Introduction to Modelling
Lesson 2: Modelling Theme Park Queues

Australian Curriculum: Mathematics (Year 9)

ACMNA208: Solve problems involving direct proportion. Explore the relationship between graphs and equations corresponding to simple rate problems. (Year 9)

- identifying direct proportion in real-life contexts

Lesson abstract

Building on the ideas developed in Lesson 1, students consider a structurally similar problem about queueing to get on a ride at a theme park. Initially they explore how many people might be expected to be in a fixed length of queue. They develop a model for time to get onto the ride by considering the length of the line and the rate of flow of people onto the ride (i.e. combining the number of people on the ride and the time taken for the ride).

Mathematical purpose (for students)

Mathematical modelling requires making assumptions about the real situation.

Mathematical purpose (for teachers)

This lesson develops students' skills in the process of setting up and using a model of a situation - theme park queues - that has the same structure as the traffic jam problem but then extends it to include the phenomenon, and the modelling, of rate of flow and its effect on waiting time. Mathematically, the difficult concept of rate of flow is introduced, as an example of proportional reasoning. There are opportunities for graphing, and estimation in common metric units, and writing formulas if desired.

Lesson Length 45 minutes approximately

Vocabulary Encountered

- Models
- Modelling
- Assumptions
- Flow rate

Lesson Materials

- Slide show: ST7_Intro_To_Modelling_2a.pptx
- Student Sheet - Theme Park Challenge (1 per student)
- Video https://www.youtube.com/watch?v=Tb7WS1SsqC4 (optional)

Lesson structure

- Theme park challenge (Teacher introduction - 5 minutes)
- Tackling the challenge (Collaborative small-group work -15 minutes)
- Finding a flow rate (Collaborative small-group work - 15 minutes)
- Reporting (Individual work: 10 minutes)

We value your feedback after these lessons via https://www.surveymonkey.com/r/J8GPD7Z

Mathematics by Inquiry is an initiative of, and funded by, the Australian Government Department of Education and Training

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Theme Park Challenge

This first section aims to get students to think about modelling queuing at a theme park, and bringing their real world experience to bear.

Show the slide Some famous rides

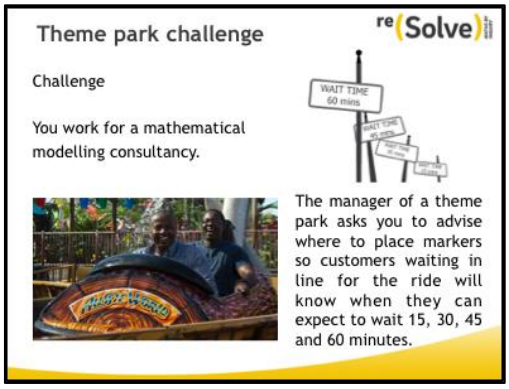
Start the lesson by talking about theme parks and, briefly, asking about experiences the students have had, eventually asking about the queues.

Then introduce the problem showing the slide Theme park challenge.

Choose as a class one ride that everyone will consider. The Buzz Saw is suggested. Some data is given on Student Sheet - Theme Park Challenge.

Have a whole class discussion about how to get started, what factors might be important, and how to include them.

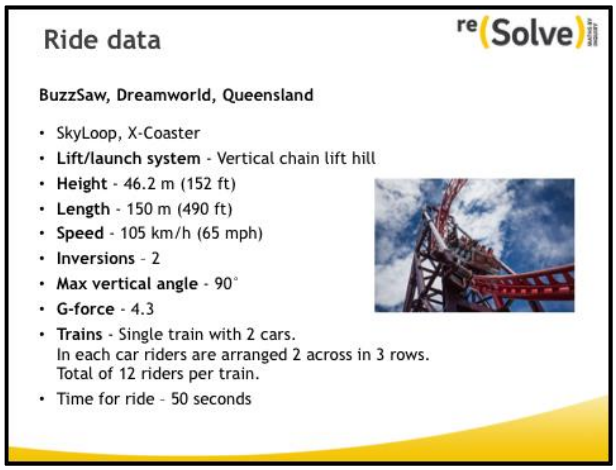
This situation is similar in some ways to the traffic jam that students modelled in Lesson 1. Tell students as they tackle it, they should watch out for the similarities and differences between the two situations.



