# Everyone is a road user – science activities

## SECTION 1: What are the "wicked problems" (problems and opportunities) for local road users wanting safer journeys?

**Bringing in ideas**
These activities provide opportunities for students to bring in ideas about the challenges and opportunities of keeping safe on the road network.

When young people share the road they do so as pedestrians, cyclists and passengers. They use the road for transit – to travel from A to B; and as a space for socialisation – for making connections, for conversation with others, for fostering friendships. The road allows them access to goods and services – to shops, supermarkets, schools, churches, sports facilities, takeaway bars and hospitals. Young people use the roads for independence, for belonging, for ownership and for community.

For example, read the following presentation to see how the mode of transport we use can affect children's imaginings and our feelings of belonging and happiness:
Is Walking Transport? Perceptions and policies of walking. Daniel Sauter, Urban Mobility Research, Switzerland www.polisnetwork.eu/uploads/Modules/PublicDocuments/sauter_is-walking-transport.pdf

The activities in this section help students bring in ideas and information about safer journeys, road users and roads. You'll find them across the English, mathematics and science resources:

- **Activity 1.1. Wonder about a local road in the real world and in poetry [English – Making and Creating Meaning]**
- **Activity 1.2. Describe the use of visual text to tell stories about the roads and road users. [English – Making and Creating Meaning – Visual Texts]**
- **Activity 1.3. Calculate the area that parked cars cover. [Maths and Statistics – Measurement and Shape]**
- **Activity 1.4. What do road users ask about a local road? [Maths and Statistics – Statistics – Statistical Investigation]**
- **Activity 1.5. How do road users move? [Science – Physical World | Nature of Science]**
- **Activity 1.6: What do road users see? [Science – Living World]**

**Learning intention: Describe** the challenges (problems and opportunities) that a local road presents for local road users wanting safer journeys.

**Differentiated self-assessment rubric.** *Insert your own marking guide on the left-hand side.*

| | |
|---|---|
| | My description identifies challenges (problems and opportunities) for local road users wanting safer journeys. |

| | |
|---|---|
| | **AND** explains why these challenges (problems and opportunities) cause issues for local road users wanting safer journeys. |
| | **AND** makes a generalisation about the importance of these challenges (problems and opportunities) for local road users wanting safer journeys. |

## Activity 1.5. How do road users move? [Science – Physical World | Nature of Science]

What makes road users move? How do they slow down and stop? How do they speed up? How do forces come into this?

What technical language do I need to describe how road users move on local roads?

Note: In this resource the term **speed** is used rather than **velocity**. Speed describes how fast an object is moving. Velocity describes how fast and in what direction the object is moving. It may be appropriate to introduce the distinction between the two terms as the students' understanding deepens across the activities.

Our everyday life experiences and understandings can get in the way when we try to understand a scientific view of forces. Even students who appear to understand the science world view on forces may hold deeply seated misconceptions formed from their everyday life experiences in a world where friction means that most objects we push or pull do not keep moving at constant speed when we let go but rather slow down and stop. (Refer to: Tytler, Russell, Darby, Linda and Peterson, Suzanne (2011) Movement and force, in Skamp, Keith (ed), *Teaching Primary Science Constructively*, pp. 99–142, Cengage Learning Australia, South Melbourne, Vic.)

**Some common student misconceptions about forces**

| What students will say when experimenting with forces in a science class | Common student misconception hidden within this statement | What a scientist will say |
|---|---|---|
| Force is a push or a pull. | Force is caused by living things – people apply forces.<br><br>Force is an internal property of a moving object. For example, the person pushing a toy car across the floor transfers the push force onto the moving car. | Forces do not always result from direct contact with a living thing. For example, gravity, friction and jet propulsion are forces.<br><br>A force is an effect on an object. If you see a change in motion, you should look for something outside of the object that is causing it to speed up, slow down or change direction. |
| Forces cause motion. For example, forces cause the toy car to move. | The initial force is carried by the toy car but leaks out or breaks down in some way as the car slows.<br><br>When the car stops, there is no motion so no forces are acting. | The toy car experiences a gravitation force down and a reaction force up from the ground and a frictional force that acts against the motion and slows the toy car down. |
| The object is moving at constant speed | The faster the speed, the greater the force acting. | An object can be moving very fast with no unbalanced force on it; for example, a rocket travelling at |

| | | |
|---|---|---|
| | Speed is proportional to force on an object | constant speed.<br><br>Acceleration (change in speed) is proportional to the force on an object.) |
| The object is moving at constant speed if the object is not speeding up, slowing down or changing direction. | Constant speed/motion requires a constant force. | Constant motion results when no unbalanced force acts on the object.<br><br>Speeding up or slowing down or deflection results when a net force (unbalanced force) acts on the object. |
| If an object is not moving (at rest), there is no force acting on it (or no unbalanced force acting on it). | Objects slow down naturally even without force.<br><br>If forces are in balance, an object will come to rest. | Objects slow down because of friction forces (air resistance or drag) acting against the motion.<br><br>If forces are in balance, an object will continue in its state of motion – either stopped or moving at a constant speed. |

Source: Adapted from Tytler, Darby and Peterson (2011)

### 1.5.1. Pushes and pulls

Give each group a selection of images of different toys cut from old toy catalogues or advertising flyers, or sourced online.

The following sites are useful when looking for copyright-friendly images online.

- Search Creative Commons: http://search.creativecommons.org
- Shahi Visual Dictionary: http://blachan.com/shahi
- Pics4Learning: www.pics4learning.com/index.php

Ask students to work in groups to:

- Sort the toys into two groups – "toys that move" and "toys that don't".
- Sort the "toys that move" group into two sub-groups – "push toys" and "pull toys".

Next go for a slow pedagogy walk in the school grounds looking for things that move. Talk about the "pushes" and "pulls" that might cause these changes. Log and/or photograph any evidence you observe on your walk.

Introduce the idea that pushes and pulls are forces and that forces change things.

Give students playdough and ask them to find out what happens when they pull or push on the playdough. Record their observations – use a digital camera to record the before and after outcomes of a pull and a push.

**Record of observations**

| Playdough before | Push/pull force | Playdough after |
|---|---|---|
| *Insert image.* | *Describe what you did to the playdough to change its shape of movement, using the language of pull and push.* | *Insert image.* |
| | | |
| | | |

Push a heavy container (box of books) across the floor. Tie some rope around the container and pull it across the floor. Increase the heaviness of the container by getting someone to sit on top. Attempt to pull and push the box across the floor. What do you notice? Increase the heaviness of the container until the students can no longer make it move. Encourage students to think about all the forces acting on the object when it is stopped and when it is changing its movement.

Draw a picture using arrows to show the direction of the pull force or push force acting on the box. Note the arrow heads should point in the direction of the movement of the box.

**Discussion prompts**
[think-pair-share, or small group or whole class discussion only]

Think about the forces acting on the playdough or box of books.

What changes in movement did you notice? Why do you think it is like that? What does it make you wonder?

If you are a citizen using the local roads as a cyclist, pedestrian or passenger, what ideas about force are worth sharing with other road users?

**1.5.2. What do forces do?**

Introduce the term “force” and the idea that “forces make things happen” and that when things happen a force must be acting.

Establish three key ideas.

- Force is a push or a pull.
- Forces change an object’s motion (speed up, slow down, direction) and/or its shape.
- If an object changes its motion, direction or shape, a force must be acting on it.

Co-construct a class definition of "force" and display this for all students to see: "We think force is [make a claim] because [state a reason] because [provide evidence to back up your claim]."

Forces change things.

You can tell a force is in action when an object (or road user) is:

- changing its state of movement,
- changing its direction, or
- changing its shape.

Use playdough/modelling clay to clarify the following terms – change, movement, starting to move, speeding up, slowing down, stopping, changing direction, shape, pushing and pulling. Emphasise that when something is changing, a force must be acting.

