the collision. Without ABS the sudden braking needed in an emergency can lock the wheels – and steering – causing the driver to lose control of the car.

Crumple zones
Once a crash happens, crumple zones at each end of the car (front and rear) absorb the kinetic energy, collapsing in a controlled way and slowing the impact and reducing forces. In doing so, they also minimise the impact on the reinforced metal safety cell containing the passengers. In some cars the heavy engine block detaches from the front of the car and slides under the cell, reducing the impact even further.

Side-impact bars
These strengthen the car and protect it against side-on collisions. The steering wheel column and brake pedals are designed to collapse away from the driver during a crash, reducing the chances of impact.

Windscreen of laminated glass
This provides a further barrier against objects that might come into contact with a car. It is made up of two layers of glass bonded together with clear plastic; once broken, the plastic keeps the window in one piece.

Seatbelts
These are crucial; they hold passengers in their seats and reduce the chances of them hitting the inside of the car or being thrown outside the car. Seatbelts must sit across hard bones – collarbones and hipbones. Slipping your seatbelt under your arm if it is rubbing against your neck will means ribs and soft tissues will be damaged in a crash. Use the seatbelt adjustor to lower the seatbelt.

Also important is how the seatbelts are designed to stretch during a crash. This slows the deceleration of the passengers, reducing the forces acting on them. A device called a pretensioner reduces slack in the belt when it senses a crash, holding passengers more securely and spreading forces more evenly across their waists and chests. Remember to replace seatbelts after a crash, as they can only be stretched once.

Airbags
These provide added protection, by inflating when a crash occurs. Like seatbelts, they slow the impact and reduce the force. They also spread the force over a larger area than the seatbelt, reducing the impact on the passengers even further. Airbags and seatbelts are designed to work together – just because you have airbags it doesn't mean you don't need seatbelts. Head restraints also prevent passengers' heads from snapping backwards in rear-end crashes.

ACTIVITY 1
BRAINSTORMING

1. Have you ever experienced a car crash? YES / NO

2. Do you know someone who has experienced a car crash? YES / NO

For the following scenarios try to explain what it would feel like to be the driver of the car. Think about how it would feel both physically and emotionally. You can draw upon your own experiences, the experiences of others, or your understanding of physics and driving.

Scenario 1

You're driving past a park when a child's ball bounces onto the road in front of you. You break quickly and suddenly. The driver behind you, who has not seen the child's ball fails to stop in time and crashes into the back of your car.

What does it feel like?

Physically:

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Emotionally:

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Scenario 2

You are driving a friend to a party in an area you don't know very well. Your friend suddenly tells you to turn left. You turn the wheel quickly to make the turn but lose control of the car and crash into a parked car.

What does it feel like?

Physically:

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Emotionally:

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ACTIVITY 2
GLOSSARY

Create a glossary. Use the table to define any science words that are related to this article.

Glossary of terms

Word	Definition
absorb	
energy	
kinetic energy	
transformation	
mass	
velocity	
speed	
deceleration	
acceleration	
force	

ACTIVITY 3
SUMMARISING

Summarise the information in Article 1 by responding to the following questions:

1. According to the article how many people died on Australian roads in 2013?

2. What happens to the kinetic energy when a car crashes and how can this be dangerous? Give an example in your answer.

3. Describe Newton's First Law: the Law of Inertia.

4. Why is the force greater when a car has to stop suddenly?

5. What does Newton's Second Law of Motion state?

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6. Why do accidents become more likely as speed increases?

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7. What formula can you use to work out the kinetic energy of a vehicle?

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8. Which car safety features work by reducing forces?

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ACTIVITY 4
QUESTIONING TOOLKIT

We have provided a series of discussion questions in the form of a Questioning Toolkit. Choose some or all of the questions, or ask some of your own. Write your ideas relating to each of the different types of questions.

Type of question	Your ideas and opinions
Essential questions These are the most important and central questions. They probe the deepest issues that confront us and can be difficult to answer. **Question:** Why is driving a car dangerous? How can the kinetic energy of car crashes be absorbed safely?	
Sorting and sifting questions These questions help us to manage our information by finding the most relevant details. **Questions:** Which has the greatest impact on car crash fatalities, speed or car safety features? How do safety features help the driver and their passengers during a crash?	
Hypothetical questions Questions designed to explore the possibilities, the 'what ifs?' They are useful when we want to test our hunches. **Questions:** Instead of road speed limits, what if cars had an individual speed limit based on their safety features? If speed limits on all roads were reduced, do you think it would save lives?	
Provocative questions Questions to challenge convention. **Questions:** Should drivers have to undertake regular reaction time tests to maintain their licence? As new vehicles are developed with improved safety features, should older vehicles without these safety features be removed from the road? Should more car safety features be developed to minimise the injuries sustained by pedestrians who are hit by cars? Should cars with more safety features be allowed to drive faster than cars with fewer safety features?	

Further reading on questioning toolkits: McKenzie, Jamie (2000) Beyond Technology, FNO Press, Bellingham, Washington, USA. **www.fno.org/nov97/toolkit.html**

ATTENTIVENESS AND MOBILE PHONE USE

Learning to drive isn't as straightforward as you think. An unfortunate statistic with learning to drive is that young drivers have more than three times the risk of a serious crash.

Mobile phone use

Nowadays, a handheld device can do a whole lot more than just call or text. You can use it as a GPS, keep up with online traffic reports, see what people are tweeting about, or check the status of your friends via social networks.

Although it is illegal for all drivers to use a hand held device while driving, people still admit to using their mobile device behind the wheel. The offence is dangerous, and it carries a heavy fine and the loss of three demerit points. The NRMA advises all drivers who need to use their mobile phones to pull over before using their phones. Attentivenss is important – split second reactions could mean the difference between being in a crash, or avoiding one.

