Challenges

Challenges

Reaction Time

An important skill drivers must have is the ability to react to obstacles that may suddenly appear in their path. You be the driver! What types of obstacles might you encounter? How quickly do you think you could react to an obstacle in the road?

You are going to calculate your reaction time.

1. Work with a partner to do the following experiment.

Materials
- 30-cm ruler

- Your partner will hold a 30-cm ruler vertically in front of you, with the zero mark at the bottom.
- Position your thumb and index finger on each side of the ruler so that the zero mark can be seen just above your thumb. Neither your thumb nor your finger should touch the ruler.
- Your partner will drop the ruler without warning. Catch the ruler as quickly as you can by closing your thumb and finger.
- Read the measurement above your thumb to the nearest tenth of a centimetre. This is your reaction distance.
- Perform this procedure five more times, recording each distance.
- Switch roles to determine your partner's five reaction distances.

Calculate your average reaction distance.

2. The formula $d = \frac{1}{2}gt^2$ can be used to calculate reaction time, where
- d is the reaction distance, in metres
- g is the acceleration due to gravity, which is 9.8 m/s^2
- t is time, in seconds

Calculate your average reaction time. Show your reasoning.

3. a) Imagine you are driving a car in a residential area and a ball rolls onto the road in front of you. You move your foot toward the brake. Based on the reaction time you calculated in #2, if you are driving at 40 km/h, how far will the car travel before you step down on the brake?

b) What distance would you have travelled before stepping down on the brake if your original speed was 100 km/h?

c) What other factors might influence your reaction time and your stopping distance? Share your ideas with your classmates.

Going Up?

You be an engineer! Your job is to design an elevator. It will work alongside an existing escalator to move people between levels at a local sports and entertainment arena.

1. The escalator that is already in place can move 30 people per minute from the main level to the upper level. Based on this information, how long would it take to use the escalator to move 100 people from the main level to the upper level?

2. The design of an elevator is based on the available building space, the load capacity, and the need to allow for people's personal space. An average person represents a load of 67 kg, and needs a radius of 26 cm for personal space. The area of the floor space for the elevator you are designing will be 3.75 m^2.

a) To maximize the number of people that can be carried, what dimensions would you recommend for the elevator?

b) Why did you choose these dimensions?

c) What is the maximum number of people that your elevator could carry?

d) What would be its load capacity? Justify your answer.

3. a) If the average time the elevator takes to move between the main level and the upper level is 8 s, how many people could move from the main level to the upper level in 1 min?

b) What assumptions did you make?

4. There is a concert tonight. You want to minimize the time for moving 2000 concert goers from the main level to the upper level.

a) What recommendations would you have for the staff who are directing people to the escalator and elevator? Justify your thinking.

b) What assumptions did you make?

***MathLinks 9*, pages 86–87**

Suggested Timing
40–50 minutes

Materials
- 30-cm ruler
- calculator

Blackline Master
Master 1 Project Rubric

Mathematical Processes
- ☑ Communication
- ☑ Connections
- ☑ Mental Mathematics and Estimation
- ☑ Problem Solving
- ☑ Reasoning
- ☑ Technology
- ☑ Visualization

Specific Outcomes

N3 Demonstrate an understanding of rational numbers by:
- comparing and ordering rational numbers
- solving problems that involve arithmetic operations on rational numbers.

N5 Determine the square root of positive rational numbers that are perfect squares.

N6 Determine an approximate square root of positive rational numbers that are non-perfect squares.

Planning Notes: Reaction Time

Students need to work with a partner.

You may wish to use the following steps to introduce and complete this Challenge.

1. Prior to discussing this Challenge in class, you may want to check with the science teacher to see what work, if any, has been done on reaction time.
2. Discuss with the class the current requirements for obtaining a graduated driver's licence. Many provinces and territories provide a *Basic Licence Driver's Handbook* that contains information on the rules and laws of the road, skills that are needed to drive and handle a motor vehicle, and the proper attitude a driver should have. Ask how many students have the handbook and have started studying for the written test.

3. Ask students to report on what they are learning about driving. Discuss what reaction time is in this context. (Reaction time is the time it takes drivers to react to danger by moving their foot from the gas pedal to the brake pedal.) Students may mention two other times associated with stopping:
   - Perception time is the length of time it takes for the brain to recognize a situation and understand the need to stop.
   - Braking time is the length of time it takes from the time the brake is applied until the vehicle comes to rest.

   This activity involves only reaction time. The other two times might also be discussed.
4. Discuss the types of obstacles a driver might encounter on the road when driving. (Examples include animals, pedestrians, potholes, other vehicles, and objects.)
5. With the class, read through the directions for #1. To clarify the procedure, you may ask two students to demonstrate to the class how to hold the ruler, drop it, and record the reaction distance.
6. Discuss why the procedure should be performed at least five times. Students may notice that the distance decreases the more times they perform the experiment. Encourage them to discuss why this happens. Students may question whether the reaction time for the foot is the same as for fingers. According to the *Alberta Transportation Basic Licence Driver's Handbook*, the average reaction time of moving the foot from the gas pedal to the brake pedal is 0.75 s.
7. Clarify that the task is to
   - perform the experiment five times
   - compute the average reaction distance of the five trials
   - calculate the average reaction time using the formula $d = \frac{1}{2} gt^2$
   - determine the distance travelled before the brake is engaged when travelling at 40 km/h and at 100 km/hr
   - list factors other than reaction time that affect stopping distance
8. Review the **Master 1 Project Rubric** with students so that they will know what is expected.