Note: When an object is not moving or when it is moving at constant speed, there are no unbalanced forces acting on the object. See the table on common student misconceptions above.

### 1.5.3. Unbalanced force detectives

Arrange for students to observe a local road. (Alternatively watch a webcam or previously videoed activity on a local road.) Note: Students should observe the road from a position that does not place them at risk or cause a distraction for other road users.

Tell students they are to act as "unbalanced force detectives" and must study the road users on the local road for any change in movement (speed and direction) or change in shape. They will keep a record of their observation in a Movement Log. Challenge them to record whether each change in movement they observed was a result of a "push" or a "pull".

Explain to students that before they can become "unbalanced force detectives", they need specialised training in categorising "movement" and in distinguishing between pushes and pulls.

Help them to classify the road user **"movements"** into four categories:

- **Speeding up** – This happens when road users have been stationary but are now starting to move **and** when objects are already moving but start speeding up.
- **Slowing down** – This happens when road users are slowing down **and** when objects are stopping moving.
- **Changing direction** – This happens when road users change the direction of their travel path – moving to the right or left or upwards or downwards.
- **Changing shape** – This happens when the road user or the road user's mode of transport changes shape

Use a simple 3-D model of road users (or a road user's mode of transport) to represent these four different "movements" for students.

If students find it hard to discriminate between a "push" and a "pull", demonstrate the difference on the school playground equipment.

Refer to: BBC Schools – Pushes and pulls (interactive):
www.bbc.co.uk/schools/scienceclips/ages/5_6/pushes_pulls.shtml

Make connections with what students already know about pushes and pulls, changing movement and changing shape. Discuss previous learning experiences with pushes and pulls in everyday life.

Be alert to the learner perspectives of forces that students will bring to the classroom. Think carefully about the strategies you will adopt to confront their science misconceptions. Refer to Physics Misconceptions: www.newyorkscienceteacher.com/sci/pages/miscon/phy.php and Tytler, Russell, Darby, Linda and Peterson, Suzanne (2011) Movement and force, in Skamp, Keith (eds), *Teaching Primary Science Constructively*, pp. 99–142, Cengage Learning Australia, South Melbourne, Vic.

Form groups of approximately two to three students.

Ask groups to:

- Choose a road user – it can be a serious choice (pedestrian, passenger, driver, cyclist, or user of a mobility scooter, wheelchair, roller blades, skateboard, scooter etc.) or a more whimsical choice (flying bike http://youtu.be/TtylFugOT_4, Orbitwheels http://youtu.be/AmNvn1e3k4Y, Loopwheel Bikes http://youtu.be/PPKY1pFyqu8 or the Solowheel http://youtu.be/WOOoFEKiK8A).
- Build a 3-D model of this road user, using recycled materials or modelling clay.
- Brainstorm movement challenges (problems and opportunities) these road users might face when using the road. Use text, quotes, drawings and/or images to express these ideas.
- Use their model to demonstrate these movement challenges (problems and opportunities) to other groups and/or the class.
- Observe a road user on a local road and record any changes in movement in the Movement Log below.

**My movement log**

| **Road user:** | **starting to move and speeding up** | **slowing down and stopping** | **changing direction** | **changing shape** |
|---|---|---|---|---|
| **What I saw** | | | | |
| **Why I think the road user movement changed (speed, direction or shape)**<br><br>*Highlight the force used (push or pull) and explain the effect of the push or pull* | **push or pull**<br><br>**effect:** *(e.g. made the scooter speed up)* | **push or pull**<br><br>**effect:** | **push or pull**<br><br>**effect:** | **push or pull**<br><br>**effect:** |
| **What it makes** | | | | |

| | | | | |
|---|---|---|---|---|
| **me wonder about movement** | | | | |

Ask students to:

- **Describe** the movement changes they observed to other students orally, through annotated diagrams (comic strip – see below) or through written language. Build student vocabulary to include terms like change, movement, starting to move, speeding up, slowing down, stopping, changing direction, shape, pushing and pulling.

**List** the movement challenges (problems and opportunities) that the road users face, recording each one on a separate blank hexagon. Include hexagons with the vocabulary terms listed above. They can do this electronically using the HookED SOLO Hexagon Generator: http://pamhook.com/solo-apps/hexagon-generator or manually using the HookED Hexagon Template: http://pamhook.com/wiki/SOLO_Hexagons

- **Make connections** between individual hexagons by looking for reasons to make straight-edge connections (tessellating the hexagons). Students should explain orally or by annotation why these ideas are related.
- **Explore** the node where three hexagons share a corner (or simply look at a cluster of hexagons) and make a generalisation about the nature of the connected ideas.
- **Step back** from the resulting tessellation (clusters of hexagons) and make a group/class claim: "Overall we think the big movement challenge for road users is … because [give a reason] … because [give evidence]."

Students may review their thinking after watching the following video clips:

- BBC Schools – Pushes and pulls (interactive): www.bbc.co.uk/schools/scienceclips/ages/5_6/pushes_pulls.shtml
- BBC Schools – Forces and movement (interactive): www.bbc.co.uk/schools/scienceclips/ages/6_7/forces_movement.shtml
- BBC Schools – Friction (interactive): www.bbc.co.uk/schools/scienceclips/ages/8_9/friction.shtml
- What is a force?: http://youtu.be/GmlMV7bA0TM
- What forces are acting on you?: http://youtu.be/aJc4DEkSq4I
- ForceMan: http://teachertube.com/viewVideo.php?video_id=540&title=ForceMan_

**Discussion prompts**
[think-pair-share, or small group or whole class discussion only]

Look at the clusters (tessellations) of hexagons showing movement problems and opportunities for road users on local roads.

What do you see? Why do you think it is like that? What does it make you wonder?

If you are a citizen using the local roads as a cyclist, pedestrian or passenger, what is worth sharing with other road users?

**Extension:** Read the section "Stopping and braking" in *The Official New Zealand Code for Cyclists* pp. 12 and 13: www.nzta.govt.nz/resources/roadcode/cyclist-code/index.html

Ask students to:

Rewrite the information report on stopping and braking, using the language of forces. Your writing should use terms like pull force, push force, change speed, slow down, speed up, stationary, friction force etc.

Include drawings and digital images in your report where necessary.

Publish your report on a class blog or wiki so that it can be read and commented on by members of the local cycling community.

Read several of the following articles about forces used when cycling.

- Science of cycling: www.exploratorium.edu/cycling/index.html
- Cycling aerodynamics: www.sciencelearn.org.nz/Science-Stories/Cycling-Aerodynamics
- Bicycle brake: http://en.wikipedia.org/wiki/Bicycle_brake

Use your science learning from this activity to arrange a series of static images in sequence to tell the story of the forces used to change the speed of a bike when slowing down.

Your images should show the forces acting on a bike at the following points in the journey.

| Stationary | Speeding up | Constant speed | Slowing down | Stationary |
|---|---|---|---|---|
| | | | | |

Use the static image sequence to make a short, five-frame comic strip to communicate an important message about the forces used when slowing down a bicycle to road users in their local community.

Note: You can use Comic Life http://plasq.com/ or any of these free online comic creators:

ReadWriteThink Comic Creator: www.readwritethink.org/files/resources/interactives/comic
Comic Master: www.comicmaster.org.uk
Pixton: www.pixton.com/uk
PBS Comic Creator: http://pbskids.org/arthur/games/comiccreator
Scholastic Graphix Comic Builder: www.scholastic.com/graphix/createcomic.htm
Artisan Cam Super Action Comic Maker:
www.artisancam.org.uk/flashapps/superactioncomicmaker/comicmaker.php

Chogger Comic Creator: http://chogger.com/creator
ToonDoo: www.toondoo.com
Strip Generator: http://stripgenerator.com/strip/create

## Activity 1.6: What do road users see? [Science – Living World]

Visibility matters. What road users can see and how road users are seen influence safer journeys. Crashes occur when drivers do not see other drivers, cyclists or pedestrians. Many of them happen at dusk, dawn or night, in poor weather conditions, when traffic or other objects block a driver's view of the road, during sun strike, or because other road users' size and shape keep them hidden from view. Pedestrians often claim they did not see or hear the car that struck them, and drivers claim they did not see the pedestrian they struck.