Learner and P1 licence holders are not permitted to use any function of a mobile phone while driving or when the vehicle ignition is switched on. This includes phones in hands-free mode, with the loud speaker operating or sending text messages. These special licence conditions, among others, for learner and provisional drivers are there for a reason – with inexperience comes a higher risk of danger. Learner drivers need to focus on the task of driving, and on developing their hazard-perception and vehicle control skills.

Text messaging – there's no excuse

The results of NRMA research provide evidence that retrieving and, in particular, sending text messages has a detrimental effect on a number of safety-critical driving measures.

In particular, when text messaging, drivers' ability to maintain lateral position and to detect and respond appropriately to traffic signs is negatively affected. In addition, when text messaging, drivers spent up to 400% more time with their eyes off the road than they did when not text messaging.

While there was some evidence that drivers attempted to compensate for being distracted by increasing their following distance, drivers did not reduce their speed while distracted, which could increase their risk of being involved in a crash because it increases the stopping distance required to avoid a collision.

"ATTENTIVENESS IS IMPORTANT - SPLIT-SECOND REACTIONS COULD MEAN THE DIFFERENCE BETWEEN BEING IN A CRASH, OR AVOIDING ONE.

Studies continue to show that using a mobile phone while driving is dangerous because it slows reaction times and interferes with a driver's perception skills – increasing the chances of having a crash.

For more information and safety tips while staying connected, go to:
www.mynrma.com.au/motoring-services/road-safety/mobiles.htm

For more information on licence conditions for learner and provisional drivers, go to:
roadsafety.transport.nsw.gov.au/stayingsafe/drivers/youngdrivers/licenceconditions.html

Sources:
www.mynrma.com.au/motoring-services/road-safety/texting.htm
roadsafety.transport.nsw.gov.au/stayingsafe/mobilephones/index.html

ACTIVITY 1
BRAINSTORMING

1. Mobile phone use is a distraction associated with an increased risk of crashing a car, but there are many other objects, events and activities both inside and outside of a vehicle that can distract a driver's attention. Write 10 driver distractions in the table below. Then write ways to prevent each distraction.

Distraction	Prevention

2. Choose the distraction from the table that you think would have the greatest impact on a driver's ability to concentrate, and state why.

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ACTIVITY 2
SUMMARISING

Summarise the key points in Article 2 by responding to the following questions.

1. According to the article under which circumstance is using a mobile phone while driving illegal?

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2. Why is using a mobile phone while driving so dangerous?

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3. Describe what a mobile phone safety campaign would look like. What would the message be and how should it be delivered? Write your ideas here.

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4. If you could conduct a study about mobile phone use and driving, what questions would you ask? Write a couple of questions here.

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5. Watch the following short video on driver distraction on the following website. Then answer the questions (a–d).
www.abc.net.au/catalyst/stories/4094069.htm

a) While driving, why do you think talking on a hands-free phone or attending to a child could be considered just as dangerous as talking on a hand-held mobile phone?

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b) Should hand-free phones also be banned? Why/Why not?

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c) What guidelines would you give a parent about interacting with children while they are driving? (What is acceptable and what should be avoided because it is dangerous?) Consider the following examples and identify some of your own: passing something to the backseat for the child, disciplining a child for bad behaviour, testing a child for a spelling test, singing a song with children.

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d) Why might it be difficult to police unsafe interactions with child passengers?

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ACTIVITY 3
QUESTIONING TOOLKIT

We have provided a series of discussion questions in the form of a Questioning Toolkit. Choose some or all of the questions, or ask some of your own. Write your ideas and opinions relating to each of the different types of questions.

Type of question	Your ideas and opinions
Essential questions These are the most important and central questions. They probe the deepest issues that confront us and can be difficult to answer. **Question:** What makes mobile phone use so dangerous when driving? Why do people still use mobile phones when driving, even when they know it is dangerous and illegal?	
Sorting and sifting questions These questions help us to manage our information by finding the most relevant details. **Questions:** Should all drivers be banned from using hands-free mobile phones? Is driving while tired or talking to passengers as dangerous as driving while using a mobile phone?	
Hypothetical questions Questions designed to explore the possibilities, the 'what ifs?' They are useful when we want to test our hunches. **Questions:** What if cars were fitted with a device that deactivates the use of all electronic devices when the engine is running?	
Provocative questions Questions to challenge convention. **Questions:** Are social media sites and mobile phone companies responsible for the increased number of car crashes associated with their use? If you are a passenger and a driver takes a call on their mobile phone, what should you do? Is there enough information about the dangers of using a mobile phone when driving?	

Further reading on questioning toolkits: McKenzie, Jamie (2000) Beyond Technology, FNO Press, Bellingham, Washington, USA. **www.fno.org/nov97/toolkit.html**

CARS OF THE FUTURE

A high demand for research into car safety has led to an increase in new features, sophisticated detection systems and auto-piloting in new cars – taking some of the risks out of driving.

CARS HAVE IMPROVED over the past 50 years. What exciting advancements are in store for the future? New technologies have already led to improvements for the environment and for the safety of drivers and passengers.

Hybrid cars are a type of fuel efficient or 'green' vehicles, using technology that combines a conventional petrol engine with an electronic motor and battery pack to create lower fuel consumption, reducing C02 emissions. To find out more about hybrid cars visit: **www.mynrma.com.au/motoring-services/buy-sell/buying-advice/green/hybrids.htm**

In safety, new research has led to cars with the ability to monitor their surroundings and essentially 'drive' on their own, at least in part, thereby reducing the impact of driver errors and increasing safety – this new ability is called 'auto-piloting'. Top-end sedan cars in Germany that are already on the road, such as BMW models, tell us what features are likely to become standard. These includes infra-red headlights that see in the dark and conventional headlights that turn with bends in the road and give drivers an improved view of the road in front.