Show the slide Ride data (which is repeated on Student Sheet - Theme Park Challenge).

This slide gives data for a famous ride -- students may use this data or you may replace this with data from a ride at a local theme park.

You may wish to show a video of this ride: https://www.youtube.com/watch?v=Tb7WS1SsqC4



Tackling the Challenge

Students work on the problem in pairs or small groups. The aim is to *give them time for productive struggle* with the problem – with you mainly observing and intervening only when essential. Hand out Student Sheet - Theme Park Challenge.

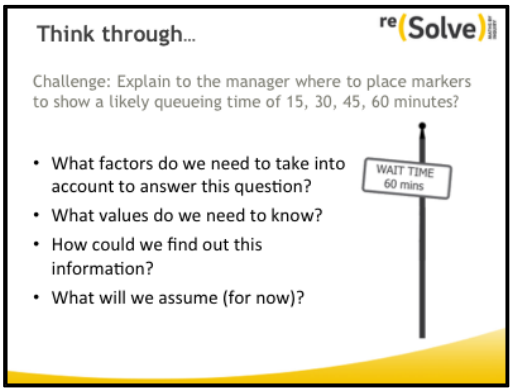
Make any interventions you think are necessary in the form of non-leading questions, in the style of those in the Common Issues table below.

Enabling prompts

- What factors are important for you to answer the questions?
- What information do you need to know?
- How could you find this information?
- What will you assume (for now)?

and/or

Show the slide Think through...



Expected responses

Simplifying assumptions or factors that should probably be included:

- Queue 'width' – People line up in single file.
  Alternatively people stand in pairs, in which case the lengths calculated will be halved.
- Queue 'density' – Each person, whether child or adult takes up same amount of space in the queue and there is the same space between people in line. (These values can be found from photographs or practically in the classroom by students lining up. Precision in the values assumed is not important at this stage of developing the model; real data could be found later)
- No queue jumping – no one joins the line near the front because of a Fast Pass type scheme or special needs.
- Ride is always full.
- Time for the ride.
- Ride operates continuously at maximum efficiency, i.e. no delays or breakdowns.

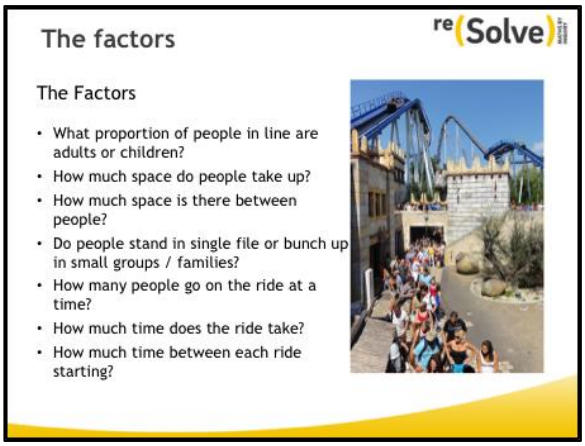
Common issues	Suggested questions and prompts
A group doesn't know how to get started e.g. What are we supposed to do?	• Think back to what you did with the traffic jam. Might some of that help here?
Students guess an answer e.g. I think the signs should be about 50 metres apart	• How would you explain to the theme park manager how you got this number? • Wouldn't this depend on factors like how many people the ride held? Would 50 m apply to all rides in the park?

The data about queueing.

At an appropriate moment discuss with the whole-class how they might take the problem forward by finding some typical values – either through researching using the web (e.g. find a photo) or carrying out some practical work to find out something like the queue density (for example, by standing in line).

To start the thinking, ask students to work in their groups to estimate the number of people in a 10 metre stretch of queue.

After a while, you may need to show the slide The Factors which suggests some factors that need to be considered.



Find queue density practically (optional whole class activity: 10 minutes)

This may be helpful if your students are making little progress.

Get the students to stand in line and measure spacing, width of people and distances.