Situational awareness matters. Young people's sense of hearing and vision are not fully developed. Primary and intermediate students do not see as far along the road and do not have as broad a viewpoint as adults. They have poor peripheral vision and, because they are usually shorter than adults, their eye level is lower and they cannot see as much. They find it hard to locate the direction of sounds and may not hear some sounds at all. They are also harder to see on the road. Because they are shorter, they are also more difficult to see and more easily obscured by parked cars, pavement signs etc.

In addition, children may see and hear vehicles on the road but they cannot judge speed or distance properly until they are about 9 or 10 years old. They may choose not to cross when it is safe and then promptly attempt to cross when it is unsafe.

Understanding how our senses work is important if we want to help make child pedestrians and cyclists safer on the roads.

### 1.6.1. Senses and living things

All living things use their senses to detect other things around them. We have five senses – sight, hearing, touch, taste and smell.

Ask students to find an open space in the playground. Sit quietly in this space and list all the different stimuli they can detect with their senses.

**Record of stimuli from the playground**

| Sense used to detect stimuli | Stimuli from the playground |
|---|---|
| Smell | |
| Sight | |
| Hearing | |
| Touch | |
| Taste | |

Repeat the experience when standing in a safe place on a pavement (or travelling as a passenger in a car). Detect the stimuli provided by the road.

**Record of stimuli from the road**

| Sense used to detect stimuli | Stimuli from the road |
|---|---|
| Smell | |
| Sight | |

| | |
|---|---|
| Hearing | |
| Touch | |
| Taste | |

Repeat the experience when cycling in a safe off-road location. Detect the stimuli provided by the off-road location.

**Record of stimuli from the off-road location**

| Sense used to detect stimuli | Stimuli from the off-road location |
|---|---|
| Smell | |
| Sight | |
| Hearing | |
| Touch | |
| Taste | |

If students can access a wearable camera or a camera that can be mounted on their bike helmet or cycle frame, they can record the sights and sounds of the journey, using the camera and microphone as sense detectors. For example, suitable cameras include: GoPro Hero cameras http://gopro.com

Ask students to determine what stimuli the camera and microphone detected that the human eyes and ears did not and vice versa.

**Record of stimuli from road detected by technology**

| Technology used to detect stimuli | Stimuli from the road |
|---|---|
| Camera (for sight) | |
| Microphone (for hearing) | |

**Discussion prompts**
[think-pair-share, or small group or whole class discussion only]

Think about the stimuli you detected in different places and while using the roads in different ways. What did you notice? What was similar/different? How could you make pedestrians more visible?

What did your senses detect? Why do you think it is like that? What does it make you wonder?

If you are a citizen using the local roads as a cyclist, pedestrian or passenger, what is worth communicating about using our senses so that young road users have safer journeys on local roads?

### 1.6.2. What is light?

Our eyes are light detectors. Ask students to brainstorm all the objects they can think of that produce light that we detect with our eyes. List their sources of light in text or drawings.

[lightbulbs, headlights, rear lights, torches, candles, fires, computer screens, mobile phones, television, sun]

Help students understand that some objects appear to be light sources when they are not. Take care to address student misconceptions about objects that reflect light produced by light sources. Make time for students to test objects such as mirrors, shiny tin foil, shiny metal, reflective safety vests and brightly coloured pens in the absence of light, using their eyes as light detectors.

Introduce the key understandings that:

- Our eyes are light detectors.
- We need light to see objects.
- Darkness is the absence of light.
- Without light (in the dark) we cannot see.

Think-pair-share: List places where it is dark. Explain why these places are dark. Is it ever possible to see something in the dark?

Many students who live in cities have never experienced total darkness. Explain that without light we cannot see anything. In the dark we have to use our other senses to understand where we are and what is going on around us.

Explore classroom caves (blankets spread over desks) and other gloomy locations with a digital light meter or data logger. For example, ask students to suggest the darkest and lightest classroom spaces in the school. Use the light meters to measure the light level in each space. Note: You may be able to borrow a digital light meter from the science department at your local high school.

Arrange a “Take your torch for a walk” event at school. Look for light emitters and light reflectors in the school grounds. Finish the walk by exploring a space filled with hanging reflective and transparent surfaces - mirrors and prisms and lenses.

Note: If we can see objects in the darkness when we go for a walk at night, it is because it is not totally dark – there is light given off from the stars and/or the street lights. If we hide under the bed, under a blanket or in a cupboard and we can still see, then there is still light getting into our eyes.

**Discussion prompts**
[think-pair-share, or small group or whole class discussion only]

Think about the senses that road users use to tell them what is going on – to tell them about the problems and opportunities for road users on local roads. Ask students to work in pairs to list things that pedestrians, cyclists and passengers do that can limit their ability to sense what is going on around them. What do road users do that limits their sense of hearing? What do road users do that limits their sense of smell? What do road users do that limits their sense of touch? What do road users do that limits their sense of taste? What do road users do that limits their sense of sight? Explain why limiting our senses can be dangerous when we are using the road.

What are road users’ senses used for? Why do you think it is like that? What does it make you wonder?

If you are a citizen using the local roads as a cyclist, pedestrian or passenger, what is worth sharing about using your senses so that there can be safer journeys on local roads?

**Extension:** Create a series of podcast "wonderings" about the five senses we use to keep safe on the roads and the things we do that limit the usefulness of these senses.

You may wish to focus on one category of young road users: passengers, pedestrians or cyclists and/or one of the senses they need to keep safe on a local road.

In each podcast, suggest a way to enhance or improve road users' senses. For example, think about making road users more visible to other road users, using reflective lighting, yellow headlights and red rear-facing lights. Read about the reflective lighting gear and lighting for cycles and cyclists. Refer to: *The Official New Zealand Code for Cyclists* pp. 74–76:
www.nzta.govt.nz/resources/roadcode/cyclist-code/index.html

Write a script for each broadcast that clearly identifies the sense, how it can be used to keep road users safe, how it can be limited and put road users at risk, and how it can be enhanced by road users' behaviour, clothing and/or equipment.

Use GarageBand or Audacity to capture and then broadcast what you see, think and wonder about keeping road users safe on a local road. Make your podcast available on your class blog or wiki.

You may need to download one of these sound recording and editing tools on to your computer or mobile device if you or your school do not have access to a suitable sound recorder:
Apple: Download GarageBand (for Mac): www.apple.com/mac/garageband/
Audacity: Download Audacity (for Windows): http://audacity.sourceforge.net/

YouTube provides numerous tutorials for beginners to experts on each of these programs, such as:
YouTube: GarageBand Tutorial – Creating a song: www.youtube.com/watch?v=DfxZxY73E30
YouTube: Audacity download and tutorial: www.youtube.com/watch?v=lrPGMjZORCM
When you have finished, share your podcast with others and respond to feedback by refining your piece.

For more information on how to create podcasts with students, refer to:

Podcasting in and out of the classroom: http://edtechteacher.org/tools/multimedia/podcasting
Creating podcasts with your students: www.readingrockets.org/article/25032
Podcasts: The nuts and bolts of creating podcasts: www.readwritethink.org/classroom-resources/printouts/podcasts-nuts-bolts-creating-30311.html
Podcasting: www.teachingideas.co.uk/ict/podcasting.htm
Sound education:
www.powertolearn.com/articles/teaching_with_technology/sound_education.shtml

## SECTION 2: Explain the "wicked problems" (problems and opportunities) for local road users wanting safer journeys.

**Relating ideas**
These activities provide opportunities for students to connect ideas about the problems and opportunities for citizens/road users wanting safer journeys on local roads.