Cars are now also capable of monitoring drivers. Companies like Volkswagen offer fatigue detection systems that look for signs in the way cars are driven, including steering and pedal usage, that indicate drivers are tired. When the car detects fatigue, it provides a warning to alert drivers and encourage them to take a break. More sophisticated systems in the research pipeline will monitor a driver's mood and determine whether they are paying full attention to the road. Sensors will detect a range of signs, from posture to eye movements, and use the data detected to work out if the driver is tired, stressed or even daydreaming.

Technology is also enabling cars to take a more active, reliable part in controlling their motion in order to lower the risks of accidents. Mercedes' Intelligent Cruise Control uses radar to detect the distance to the car in front and alter speed to maintain a safe driving distance. When the car in front becomes too close, the car will brake automatically to prevent a crash. In Volvo models, similar sensing and braking technology is being used to avoid collisions with pedestrians and cyclists who suddenly move in front of a car. This 'intelligent cruise control' is a crucial part of the self-driving cars of the future. Many safety assist technologies now come standard in new cars, such as autonomous emergency braking in the Volvo V40.

> **"TECHNOLOGY IS ENABLING CARS TO TAKE A MORE ACTIVE, RELIABLE PART IN CONTROLLING THEIR MOTION IN ORDER TO LOWER THE RISKS OF ACCIDENTS.**

For NRMA car reviews and information about new car safety features visit: **www.mynrma.com.au/motoring-services/reviews.htm**

To find out how new cars are performing, visit the Australasian New Car Assessment Program (ANCAP) Crash Tests: **www.mynrma.com.au/motoring-services/reviews/ancap.htm**

Several cars are now also taking the effort out of parking by doing it themselves. Sensors work out the position of the car and the size of the parking spot, then a computer calculates and implements the steering needed to manoeuvre it safely into place.

Auto-piloting powers are set to increase. In April 2014, Volvo began testing self-driving cars in Sweden. Already, they can keep to the lane they are driving in, vary their speed as needed and merge into traffic without any help. By the end of the testing, researchers expect them to be able to drive themselves.

Like something out of a sci-fi novel, US consultants IHS Automotive have predicted that by 2050 almost all cars will be driving themselves. By removing human judgement from the equation, they predict accident rates will plunge to near zero in the same time – a far cry from the dangerous seatbelt-free driving of the 1960s.

ACTIVITY 1
BRAINSTORMING

1. If you could change one thing to make driving safer what would it be? For each of the following headings, suggest an idea that could improve safety.

Cars

Roads

Driver Behaviour

2. In your opinion, which of your three ideas would have the greatest impact on safety? Explain the reasoning behind your opinion.

ACTIVITY 2
GLOSSARY

Create a glossary. Use the table to define any science words that are related to this article.

Glossary of terms

Word	Definition
infra red	
monitor	
sensors	
autonomous	

ACTIVITY 3
SUMMARISING

Summarise the information in Article 1 by responding to the following questions:

1. According to the article, which car safety features have helped cut death rates on Australian roads by a factor of six since 1970?

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2. What signs do driver fatigue detection systems look for to indicate that a driver is tired?

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3. In the near future, how might a driver's mood be monitored?

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4. How are car manufactures using sensor and braking technology to improve safety?

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5. How does auto piloting enable cars to park themselves and how is its use set to increase?

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6. According to US consultants, HIS Automotive, when will most cars be driving themselves, and how is this expected to affect accident rates?

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ACTIVITY 4
QUESTIONING TOOLKIT

We have provided a series of discussion questions in the form of a Questioning Toolkit. Choose some or all of the questions, or ask some of your own. Write your ideas and opinions relating to each of the different types of questions.

Type of question	Your ideas and opinions
Essential questions These are the most important and central questions. They probe the deepest issues that confront us and can be difficult to answer. **Question:** As the technology in our cars improves will the accident rate continue to decrease?	
Sorting and sifting questions These questions help us to manage our information by finding the most relevant details. **Questions:** Which do you think contributes more to car safety, monitoring drivers or automated systems?	
Hypothetical questions Questions designed to explore the possibilities, the 'what ifs?' They are useful when we want to test our hunches. **Questions:** What if car manufacturers are successful in their plans to make cars that can drive themselves, what will the roads of 2050 look like? If in the future cars are driving themselves who would be responsible if an accident was to occur?	
Provocative questions Questions to challenge convention. **Questions:** Should driver fatigue systems stop the car from working if a driver ignores the advice to rest? When cars can drive themselves, will we still have to have a driver's licence or could anyone regardless of age and ability operate a car?	

Further reading on questioning toolkits: McKenzie, Jamie (2000) Beyond Technology, FNO Press, Bellingham, Washington, USA. **www.fno.org/nov97/toolkit.html**

ABOUT THE REFRACTION SCIENCE MATRIX

TEACHER'S ★★★★★ RESOURCE

What is the Refraction Science Matrix?
A learning matrix, such as the Refraction Science Matrix, is a flexible classroom tool designed to meet the needs of a variety of different learning styles across different levels of capabilities. Students learn in many different ways – some are suited to hands-on activities, others are strong visual learners, some enjoy intellectually challenging, independent, hands-off activities, while others need more guidance. The matrix provides a smorgasbord of science learning activities from which teachers and/or students can choose.

Can I use the Matrix for 1 or 2 lessons, or for a whole unit of study?
Either! The Matrix is designed to be time flexible as well educationally flexible. A time frame for each activity is suggested on the Matrix. Choose to complete one activity, or as many as you like.

Is there room for student negotiation?
Yes! Students can be given a copy of the Matrix and choose their own activities, or design their own activities in consultation with their teacher.

Can I use the Matrix for a class assessment?
Yes! You can set up a points system – perhaps one lesson equals 1 point. Students can be given a number of points to complete. If they choose less demanding activities, they will have to complete more of them.

What do the row headings mean?