Meeting Student Needs

- Students who have poor eye–hand coordination may need to practise catching the ruler several times before they catch it between their fingers. Alternatively, you may wish to have them use a ruler longer than 30 cm.
- Some students may find it useful to review how to solve one-step equations.
- Students may need coaching in changing kilometres per hour into metres per second. Have them check the number of metres in a kilometre, and then work with them to change 30 km/h to $\frac{30\ 000\ \text{m}}{3600\ \text{s}}$ or 8.3 m/s.
- Students may need guidance when substituting their reaction distance into the formula. They will need to change the average reaction distance that they found in centimetres into the equivalent in metres. Alternatively, the formula could be changed so that the replacement for g is 980 cm/s^2.
- Students should be made aware that this experiment is not a scientific proof of their reaction time. They should not be concerned that the results that are determined for their reaction time will indicate their ability to drive a motor vehicle.

Gifted and Enrichment

- Have students read through the *Basic Licence Driver's Handbook* and identify stopping distances under normal road conditions. The stopping distance may be subdivided into distance based on perception time, distance based on reaction time, and distance travelled after the brakes are applied. Have students compare their calculated reaction distance to the values stated in the handbook.
- Have students research exercises or drills that can improve an individual's reaction time.

Answers

Reaction Time

1. Example: The average reaction distance is 20 cm to 30 cm.

2. Example: For a reaction distance of 25 cm, the reaction time would be:

$25 = \frac{1}{2}(980)t^2$

$25 = 490t^2$

$0.051 = t^2$

$0.226 = t$

Reaction time is 0.226 s.

3. a) 40 km/h $= \frac{40000 \text{ m}}{3600 \text{ s}}$, or 11.1 m/s

$d = rt$

$d = 11.1(0.2256)$

$d = 2.5$

The car will travel 2.5 m before the brake is engaged.

b) 100 km/h $= \frac{100000 \text{ m}}{3600 \text{ s}} = 27.8$ m/s

$d = rt$

$d = 27.8(0.226)$

$d = 6.28$

The car will travel 6.28 m before the brake is engaged.

c) Example: Other factors that might affect stopping distance include perception time, braking time, road conditions, condition of the brakes and tires, weight or mass of the car, driver fatigue, and the driver's experience.

This Challenge can be used for either Assessment *for* Learning or Assessment *of* Learning.

Assessment	Supporting Learning
Assessment *for* Learning	
Reaction Time Discuss the Challenge as a class.	• Have students work on their calculations with a partner.
Assessment *of* Learning	
Reaction Time Introduce the Challenge to the class. Have students provide individual responses.	• **Master 1 Project Rubric** provides a holistic descriptor that will assist you in assessing student work on this Challenge. Page 119 provides notes on how to use this rubric for the Challenge. • To view student exemplars, go to www.mathlinks9.ca, access the Teacher Centre on the Online Learning Centre, go to Assessment, and then follow the links.

The chart below shows the **Master 1 Project Rubric** for tasks such as this Challenge, Reaction Time, and provides notes that specify how to identify the level of specific answers for this project.

Score/Level	Holistic Descriptor	Specific Question Notes
5 (Standard of Excellence)	❑ Applies/develops **thorough** strategies and mathematical processes making **significant** comparisons/connections that demonstrate a **comprehensive** understanding of how to develop a complete solution ❑ Procedures are **efficient and effective** and may contain a **minor mathematical error** that does not affect understanding ❑ Uses **significant** mathematical language to explain their understanding and provides **in-depth** support for their conclusion	• a complete and correct solution
4 (Above Acceptable)	❑ Applies/develops **thorough** strategies and mathematical processes for making **reasonable** comparisons/connections that demonstrate a **clear** understanding ❑ Procedures are **reasonable** and may contain a **minor mathematical error** that may hinder the understanding in one part of a complete solution ❑ Uses **appropriate** mathematical language to explain their understanding and provides **clear** support for their conclusion	Demonstrates one of the following: • provides a complete response to all parts of the problem, with no more than two weak explanations or justifications • provides complete and correct responses to #2 and 3, based on an incorrect average in #1
3 (Meets Acceptable)	❑ Applies/develops **relevant** strategies and mathematical processes making **some** comparisons/connections that demonstrate a **basic** understanding ❑ Procedures are **basic** and may contain a **major error or omission** ❑ Uses **common** language to explain their understanding and provides **minimal** support for their conclusion	Demonstrates one of the following: • correctly completes #1, 2, and 3a) and c), with some weak communication • correctly completes #1, 2, and 3b) and c), with some weak communication • provides correct answers for all parts, without any work or justification
2 (Below Acceptable)	❑ Applies/develops **some relevant** mathematical processes making **minimal** comparisons/connections that lead to a **partial solution** ❑ Procedures are **basic** and may contain **several major mathematical errors** ❑ Communication is **weak**	Demonstrates one of the following: • provides correct #1 and 2, without justification • provides a correct #2, based on an incorrect average in #1
1 (Beginning)	❑ Applies/develops an **initial start** that may be **partially correct** or could have led to a correct solution ❑ Communication is **weak or absent**	Demonstrates one of the following: • provides a correct response to #1 • identifies some correct values for #1 but either the average is not calculated or is incorrect or is based on fewer than five values

For student exemplars, go to www.mathlinks9.ca and follow the links.