Local roads provide both opportunities and problems for young people who use them as cyclists, pedestrians and passengers. After identifying some of the challenges (problems and opportunities) in section 1, students are ready to make connections, to compare, to classify and to explain in order to build a deeper appreciation of the complexities involved in safer journeys for road users.

The activities in this section help students connect ideas and information about safer journeys, road users and roads. You'll find them across the English, mathematics and science resources:

- **Activity 2.1. Compare road users: using local roads and as represented in poetry. [English – Making and Creating Meaning]**
- **Activity 2.2. Compare road users: using visual text. [English – Making and Creating Meaning]**
- **Activity 2.3. Compare the area covered by a parked vehicle with the total area needed to park. [Maths and Statistics – Measurement and Shape]**
- **Activity 2.4. Connect the questions that road users ask about a local road. [Maths and Statistics – Statistics]**
- Activity 2.5: What types of forces do road users experience? [Science – Physical World]
- Activity 2.6: Explain how road users see other road users. [Science – Living World]

**Learning intention: Explain** the challenges (problems and opportunities) that a local road presents to road users.

**Differentiated self-assessment rubric.** *Insert your own marking guide on the left-hand side.*

| | |
|---|---|
| | My explanation gives reasons for the challenges (problems and/or opportunities) for road users on a local road. |
| | **AND** explains why these reasons are relevant for local road users. |
| | **AND** makes a generalisation about the importance of these reasons for road users on local roads. |

## Activity 2.5: What types of forces do road users experience? [Science – Physical world]

Activity 1.5 established that:

- Force is a push or a pull.
- Forces change an object's motion (including direction) and/or its shape.
- Objects cannot change motion, direction or shape unless a force is acting on them.

If we think of a force as something that acts from the outside to push or pull an object, we can see how forces can be used to explain the different movements of road users. For example, a student pushing on the ground exerts a force on a scooter.

Set up a circuit of force-related learning experiences around the room and outside to build language and understanding of the way the movement of road users can be represented.

Ask students to work in pairs to complete each activity. Encourage the use of scientific vocabulary throughout.

The "Forces response sheet" below describes a number of activity stations you could set up to explore how push and pull forces can change the movement (speed, direction and shape) of an object.

Observe the push and pull forces in action at each station.

Categorise (classify) the force/s involved in each station as one or both of the following:

- contact forces (e.g. push with hand, pull with rope, support from the ground, friction, air resistance, water resistance, wind force), and/ or
- non-contact (field) forces (magnetic, gravitational, electrical field forces).

Depending on the depth of understanding of the students, you may wish to introduce the terms:

- friction force (contact force), and
- weight force (gravity).

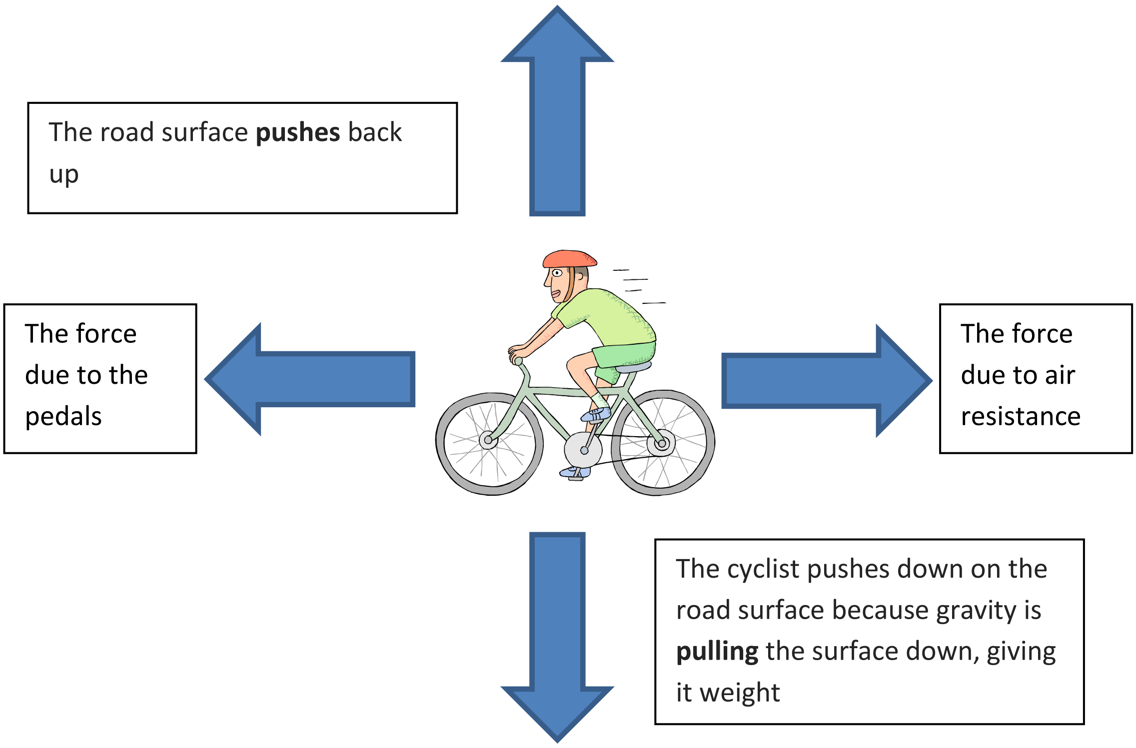
Note: Mass and weight are different. The mass of an object is how much matter it contains. The weight of an object is the force caused by gravity pulling down on the mass.

**Misconception alert:** It is a common misconception that stationary objects have no net force acting on them. It is hard for students to appreciate balanced and unbalanced forces. A stationary object still has the force of gravity acting on it and furthermore this force is balanced by the active push force of the surface that the object is sitting on.

Likewise many people (students and teachers) fail to understand that if an object is moving at constant velocity (neither speeding up nor slowing down); the forces acting on it must be balanced. These people mistakenly believe that the object moves at constant velocity because there is a push force acting on the object that is greater than any friction force (drag or air resistance) slowing it down. From a scientist's perspective, when the object is moving at constant speed – that is, the push force is balanced by any friction force – there is no nett force acting on the object. Any object sliding on “frictionless surfaces” can be used to show that once the initial push force is applied to an object in a frictionless environment, it will just keep moving at constant speed. We find this hard to understand because our experience of push forces usually happens in high friction environments – when we stop applying the push force, the object stops moving; we do not have many experiences in which, when we stop applying a force, the object continues at constant speed.

Sharing examples of different objects moving at constant velocity and stationary can help students start to appreciate the effects of balanced forces. Also useful are simple diagrams using arrows to show the weight force due to gravity pulling the object towards the centre of the Earth and the surface pushing back, as in the diagram below.

**Forces acting on a cyclist**




When a cyclist is travelling at **constant speed** (neither speeding up nor slowing down), and is not changing shape or direction, the **forces on the cyclist are equal and balanced**.

Unbalanced forces change an object’s speed, direction and shape. If you see an object speeding up or slowing down, changing direction or changing shape, an unbalanced force must be acting.

Ask students to:

- Describe how each unbalanced force changes an object’s motion or changes its shape.
- Record their observations on a “Forces response sheet” as shown below.