Row heading	Description of activity
Scientific procedure	Hands-on activities that follow scientific method. Includes experiments and surveys. Great for kinaesthetic and logical learners, as well as budding scientists.
Science philosophy	Thinking about science and its role in society. Includes discussion of ethical issues, debates and hypothetical situations. An important part of science in the 21st century.
Being creative with science	For all those imaginative students with a creative flair. Great for visual and musical learners and those who like to be innovative with the written word.
Science time travel	Here we consider scientific and technological development as a linear process by looking back in time or travelling creatively into the future.
'Me' the scientist	Personalising the science experience in order to engage students more deeply.
Communicating with graphics	Using images to communicate complex science ideas.
ICT	Exploring the topic using computers and the Internet.

What do the column headings mean?

1. Read and revise	2. Read and relate	3. Read and review
Designed to enhance student comprehension of information.	Gives the student the opportunity to apply or transfer their learning into a unique format.	Requires the more challenging tasks of analysing and/or assessing information to create and express new ideas and opinions.

	1. Read and revise	2. Read and relate	3. Read and review
Scientific Procedure – Physics and Psychology	Why do we have a lap sash seatbelt in cars, rather than just a lap seatbelt (such as in airplanes), or a harness seatbelt (like toddlers in booster seats)? See Activity 1 to model what happens to someone in an accident when wearing the three different kinds of seatbelts. OR Do you have a mobile phone addiction? If so, it could be a major distraction and potential problem for you in the future when driving. See Activity 4 to find out if you will need to be proactive in curbing your mobile phone addiction whilst driving.	How does the speed of a car affect stopping distance? See Activity 2 to investigate the relationship between the speed of a car and stopping distances. OR What happens when methane combusts? Watch this teacher demonstration to find out. See Activity 5.	How effective are crumple zones in reducing the impact of collisions? Design, build and test your own model crumple zone. See Activity 3. OR Carry out a survey of family and friends that drive to find out if they are talking on a phone and texting on a daily basis. Write your results up as a full scientific report and compare your findings with a partner.
Science philosophy	The NRMA believe that 'Driver education and attitude are critical to becoming a safer driver'. As a teenager, suggest how the NRMA could teach you about safe driving. What approach would they need to take? Would they have to explain the science, come to your school, shock you into safety, provide real-life scenarios to learn from? Suggest what you think would be the most effective way to not only learn, but to heed and act on information about driver and road safety. Discuss and share your ideas with the class.	Should cars with more safety features be allowed to drive faster than cars with fewer safety features? Why/Why not? What would your opinion be if someone asked you this question in conversation?	Use argument mapping software, such as Rational, or have a class debate to explore ideas around whether it is better to invest time and effort into preventing road crashes in the first place, rather than spending time reducing their impact when they do happen. Use examples and counter examples to support your arguments.
Being creative with science	Design a poster, pamphlet, mural, ad, or any other visual aid to help promote the dangers of using a mobile phone while driving.	Write and perform a skit of four teenagers in a car unknowingly risking their lives. Communicate four or five different examples of how they might inadvertently distract the driver when they are all in a car together.	If style and money were no object, design a safety car with internal and external features that could reduce the amount of injuries to the passengers after a collision. Consider how the kinetic energy from the impact could be converted or transferred to the car rather than to the occupants of the car. Ideas to consider: changing the length of the crumple zone of the bonnet, the position and size of airbag.
Science time travel	Use the information in the articles to write yourself a letter, which you will read when you have passed your Learners. The letter will remind you about all the ways you can focus on being a safer driver.	How can we secure enough fuel for the future so that we can continue to be just as mobile as we are today once petrol begins to run out? Research and prepare case studies of two or three different fuel systems cars have, explaining their features, the fuel they use, and how they work.	Create a timeline of car safety features as they were introduced, such as seatbelts, airbags, rear vision video. Include information about the year and manufacturer of the cars. Analyse your timeline to identify any trends. Project your timeline into the future by adding a new safety feature not yet in cars for the year 2025. How much safer can a car become?
'Me' the scientist	Imagine you are a behavioural psychologist. Why do you think so many people use their mobile phones when driving when they know it is both dangerous and illegal? Recall instances where you have seen people using phones while driving. Think of what you could say to them as their passenger to help them avoid such distractions in the future.	Imagine you are an engineer working for a car manufacturer and you have been asked to show-off the latest smart car safety features at a car expo. Using the information in Article 3 as well as extra research, describe how each safety feature works and why it is considered safer.	You work for the NRMA education team that goes around to schools promoting driving safety. Design a series of simple experiments or demonstrations with toy cars that explain each of Newton's three Laws of Motion and how they relate to the motion of cars on the road.
Communicating with graphics	Look at the table entitled 'How dangerous is speeding?' in Explain Article 1. Use informative and eye-catching graphics to visually show the relationship between the data for 65, 70 and 75 km/h for one or more of the three columns.	Different hydrocarbons used as fuel for vehicles produce different amounts of energy when combusted or burned. Research the amount of energy (in kJ) produced by different hydrocarbons as they are combusted. Then graph your data.	Design your own road safety app to teach students about one aspect of the science of safe driving.

ACTIVITY 1
WHICH SEATBELT CAUSES THE LEAST DAMAGE IN A HEAD-ON COLLISION?

Background Information:
Depending on which type of vehicle you travel in, how old you are and which decade you spent the most time in a car, there are three types of seatbelts you could have worn. Lap seatbelts, like those on airplanes, are worn across the lap. Lap-sash seatbelts are those that have both a strap across the waist and one diagonally across the chest. Harness seatbelts have straps over both shoulders which meet across the chest.

Aim:
To find out which seatbelt is the safest.

Materials:
- Plastic doll (optional)
- Plastecine
- Cardboard box (e.g. a shoe box) that the doll can fit inside
- String
- Scissors
- Masking tape

Risk Analysis:
Complete the following risk analysis.