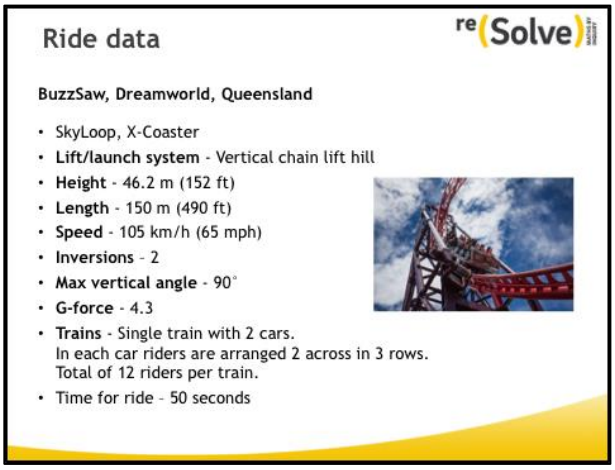
- A queue 'density' of 2 people per metre for single file is reasonable.

Finding a Flow Rate

The aim is to support students to develop an understanding of, and estimate, a rate of flow – a potentially difficult concept, fundamental to this unit and much else.

Ask students to work in their pairs/groups to estimate the number of people who can go on a ride in an hour.

They should be able to explain fully their reasoning.



Expected responses

Using these data:

- There are 12 riders per train, only one train on the track, each ride taking 50 seconds approx. This means there are less than 3,600/50 = 72 trains per hour.
- Flow rate is 72x12 = 864 people per hour
- But this assumes instant loading and unloading; with 30 seconds for unloading and reloading each train 'ride time' becomes 80 seconds, so that the flow rate is approx. 540 people per hour

The ride company says the capacity is 600 people per hour. Is our estimate good enough? Why the discrepancy?

If you have time, take 5-10 minutes to share with the class some students' working. Use this to highlight how different assumptions affect the outcomes of the models.

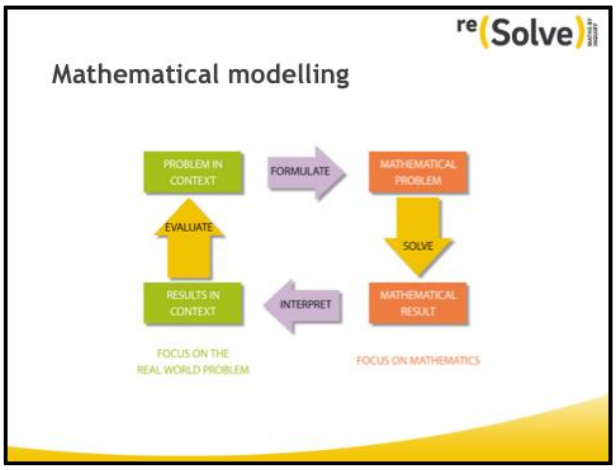
Reporting

The aim in this final section is to allow students to reflect on the process they have just completed by writing a brief report of their work (a memo to the theme park manager) – and to prepare them for the next lesson when they will related their work to the standard diagram of the modelling process (Shown here as an advanced organiser).

Allow 5 – 10 minutes for students to individually write a brief memo for the theme park manager that gives their group solution to where they should put signs for 30 and 60 minute wait times, showing their reasoning.

Show the slide Mathematical modelling

Explain that next time they are going to look at the modelling process in more detail. Emphasise how the process moves from the real world context in the top left of the diagram to the mathematical model, then to results, which we interpret in the real context, then evaluate whether they make sense.



Theme Park Challenge

Name: _____

You work for a mathematical modelling consultancy.

The manager of a theme park asks you to advise where to place markers so customers waiting in line for the ride will know when they can expect to wait 15, 30, 45 and 60 minutes.

BuzzSaw, Dreamworld, Queensland

SkyLoop, X-Coaster

Lift/launch system - Vertical chain lift hill

Height - 46.2 m (152 ft)

Length - 150 m (490 ft)

Speed - 105 km/h (65 mph)

Inversions – 2

Max vertical angle - 90°

G-force - 4.3

Trains - Single train with 2 cars.
In each car riders are arranged 2 across in 3 rows.
Total of 12 riders per train.

Time for ride – 50 seconds

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