**Forces response sheet**

| **Station** | **What changes?** ***speed / direction /*** | **Push or pull force?** | **Contact or non-contact force?** | **What happens if you increase** |
|---|---|---|---|---|

| | *shape* | | | **the push/pull force on the object?** |
|---|---|---|---|---|
| Squeeze (two pushes) a can or the juice from a lemon. | | | | |
| Hit a nail with a hammer. | | | | |
| Pull a heavy weight using a rope. | | | | |
| Push a bath-toy duck under the water. | | | | |
| Drop a rugby ball. | | | | |
| Glide a paper aeroplane. | | | | |
| Hold a magnet near an iron nail. | | | | |
| Put a brick on a table. | | | | |
| Rub a plastic ruler on a piece of wool then hold the ruler next to small, torn pieces of paper. | | | | |
| Stretch a rubber band and use it to fire a small wad of paper. | | | | |
| Push or pull an upended table across the floor. | | | | |
| Pull a heavy object above the surface using a pulley and a rope. | | | | |
| Turn the driver of a gear chain. | | | | |
| Use brakes to slow down a bicycle. | | | | |
| Blow a table tennis ball across a table with a small fan. | | | | |
| Let a small toy vehicle roll down a slope. | | | | |
| Push a small boat across a water trough. | | | | |
| Ride a bike with a | | | | |

| | | | | |
|---|---|---|---|---|
| gear chain. | | | | |

Discuss the forces at work at each station, using appropriate vocabulary.

Review the class definition of forces in Activity 1.5. Is there anything we should add, delete, re-phrase or change? For example, students may wish to add the idea that the greater the push or pull force, the bigger the effect. Continue to revisit this definition as students gain a deeper understanding of the movement of road users.

**Discussion prompts**
[think-pair-share, or small group or whole class discussion only]

Think about the push and pull forces affecting local road users.

What do you see? Why do you think it is like that? What does it make you wonder?

If you are a citizen using the local roads as a cyclist, pedestrian or passenger, what is worth sharing about push and pull forces on local road users?

**Extension:** Throw a tennis ball up in the air. Watch as the tennis ball changes speed, stops, changes direction and then changes speed (speeds up) as it falls to the ground. Imagine the ball at different stages of its flight. What is changing? What push/pull forces are operating?

Make links to the effect of forces on the movements of road users on a local road.

Alternatively, you may choose to video a vertically thrown tennis ball in flight. Examine any change in speed or direction, using video analysis tracking software such as Video Physics for iPad, iPhone and iPod touch: www.vernier.com/products/software/video-physics

**Results of thought experiment with tennis ball**

| **Action of tennis ball** | **What changes?** ***speed \| direction \| shape*** *[If anything is changing, a force must be acting]* | **Push or pull force?** | **Contact or non-contact force?** | **What happens if you increase the push/pull force on the object?** |
|---|---|---|---|---|
| Imagine a tennis ball held stationary in the palm of your hand. | *No change in speed, direction or shape.* | *Pull force due to gravity is balanced by the push force of your hand* | *Gravity (non - contact force)* *Push force of hand (contact force)* | |
| Imagine throwing the tennis ball vertically in the air. | | | | |

| | | | | |
|---|---|---|---|---|
| Imagine a tennis ball at its highest point after it has been thrown vertically. | | | | |
| Imagine a tennis ball as it starts to fall back to the ground. | | | | |

Repeat the thought experiment with a heavier object (e.g. tennis ball filled with water). Ask students to predict what they will have to do to achieve the same flight path with a heavier object. (A greater push force is required if it is to have the same effect.)

**Results of thought experiment with heavier object**

| **Action of tennis ball** | **What changes?** ***speed \| direction \| shape*** *[If anything is changing a force must be acting]* | **Push or pull force?** | **Contact or non-contact force?** | **What happens if you increase the push/pull force on the object?** |
|---|---|---|---|---|
| Imagine a tennis ball filled with water (to make it heavier) held stationary in the palm of your hand. | *No change in speed, direction or shape.* | *Pull force due to gravity is balanced by the push force of your hand* | *Gravity (non - contact force)* *Push force of hand (contact force)* | |
| Imagine throwing the tennis ball filled with water (to make it heavier) vertically in the air. | | | | |
| Imagine a tennis ball filled with water (to make it heavier) at its highest point after it has been thrown vertically. | | | | |
| Imagine a tennis ball filled with water (to make it heavier) as it starts to fall back to the ground. | | | | |

## Activity 2.6: Explain how road users see other road users. [Science – Living World]

### 2.6.1. How do we see?

Most living things are sensitive to light – but they respond to light in different ways.

Some living things, like plants, grow towards or away from the light. In other living things like mammals, light is used to make images of the outside world.

Mammalian eyes are great light detectors. If you close your eyelids, no light strikes the eye, so no image will form. Open your eyes again and a picture forms. Try it out: picture – no picture – picture – no picture. Not being seen by a mammalian light detector (the eye of another road user) is a risk factor for any road user. Cyclists and pedestrians are especially vulnerable because they are less visible than a car or truck. So if you need to increase your visibility, it is worth finding out how mammalian eyes work.

Refer to: BBC Science – Nervous System – Sight:
www.bbc.co.uk/science/humanbody/body/factfiles/sight/sight_animation.shtml

Light travels into the eyes of mammals through a little hole that lets the light in (pupil). The light stimulates receptors on the surface of the retina at the back of the eye, causing nerve impulses to travel to the nerve cells in the brain. The nerve impulses are interpreted in the brain and changed into images of the outside world.

Key understanding:

- We see because light travels into our eyes and forms images.

Ask students to draw a picture to explain why road users cannot see objects on the road when there is no light but can see objects when there is light.

Te Kete Ipurangi student exemplars
How do we see? (L1): www.tki.org.nz/r/assessment/exemplars/sci/physical/pw_1a_e.php
How do we see? (L2): www.tki.org.nz/r/assessment/exemplars/sci/physical/pw_2b_e.php
How do we see? (L3): www.tki.org.nz/r/assessment/exemplars/sci/physical/pw_3c_e.php
Colourful messages (L5): www.tki.org.nz/r/assessment/exemplars/sci/physical/pw_5b_e.php

**Discussion prompts**
[think-pair-share, or small group or whole class discussion only]

Look at the drawings that explain why road users can see objects on the road when there is light.

What do you notice? Why do you think it is like that? What does it make you wonder?

If you are a citizen using the local roads as a cyclist, pedestrian or passenger, what is worth sharing about how road users can see objects on local roads?

## 2.6.2. Using your eyes to look at someone else's eyes

Ask students to:

- **Look** at one of your own eyes in a magnifying mirror or look closely at another person's eye from the front and from the side. Notice how the cornea is transparent and bulges out. Use a magnifying glass to observe the detail.
- **Take a photograph** and/or make a sketch of everything you observe.
- **Label** your sketch or photograph. (Upper eyelid, tear glands behind the skin, duct draining tears into nose, third eyelid (does not move), sclera, iris, pupil, lower eyelid, eyelashes.) Refer to: Science Learning Hub: www.sciencelearn.org.nz/Science-Stories/Our-Senses/Sight

The eyeballs are fixed into eye sockets in the skull, which enclose and protect all but the front of the eye. Each eye has six muscles attaching it to an eye socket. The muscles contract and relax, rotating the eye so that it can follow moving objects in the line of sight. The movements of both eyes are coordinated and directed at the same spot – meaning we cannot easily look at objects at the edges of where we are looking.

Ask students to:

- **Look** up, down, left and right and decide the position of the muscle contracting – top, bottom, left or right.

In contrast, a chameleon's eyes can move independently of each other so that they can watch an object while keeping an eye on the rest of the environment. Refer to: YouTube – Chameleon eyes: http://youtu.be/Pwymtmj3ouU

**Discussion prompts**
[think-pair-share, or small group or whole class discussion only]

Look at the similarities and differences noted between the movements of a human eye and the movements of a chameleon's eyes.

What do you notice? Why do you think it is like that? What does it make you wonder?

If you are a citizen using the local roads as a cyclist, pedestrian or passenger, what is worth sharing about road user's eye movements?

## 2.6.3. Dissecting a cow's eye

Obtain a set of cow's eyes from a reputable source e.g. an abattoir, tertiary institution or butcher shop. Take care to follow the safe practice guidelines for dissections on page 32 in Safety in Science http://stanz.nzase.org.nz/resources Alternatively explore the structure of an eye by watching a YouTube video of a dissection or use a virtual dissection app online.