Risk	Precaution	Consequence
Sharp pointy scissors		

Method:
1. Cover the plastic doll with a thin layer of plastercine across the chest, head, arms and legs, or make a plastecine figure.
2. Make two holes in the back of the box with the pointy end of the scissors.
3. Put the doll in the box with the back of the doll between the two holes.
4. Feed the string into the box via one of the holes, around the waist of the doll and out the back of the box via the second hole. Tie a knot in the string so that the model of the lap seatbelt fits securely around the waist of the doll.
5. Put the lid on the box or fold lid over and secure with masking tape.
6. Hold the box so that the doll inside the box is facing the floor.
7. Let the box go so that it hits the floor.
8. Open the box and examine the markings on the plastecine caused by the impact of the lap seatbelt you put around the doll.
9. Record the damage to the plastecine around the doll in the results table on page 45.
10. Repeat steps 3–9 using a lap-sash seatbelt on the doll. Make extra holes in the back of the box if needed in order to place the seatbelt in the correct place.
11. Repeat steps 3–9 using a harness seatbelt on the doll.

Results:

Observations after head-on collision (dropping the box)				
Seatbelt type	**Trial 1**	**Trial 2**	**Trial 3**	**Summary of observations**
Lap				
Lap-sash				
Harness				

Discussion:

1. Identify the independent variable in this experiment. ____

2. Identify the dependent variable in this experiment. ____

3. What are the variables that you had to keep the same in order for this to be a fair test? Write them here.

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4. Do you think this experiment was able to demonstrate the real-life scenario of how a seatbelt would affect a driver in a head-on car collision? Give reasons for your answer.

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5. How did the doll and box seatbelt model show the effects of a real-life head-on collision in a car?

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6. How was the seatbelt model limited in showing the effects of a real head-on collision in a car?

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7. Suggest an improvement to this investigation to make it more like real life. Give reasons for your answer.

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8. Which seatbelt caused the least damage to the doll? Why do you think this is?

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9. Why do you think the other two seatbelts are used in moving vehicles, if this one is the safest?

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10. Are your results reliable? Explain.

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Conclusion:

Write a conclusion that responds to your aim and summarises your results.

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ACTIVITY 2
SPEED AND STOPPING DISTANCE

Background Information:

Brakes
A car's braking system takes the force you apply to the brake pedal and magnifies it through a series of fluid filled lines to the wheels. Friction is generated when the brake pads rub against the surface of either a disk or drum brake. The car's tyres apply friction to the surface of the road to slow the vehicle or bring it to a complete stop. If too much force is applied too quickly, the wheels may lock, which causes the car to skid. Many cars are fitted with anti-lock braking systems (ABS), which prevent the wheels from locking during hard braking. ABS uses sensors on each wheel to detect when a wheel is about to lock and momentarily releases the brake before reapplying it. On a dry, sealed road ABS will not stop a moving car a great deal faster than a non-ABS-equipped vehicle, but it does make it possible to maintain steering. In rain and snow, ABS will not allow the driver to get into a brake-induced skid – but if the driver is travelling too fast into a corner on a slippery road, or travelling too close to a car in front and then brakes suddenly, ABS will not be much use.

Stopping distance
Stopping distance is made up of thinking distance and braking distance. Thinking distance increases linearly with speed. This is because the thinking time stays the same but a car going faster travels further in that time. Braking distance does not increase linearly. In this investigation a trolley car and cardboard box collision is used to investigate the relationship between speed and braking distance.

For more information and tips on better braking visit:
www.mynrma.com.au/motoring-services/motorserve/motorserve-car-brakes.htm
www.mynrma.com.au/images/Motoring-PDF/ABS.pdf

Aim:
To investigate the relationship between braking distance and speed.

Materials:
- Ramp
- Blocks or books (for increasing the height of the ramp)
- Trolley car or toy car
- Box (that the car being used can fit inside)
- Metre rule or tape measure
- Light gate (optional)

Note:
Light gates are used to measure the speed of the trolley or toy car. If light gates are not available, students can measure the angle or height of the ramp. Increasing the height or angle of the ramp will increase the speed of the car.

Method:

1. Set up the ramp with enough of an angle to allow the car to roll down the ramp and onto the floor.

2. Place a cardboard box at the bottom of the ramp so that the car will run inside of the box. You may need to use trial and error to find the best position for your box.

3. If using a light gate, this can be placed at the bottom of the ramp to measure the speed of the car. If you are not using a light gate, record the height of the ramp or the angle of the ramp.

4. Release the car from the top of the ramp. Use a metre rule or tape measure to measure the distance the car/box skids across the floor in metres. Record this as the braking distance. You may want to use a metre rule each side of the box to make the car/box skid in a relatively straight line.

5. Repeat Steps 2–4 two more times and calculate the mean average braking distance. If using a light gate, also calculate the mean average speed.

6. Increase the angle of the ramp by adding a block or a book under it, and then repeat Steps 2–4 again. Continue to increase the angle and repeat the steps until you have a range of results.

Results:

1. Choose the correct heading for the first column. Write it in the table below.
   (a) Mean average speed (m/s)
   (b) Angle of ramp (°)
   (c) Height of ramp (m)

2. Record your results in the table.

	Braking distance (m)			Mean average braking distance (m)
	Run 1	Run 2	Run 3	

Discussion:

1. Graph your results on the grid below.

2. Was there a relationship between the speed of the car and the braking distance? Give reasons for your answer.

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3. Mathematically, speed and braking distance show a squared relationship. If the speed doubles, the braking distance quadruples. If the speed trebles, the braking distance increases nine times, and so on. In real-life driving situations, cars undertaking an emergency stop often have an even greater braking distance. What factors can increase the braking distance of a car?

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4. Based on the results of your investigation explain why it is important to leave a greater following distance when travelling on a highway.

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5. List at least one improvement you could make to how this investigation was carried out.
Give reasons for your answer.

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Conclusion:

Write a conclusion that responds to the aim and summarises your results.

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ACTIVITY 3
CRUMPLE ZONES

Background Information:

Crumple zones are areas of a vehicle that are designed to crush in a controlled way. They absorb the kinetic energy of a crash and increase the time it takes for a vehicle to come to a complete stop. This reduces the force exerted on the occupants, which reduces injuries. Not all crumple zones are the same; they are constructed in many different ways and with many different materials.

In this investigation you will work in a small group to design, build and test a model crumple zone. All models are to be submitted for final safety testing to determine which design is the most effective. As a class, you will have to decide on a fair way to test and judge the models.

Aim:

To design, build and test a model the effectiveness of crumple zones in a head-on collision.

Research question:

Turn the aim above into a question to research:

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Materials:

- Dynamics trolley
- Various recycled materials to construct a crumple zone, e.g. disposable plastic cups, egg cartons, polystyrene, cereal cartons, glue, scissors, stapler
- Ramp
- Collision object, e.g. a wall or a concrete block

Optional additional materials:

- Plastecine on the collision object (to help measure the impact of the trolley with and without the crumple zone)
- Light gates (to measure the speed of the trolley before the collision)
- Video camera with slow motion replay (or smartphone video app with slow motion replay)
- Egg (creating a seat and seatbelt for an egg passenger can extend the activity and make for a messy finale)

Method:

1. **Design:** Look at the available materials. Design a crumple zone using the materials to fit the front of your dynamics trolley. Draw and label your design here:

2. **Build:** Work in a small group and compare your designs. Agree on one design and use the materials to add a crumple zone to the front of your dynamics trolley.
3. **Test:** Place the trolley on a ramp (the ramp should be on enough of an angle to allow the trolley to roll freely). Place the collision object at the bottom of the ramp. If you are using a light gate to measure speed, it should be placed towards the bottom of the ramp before the collision object.
4. **Modify:** Based on your test results modify the design and build to improve the effectiveness of the crumple zone. Add any changes to the drawing of your model. Prepare the crumple zone for final safety testing.
5. **Plan:** Design your experiment before you carry it out to make sure it answers the research question as well as possible. Think about the following things.

(a) How will you quantitatively measure (with numbers) the dependent variable (i.e. the effectiveness of your crumple zone)? Possible measurements include:

- **i.** How much it has crumpled (3 = completely, 2 = partially, 1 = barely, or 0 = not at all)
- **ii.** The reduction of the amount of rebound of the trolley after the collision (compared to without the crumple zone attached)
- **iii.** The indentation in plastecine placed on the collision object where the trolley crashes

(b) How many times will you repeat the investigation in order to test for reliability of results?

(c) Which variables will you keep the same for the control (trolley crashing into the collision object without the crumple zone) and the independent variable (the trolley crashing into the collision object with the crumple zone)?

6. At the end of the investigation report back to the class on the following things.

(a) Your research question

(b) Your dependent variable

(c) The results of your investigation

(d) Whether or not you think you managed to answer your research question

(e) The difficulties you had and how you overcame them

(f) Improvements you would make or advice you could give to someone if this experiment was to be carried out again

Results:

1. Your dependent variable is: ____________________________________

2. Design a data table in the space below to collect your data for the dependent variable. Don't forget to include a calculation of the average of all the trials that you carry out for both the control and the experimental trials.

3. Graph your data to visually represent it. Label the axes.

4. Write a sentence or two to summarise your results.

Discussion:

1. Identify the possible injuries to the driver and passengers as a result of a head-on collision.

2. Based on your understanding of Newton's laws of motion explain how crumple zones reduce the risk of injury to the driver and passengers in a car after a head-on collision.

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3. After hearing about the investigations carried out by other members of your class, which design do you think could be the most effective at reducing injury to a driver and passengers after a head-on collision.

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4. List at least one change you could make to improve the effectiveness of your crumple zone. Give reasons for your answer.

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5. Describe how you imagine engineers might design and test crumple zones on real cars.

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Conclusion:

How effective was your model crumple zone at absorbing the energy of the collision and therefore possibly reducing injury to the people inside the car? Write a conclusion that responds to your aim and summarises your results.

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ACTIVITY 4
MOBILE PHONE USE

What to do:

Tick the statements that describe your mobile phone use. When you have finished, use the answer key to find out if you have addictive tendencies with your mobile phone use.

- ☐ **1.** I often think about my mobile phone when I am not using it.
- ☐ **2.** I often use my mobile phone for no particular reason.
- ☐ **3.** Arguments have arisen with others over my mobile phone use.
- ☐ **4.** I interrupt whatever I am doing when I am contacted on my mobile phone.
- ☐ **5.** I feel connected with others when I use my mobile phone.
- ☐ **6.** I lose track of time when I am using my mobile phone.
- ☐ **7.** The thought of being without my mobile phone makes me feel distressed.
- ☐ **8.** I want to reduce my mobile phone use but I have been unable to.

Analysis of results

If you ticked any one of the above statements, you could have mobile phone addiction! These eight statements were examples of different components of addiction matched to Brown's (1997) different types of behavioural addiction.

To identify which behaviour component(s) of addiction you have, you need to match the box(es) you ticked with the following behavioural addiction components.

Addiction behaviour component	Description
1. Salience – cognitive	This is when a particular activity becomes the most important activity and dominates what they think.
2. Salience – behavioural	This is when a particular activity becomes the most important activity and dominates what they do.
3. Conflict – interpersonal	This is when the activity causes conflicts with others.
4. Conflict – other activities	This is when the activity causes conflict with other activities.
5. Relief and/or euphoria	This is thought to be a way of coping with the activity by allowing it to provide positive feelings.
6. Loss of control and/or tolerance	This occurs when an increasing amount of time in a particular activity is required in order to feel satisfied.
7. Withdrawal	This is when unpleasant thoughts or feelings occur when an item or activity is removed or denied.

Walsh, White, Young (2008). Over-connected? A qualitative exploration of the relationship between Australian youth and their mobile phones. *Journal of Adolescence* Vol 31 77–92.

Possible consequences of mobile phone addiction

Read and discuss the following questions:

1. Was there anyone in the class that had a mobile phone and didn't tick any of the eight boxes? How many people didn't tick a box?