- Remove the eyelids.

- Look for the optic nerve at the back of the eyeball.
- Cut around the eyeball with scissors to divide the eye into front and back halves.
- Remove the lens and lay it on a sheet of newspaper. Read through the lens.
  Note: The part of the eyeball in front of the lens is filled with liquid. The part of the eyeball behind the lens is filled with jelly.
- Examine the iris and the pupil.

**Virtual dissection**

Exploratorium – Cow's eye dissection: www.exploratorium.edu/learning_studio/cow_eye/how.html

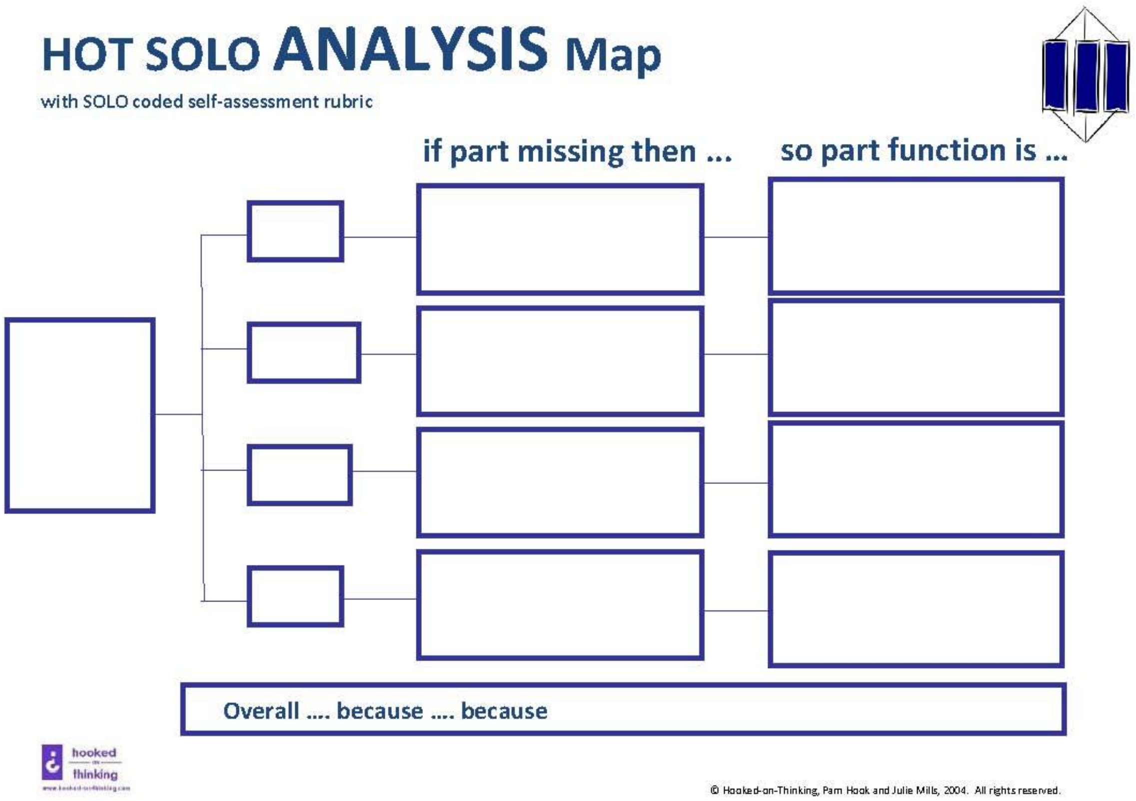
Anatomy Corner – Cow eye dissection: http://anatomycorner.com/main/image-gallery/cow-eye

Biology Corner – Cow eye virtual dissection:
www.biologycorner.com/anatomy/senses/cow_eye_dissection_virtual.html

eSchool Online – Eye dissection:
www.eschoolonline.com/company/examples/eye/eyedissection.html

Froguts – Cow eye dissection: www.froguts.com/products/labs.html

Use the HOT SOLO Analysis map template to describe the eye from a scientist's perspective. Use correct scientific terms to label the parts of the eye and describe what they look like. How would the function of the whole eye be affected if the part was damaged or missing? What is the purpose of each part of the eye? Make a generalisation about the ways in which the different parts of the eye work together to help us sense visual stimuli when we are using the road.



The structure of the eye is a little like that of a camera. Like a camera, the eye has a mechanism to focus the light, a receptive surface to receive the focused image and a mechanism to control the amount of light reaching the light-sensitive surfaces. Complete the table below by identifying the mechanism involved in each case and adding any other similarities you discover.

| Mechanism | Camera | Eye |
|---|---|---|
| Focus the light | | |
| Receptive (light-sensitive) surface to receive focused image | | |
| Control amount of light reaching light-sensitive surface | | |
| | | |
| | | |
| | | |

**Discussion prompts**
[think-pair-share, or small group or whole class discussion only]

Look at the parts making up a mammalian eye.

What are the relevant parts of a functioning eye? Why do you think its structure is like that? What does it make you wonder?

If you are a citizen using the local roads as a cyclist, pedestrian or passenger, what is worth sharing about the road users' eyes?

## 2.6.4. Reaction to an incoming pedestrian (reaction times)

How do we react? How long does it take?

What happens when a driver first notices a pedestrian approaching?

Ask students to work in groups to role play a messaging machine that mimics the steps taken when a driver reacts to a stimulus (e.g. pedestrian approaching). The steps start with "seeing" a pedestrian and finish with "doing something" to avoid hitting the pedestrian. Possible steps are outlined below. The level of detail can be reduced or increased depending on the students involved.

**Pedestrian approaching**

**Step 1. Eyes** register incoming light reflected from the pedestrian and send information via the optic nerve to the visual lobe of the brain.

**Step 2. Visual lobe of brain** sends information to frontal lobe of brain.

**Step 3. Frontal lobe of brain** decides incoming pedestrian is a collision hazard and must be avoided. Decisions are made to apply brakes to avoid collision.

**Step 4. Motor cortex in brain** receives instructions from frontal lobe of brain.

**Step 5.** Motor cortex sends motor control signals to **spinal cord**.

**Step 6.** These signals travel through spinal cord to nerves controlling muscles in the **driver's braking leg and foot.**

**Step 7.** The driver's foot begins to move towards and then moves to depress the **brake pedal.**

**Discussion prompts**
[think-pair-share, or small group or whole class discussion only]

Look at the pathway of steps involved in transmitting a message telling a road user to apply the brakes.

What is the sequence like? Why do you think it is like that? What does it make you wonder?

If you are a citizen using the local roads as a cyclist, pedestrian or passenger, what is worth sharing about the steps involved from seeing a hazard on a local road to doing something about it?

## 2.6.5. How much time does it take to react to a stimulus? (Measuring reaction time)

Ask students to work in pairs.

**Visual response test**

Student 2 holds a metre ruler suspended by one end. Student 2 rests their hand over the edge of a bench or table, positioning finger and thumb on either side of the ruler without actually touching it. Note the centimetre mark on the ruler.

Student 2 releases the ruler with no prior warning.

Student 1 responds to visual stimuli and grabs between finger and thumb as fast as possible.

Record the new centimetre mark for the visual stimulus response.

Calculate the distance the ruler dropped before student 1 reacted.

Repeat the experiment five times. Calculate the average distance the ruler dropped.

Change places and reverse roles.

**Auditory response test**

Repeat the experiment only this time remove all visual stimuli by asking student 1 to wear a blindfold or eyeshades.

Student 2 says, “Release” as they release the ruler (auditory stimulus).

Record the centimetre mark for each grab by student 1. Repeat the experiment. Then change places and reverse roles.