2. As a class, how many people had possible multiple mobile phone addiction components?

3. Which addiction components were the most common?

4. How widespread do you think mobile phone addiction is in the general public? Do you think your class results are indicative of mobile phone addiction in the general public? Why/Why not?

5. Have you ever seen someone using a mobile phone while driving? Examples of mobile phone use include texting, looking to see who has called and taking a call (either hand free or hand held).

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6. What might are some of the consequences of using a mobile phone while driving?

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7. Is it appropriate under any circumstances to use a mobile phone under while driving, e.g. at a red traffic light?

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8. Which mobile phone addiction component(s) do you think someone using a mobile phone while driving would display?

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9. Suggest different ways to make drivers think twice about using a mobile phone while driving.

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ACTIVITY 5
COMBUSTION OF METHANE (TEACHER DEMO)

Background:
This is a fun demonstration, but students must not crowd around the teacher during the demonstration. They should remain a safe distance away.

Materials:
- One large clean coffee tin (the larger commercial size rather than the size that is for general domestic use)
- Rubber or plastic hose from a Bunsen burner
- Tripod
- Gas outlet
- Matches

Before the demonstration:
1. Wash and clean a large coffee tin with a lid that seals tightly.
2. Make a small hole in the lid of the tin.
3. Make a second larger hole at the bottom large enough for the Bunsen burner hose to fit into.

During the demonstration::
1. Ensure the lid is secured tightly on the tin.

2. Sit the tin on a tripod.

3. Attach one end the Bunsen burner hose to the gas supply. Attach the other end of the hose to the second larger hole at the bottom of the tin. Turn on the gas for approximately one minute so that the entire tin is full of methane from the gas tap and the air is pushed out.

4. Turn off the gas supply and remove the hose from the bottom of the tin.

5. Place a lit match near the small hole in the lid of the tin so that a flame is produced from the gas escaping through the top.

6. The flame will need to burn for a few minutes so that some oxygen can enter the hole at the bottom as the methane is burned. The flame will sink low into the can. While you are observing the flame, predict what is going to happen during the remainder of the experiment.

7. After a few minutes, once the ratio of oxygen to methane is optimum, the methane will combust and make a loud 'pop' sound as the lid flies up. Students do not usually expect this as they think the experiment has not worked when the flame dies down.

8. When the can has cooled examine it for the presence of water, which should be visible inside the can as tiny droplets.

9. Repeat Steps 1–8 if necessary! The same tin may be used again, as long as the lid of the tin still fits tightly.

Discussion:

1. What type of reaction was this?

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2. Suggest what the reactants for the reaction that took place might be. Which chemicals were used up during the reaction?

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3. Suggest what the products for the reaction that took place might be. Which chemicals were produced during the reaction?

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4. Suggest a word equation for the demonstration. Do research as necessary to find a word equation.

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5. What was the energy from the combustion reaction converted or transformed into? Write an energy flow chart for the combustion of methane.

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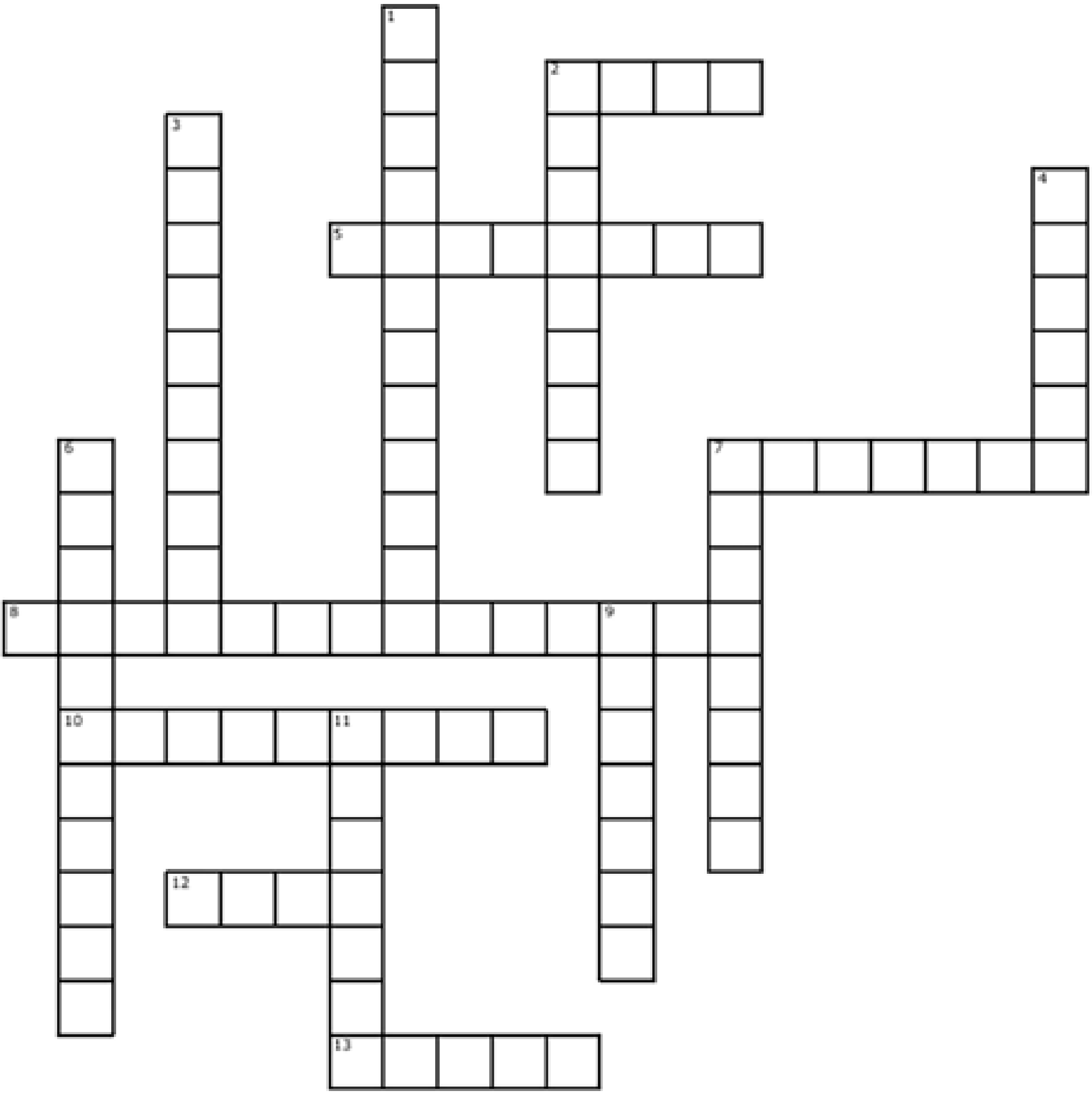
SECTION 1
CROSSWORD



Across

2. This goes into a car to power it.

5. Another way of describing speed.

7. A form of electronic socialising that is illegal to do while driving.

8. Energy changed from one type to another.

10. Driver distraction can cause this.

12. The 'm' in m = fa.

13. The distance covered in a set time.

Down

1. Reduces the slack in a seatbelt.

2. This force is needed to help you brake.

3. The type of reaction taking place in a car engine.

4. This inflates on impact.

6. A type of fuel used in cars that comes from fossil fuels.

7. Energy moved from one place to the next.

9. Newton's first Law of Motion.

11. Smart cars of the future will use these to detect if a driver is fatigued.

SECTION 2
CREATING A DRIVING DISTRACTION QUIZ

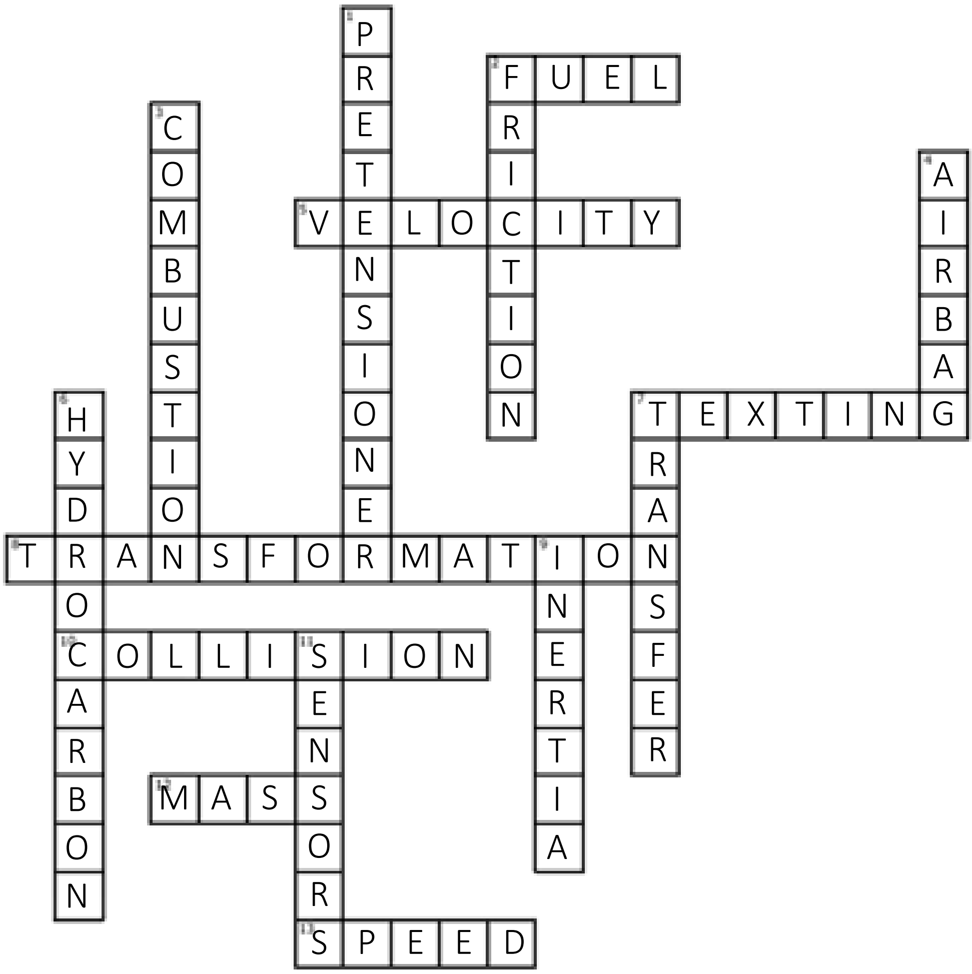
(a) Ask each student to call out a word related to the activities you have carried out and what you have learnt during this unit on road safety. Record these words on the board.

(b) Each student must pick six words from the board and write a definition for each word.

(c) Students then pick four more words from the board and write a paragraph describing them. They should highlight their chosen words in the paragraph.

(d) Students create a concept map showing all they have learnt about driving distraction, using at least half the words from the board. They should show links between words and write along lines connecting words to show how the terms are related.

SECTION 1
CROSSWORD – ANSWERS



SECTION 3
INDIVIDUAL UNIT REVIEW

What about you?	Drawing
Describe your favourite activity during this unit of study.	Create an image that summarises this unit of work and how to be a safe road user.
Learning summary	**Your philosophy**
Write five dotpoints of things you learned in this unit of study.	How has this unit of work changed your thinking about driving, road safety and cars?
More questions?	**Metacognition**
Write three questions that you still have about driver distraction, road safety, the physics of driving or anything else related to this unit of study.	Which activities did you find helped you learn the best? Why?

The National Roads & Motorists' Association

www.mynrma.com.au/youngdrivers

REFRACTION MEDIA

www.refractionmedia.com.au