Investigate your reaction distance to light/sound/touch stimuli under different conditions and distractions and at different times of the day. Compare your reaction distance with the distances achieved by older and younger people.

**Discussion prompts**
[think-pair-share, or small group or whole class discussion only]

Look at the time taken (as measured by cm grasp point) to respond to visual and auditory prompts.

What do you see? Why do you think it is like that? What does it make you wonder?

If you are a citizen using the local roads as a cyclist, pedestrian or passenger, what is worth sharing about road users’ reaction time to visual and auditory messages?

**Extension:** How long does it take for a nerve impulse to travel from your eye (or your ear) to the muscles involved in gripping the ruler?

Convert your reaction distance in centimetres to a reaction time in seconds using the following formula.

$$y = \frac{1}{2} g t^2$$

$y$ = distance measured in centimetres
$g$ = acceleration due to gravity (980 cm/s$^2$)
$t$ = time in seconds

If we solve the equation for time, it becomes:

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

**Record of reaction distance and time**

| | **Reaction distance (cm) (measured)** | **Reaction time (s) (calculated)** |
|---|---|---|
| **Visual stimulus** | | |
| **Auditory stimulus** | | |

Compare your reaction times with the average reaction times for humans, which are 0.25 seconds to a visual stimulus and 0.17 seconds to an audio stimulus. Why do you think your time was the same as or different from the average recorded times?

Next, work out the approximate length of the nerve pathway involved. Use this measurement to calculate the speed of the nerve impulse in metres per second.

# SECTION 3: Extend ideas about the "wicked problems" (challenges and opportunities) for local road users wanting safer journeys.

**Extending ideas**
These activities provide opportunities for students to extend their thinking and experiment with ideas and information about safer journeys for road users on local roads.

The activities in this section prompt students to think about (and act on) tentative solutions to the problems and opportunities for citizens/road users wanting safer journeys on local roads. You'll find them across the English, mathematics and science resources:

- **Activity 3.1. Write to an author/poet about safer journeys for road users. [English – Making and Creating Meaning]**
- **Activity 3.2. Create a visual text for road engineers, architects and builders.[English | Maths and Statistics – Measurement and Shape]**
- **Activity 3.3. Is parking an issue? [Maths and Statistics – Measurement and Shape]**
- **Activity 3.4. What are the challenges (problems and opportunities) for road users on a local road? [Maths and Statistics – Statistics | English]**
- **Activity 3.5. Consider road users and local roads as wild life and waterholes. [Science – Physical World]**
- **Activity 3.6. Does "I can see you" mean "you can see me"? [Science – Living World]**

**Learning intention:** Draw conclusions about the challenges (problems and opportunities) presented by a local road.

**Differentiated self-assessment rubric.** *Insert your own marking guide on the left-hand side.*

| | |
|---|---|
| | I can draw a conclusion **BUT** I am not sure whether it is a key conclusion. |
| | I can draw a conclusion **AND** I can explain why it is a key conclusion. |
| | **AND** I can seek feedback from other road users on my conclusion.<br><br>**AND** I can act on the feedback to improve the effectiveness of my conclusion. |

## Activity 3.5: Consider road users and local roads as wildlife and waterholes. [Science – Physical World]

Talk like a scientist: using scientific language to describe every day phenomena.

Ask students to:

**Watch** an extract from a wildlife documentary describing the movements of a mammal in the wild. For example: BBC Earth – Attenborough – Saying Boo to a Sloth!: http://youtu.be/ndMKTnSRsKM

**Imagine** you are wildlife documentary makers exploring the movements of a cyclist, passenger or pedestrian road user on a local road.

**Write** a test script for an audio track to accompany a one- to two-minute video of a road user (cyclist, pedestrian or passenger using a local road).

The audio track should

- Describe the movements of the road user in the context of the challenges (problems and opportunities) provided by a local road.
- Describe the movements using the following categories:
  - **Speeding up** – This happens when road users have been stationary but are now starting to move **and** when objects are already moving but start speeding up.
  - **Slowing down** – This happens when road users are slowing down **and** when objects are stopping moving.
  - **Changing direction** – This happens when road users change the direction of their travel path, moving to the right or left or upwards or downwards.
  - **Changing shape** – This happens when the road user or the road user's mode of transport changes shape.
- Identify that increasing the size of the push or pull forces involved will increase the effect of the force on the road user.

Perform the audio script in front of a mock-up screenshot of a road user in your local area.

Seek and act on feedback on your performance.

Draft, rehearse and then present a two- to three-minute role play showing different road users (cyclists, pedestrians and passengers) dealing with challenges (problems and opportunities) when changing movement, direction and/or shape while using a local road. Feature challenges (problems and opportunities) and use scientific language and terms throughout.

Video the role play and then add the voiceover comments from your test script.

Share your science documentary on the "movement of road users" with your class, school and local community.

**Suitable video editing software**

Windows Movie Maker: free to download to Windows
Apple iMovie: free on some Apple computers

**Discussion prompts**
[think-pair-share, or small group or whole class discussion only]

Look at the documentaries on the “movement of road users”.

What did you notice about the movements described in the documentaries? Why do you think it is like that? What does it make you wonder?

If you are a citizen using the local roads as a cyclist, pedestrian or passenger, what is worth sharing about road user movements from your documentaries?

## Activity 3.6: Does "I can see you" mean "you can see me"? [Science – Living World]

**What do drivers see?**

Being able to "see" the pedestrian or cyclist is not as straightforward as it might seem. Just because you can see the car driver does not mean that the driver can see you.

After a collision a driver will sometimes claim that they did not see the pedestrian or cyclist. When travelling on the road, drivers focus most of their visual attention directly ahead (in a 60° cone of vision). Their focus on what is in front of them increases when visibility is poor or the traffic density is high. Drivers genuinely do not see objects on the edges of their gaze.

Pedestrians and cyclists are often outside the driver's direct line of sight. If the driver sees them at all, it is in the driver's peripheral vision ("out of the corner of my eye"). The eye finds it harder to detect objects seen in peripheral vision because there are fewer light-detecting cells in these areas of the retina.

### 3.6.1. Exploring peripheral vision

Ask students to work in pairs to complete one of the following activities.

**Either – Map your field of view**

- Pin a large sheet of paper on the classroom wall.
- Student 1 stands close to the wall, in a position where the tip of his/her nose will be approximately 20cm away from the paper.
- Student 2 uses a marker pen to put a spot on the paper directly opposite the first student's right eye.
- Student 1 covers their left eye and looks straight ahead – directly at the spot – with their right eye.
- Student 2 stands on the right-hand side of Student 1. Student 2 holds a marker pen against the paper about 2m away from the spot in front of the right eye of Student 1.
- Student 2 moves the marker slowly towards the spot. When the marker moves into Student 1's field of view, they call out and Student 2 marks this position on the paper.
- This process is repeated for three further positions: 2m to the left of the spot; 2m above the spot; and 2m below the spot.
- The students join the four marks in a circle to represent the field of view (FOV) for the right eye of Student 1.
- This process can be repeated to determine the field of view for the left eye, while Student 1 covers their right eye.
- Look for any overlap between the two fields of view – this area represents binocular vision where the judgement of distance is easier.

Note: Some students will be interested in reading more about the use of FOV in video game design. Refer to: FZD School of Design – EPISODE 29 FOV in Games part 1: http://youtu.be/blZUao2jTGA

**Or –**

**Test the limits of your peripheral vision**

Complete the activity described in Exploratorium Snacks – Peripheral vision:
www.exploratorium.edu/snacks/peripheral_vision

Then read the following information in *The Official New Zealand Road Code*:

- About other road users: Sharing the road, pp. 248 and 249: www.nzta.govt.nz/resources/roadcode/about-other-road-users/sharing-road-with-pedestrians.html
- About other road users: Information for pedestrians, pp. 255 to 258: www.nzta.govt.nz/resources/roadcode/about-other-road-users/information-for-pedestrians.html

Choose three pieces of information from the text and describe how each can be explained in part by thinking like a scientist about "field of view" and "peripheral vision".

Use field of view to explain why, when you can clearly see a car approaching, the driver may not have seen you.

| **Text from "About other road users: Sharing the road"** | **Explanation** |
|---|---|
| For example<br>"Always be ready to stop near schools, bus stops and pedestrian crossings." | *These are all places where pedestrians might step out into the road. If the driver is looking straight ahead, their field of view may not be wide enough to notice the pedestrian in time to put on the brakes and bring the car to a stop.* |
| "Young children have narrow vision. This means they may not see vehicles as easily as adults do." | *Young children have a narrower field of view than adults. They will not see the same hazards that an adult sees; as a consequence, they may step into the road without seeing an approaching vehicle.* |
| | |
| | |
| | |

## 3.6.2. Stopping distances

Many road safety initiatives are designed to enhance the visibility of pedestrians and cyclists to other road users who may be relying on their peripheral vision. Pedestrian flags, reflective clothing, LED clothing, kerb build-outs, pedestrian refuges, pedestrian barriers, traffic-slowing devices and walking school buses are designed to make it more likely that drivers will see pedestrians and cyclists on the road.

However, seeing and stopping are different problems. Even when the driver sees the pedestrian or cyclist in high-visibility gear, they may not be able to stop their vehicle in time. To avoid a collision, a driver has to: see the pedestrian/cyclist; recognise there is a chance of collision; react; and apply the brakes to slow the vehicle and bring it to a stop.

Applying the brakes does not immediately stop the vehicle. The car will keep moving forward after the brakes are depressed until friction eventually stops the vehicle. All this takes time and during that time the car keeps moving forwards towards the cyclist or pedestrian.

Many road users think that if the vehicle in front brakes suddenly, the driver in the following vehicle will be able to react and brake and both cars will stop the same distance apart. However, the total stopping distance is made up of four factors, as described in the table below. Delays can be built in to any of these components, which can markedly increase the stopping distance and result in a collision.

Ask students to work in pairs to come up with situations that could increase the length of time that each of these components contributes to stopping time.

**The four components in the total stopping distance of a vehicle**

| | | | |
|---|---|---|---|
| How long it takes **the driver to notice or see the hazard**. If a driver is distracted by text messaging or a squabble breaking out between passengers they may not immediately notice the hazard. | How long it takes for **the driver to react** to the hazard and move their foot from the accelerator to the brake. | How long it takes for **the vehicle to react** to the driver's actions, which depends on the working order of the braking system. | **How effective the car's braking system is**, which depends on tyre pressures, type of brakes, road surface, slope of road, car weight, tyre tread, suspension etc. |
| *Describe a situation that could increase this time.* | *Describe a situation that could increase this time.* | *Describe a situation that could increase this time.* | *Describe a situation that could increase this time.* |

The Road Code Test provides a useful diagram showing how the stopping distance changes as the vehicle speed changes: www.roadcodetest.co.nz/stopping-distance

Ask students to:

Watch a video demonstration of the distance it takes to stop a car: Stopping distances demonstrations: www.tasman.govt.nz/transport/road-safety/stopping-distances-demonstrations

Use the NZCI stopping distance calculator: http://www.nzci.co.nz/tools-calculators/stopping-distances.html to calculate stopping distances on different road surfaces and when travelling at different speeds.

In the school playground, use chalk and metre rulers to mark out the approximate stopping distances for vehicles travelling above, at and below the speed limit of a local road near you.

The stopping distance required is often too great to prevent a collision. If the road is slippery or wet, if the driver is travelling fast, or is slow to react because of distractions (e.g. texting, changing a music track, using a cell phone, interacting with the other passengers, tired, under the influence of drugs, alcohol, medication or age), then the car will take even longer to stop. A driver can only avoid a collision if they see the cyclist or pedestrian far enough ahead.

The requirements for stopping distance apply to cyclists as well as drivers. When cyclists are following other vehicles, they must leave enough clear space to stop, should the vehicle in front stop suddenly or should a vehicle pull out suddenly in front of them. *The Official New Zealand Code for Cyclists* (page 25) describes how to follow the two-second rule.

> ***The two-second rule***
> *Under normal conditions, the two-second rule is an easy way to make sure you have allowed enough following distance between your cycle and the vehicle in front, no matter what speed you're travelling at.*
> *To check if you are travelling two seconds behind the vehicle in front:*
> - *watch the vehicle in front of you pass a road marking or other feature on or off the road*
> - *as it passes the marking, start counting 'one thousand and one, one thousand and two'*
> - *if you pass the marking before you finish saying those eight words, you are following too closely – slow down, pick another marking and repeat the words to make sure you have increased your following distance.*

The Exploratorium has an online calculator that lets you calculate the stopping distance for cyclists: http://www.exploratorium.edu/cycling/brakes2.html However, it bases its calculations on the speeds you supply in miles per hour so you will need to convert speeds from kilometres per hour to miles per hour before you enter this information. The calculator then gives stopping distances in metres as well as feet.

For more information on stopping distances, refer to:
GEM Motoring Assist guide to motorway stopping distances:
www.youtube.com/watch?v=CzHklqaiTXI

Stopping distance demonstration: www.youtube.com/watch?v=Z_n-HIBnfts

*The Official New Zealand Road Code* – Key driving skills – Following distance:
www.nzta.govt.nz/resources/roadcode/about-driving/following-distance.html

www.rulesoftheroad.ie/rules-for-driving/speed-limits/speed-limits_stopping-distancescars.html

20mph speed limits – Why they are the future of urban transport:
www.transportpolicy.org.uk/Future/20mph/20mph.htm

Safe Drive Directory – Stopping distance: www.sdt.com.au/safedrive-directory-STOPPINGDISTANCE.htm

### 3.6.3. Extend your vision

*The Official New Zealand Road Code*'s "Safe driving tips" (pages 192–193) suggests ways for drivers to extend their vision: www.nzta.govt.nz/resources/roadcode/about-driving/safe-driving-tips.html

It suggests drivers should:

- "scan the road in front",
- "move your eyes regularly", and
- "ignore distractions".

Ask students to:

Use the science of how we see to explain why these behaviours are important for all road users – drivers, pedestrians and cyclists.

Create a short animation with a message for young road users, explaining why extending your vision is important.

**Suitable animation software**

Pivot animator: http://pivotanimator.net

Stykz: www.stykz.net

ABCya! Animate: www.abcya.com/animate.htm

MonkeyJam: http://monkeyjam.en.softonic.com

Clay Animator: www.clayanimator.com

CrazyTalk: www.reallusion.com/crazytalk

Scratch (MIT): http://scratch.mit.edu

Toon Boom: www.toonboom.com/education

Zu3D: www.zu3d.com

Hue Animation: www.hueanimation.com

Note: Students wishing to use Minecraft as an animation platform can use video recording software or simply grab a series of screenshots and use photo editing software to add annotations. For more detailed instructions, refer to:

Minecraft Wiki – Tutorials/Videos: http://minecraft.gamepedia.com/Tutorials/Videos

Minecraft Forums – Tips on making a good video: www.minecraftforum.net/topic/558294-tips-on-making-a-good-video

How to make a Minecraft video: www.apowersoft.com/make-minecraft-video.html

Bandicam – Minecraft game recording:
www.bandicam.com/product/how_to_record_minecraft_gameplay

Minecraft Animations – Mine-imator: www.stuffbydavid.com/mineimator

**Discussion prompts**
[think-pair-share, or small group or whole class discussion only]

Look at the "extending your vision" animations.

What do you notice about the common message in the animations? Why do you think it is like that? What does it make you wonder?

If you are a citizen using the local roads as a cyclist, pedestrian or passenger, what "extending your vision" message is worth sharing with other road users?