In this activity you will model the motion of a train rolling down a slope. You will plot a graph of your data and use this to help you interpret the data and make predictions about the train's motion.

Information sheet

On 6 October 1991, *The Independent on Sunday* reported the launch of an inquiry into an accident in which a train crashed into a platform at Liverpool's Lime Street station. The runaway diesel engine pulling two empty passenger carriages had smashed though the crash barrier, reared 12 feet into the air, and hit a British Rail office. The driver and guard, a pregnant woman and a BR employee were taken to hospital suffering from shock.

Accident investigators might ask questions such as 'How fast was the train going when it hit the crash barrier?', 'How far did it roll and for how long?'

To answer questions like these, they would set up a model using their experience and observations of similar motion.

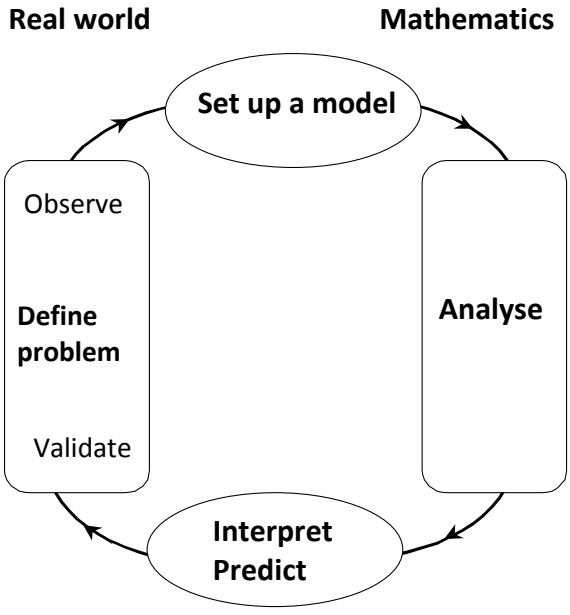
Think about

What would affect the motion of the train down the track?

How could you simulate the motion of the train in a classroom?

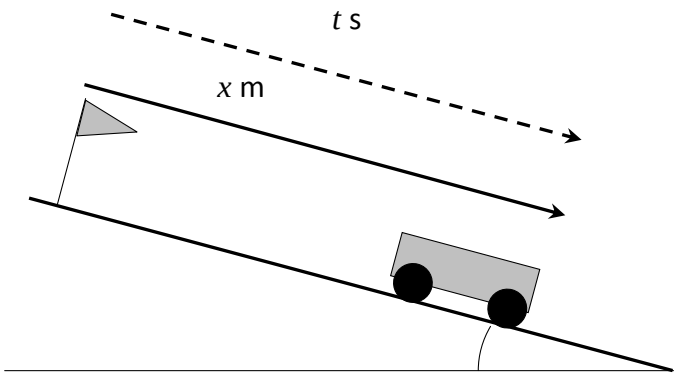
Which variables can you control?

What assumptions will you make?

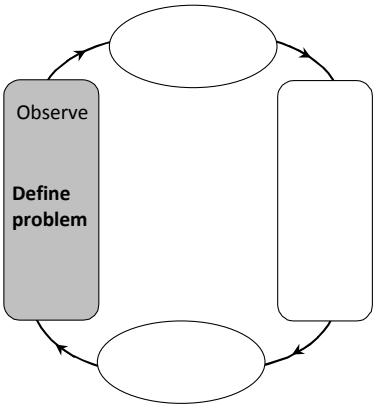


A The modelling process

You can investigate the key features of the motion of a train by timing how long it takes for a trolley to roll down a slope, as shown below.



B Define the problem



This activity can be used to answer questions like:

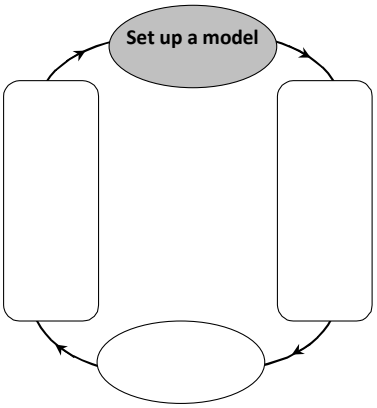
How does the time taken by a trolley to roll down a slope vary with the distance it rolls?

If it takes t seconds to travel x metres, does it take $2t$ seconds to travel $2x$ metres?

How far does the trolley travel in t seconds?

How long does it take the trolley to travel x metres?

c Set up the model



Assumptions

The slope has constant gradient.

The trolley is released consistently.

At release, the distance travelled and the velocity are zero.

All resistances to motion are constant.

Constants

The angle of the slope

Variables

the distance travelled, x metres

the time taken, t seconds

To do

1 Experiment

You need: a trolley, tape measure, stopwatch, track.

a Time how long the trolley takes to travel set distances. Put a block on the track at the distance you require so that you can hear when the trolley meets the block.

b For each distance repeat the experiment several times (or have a number of people timing) and use an average value.

c Use the blank table on the next page. You can enter up to 5 values of the time for each of 6 distances, and the average values.

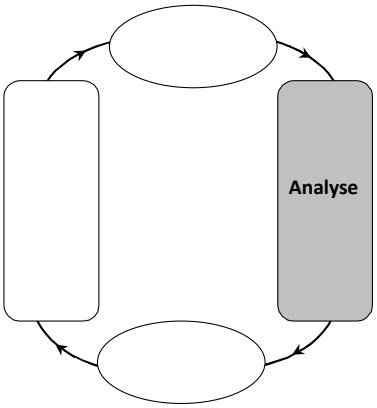
Values for time and distance

x						
t_1						
t_2						
t_3						
t_4						
t_5						
Average t						

2 Analyse

Use the data that you have collected to draw a distance-time graph on a graphic calculator or spreadsheet.

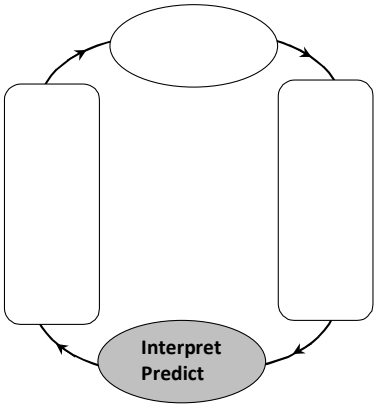
Find a function $x = f(t)$ whose graph passes through or near to the plotted points.



3 Interpret and predict

What have you discovered about the relationship between the distance the trolley travels down the slope and the time taken?

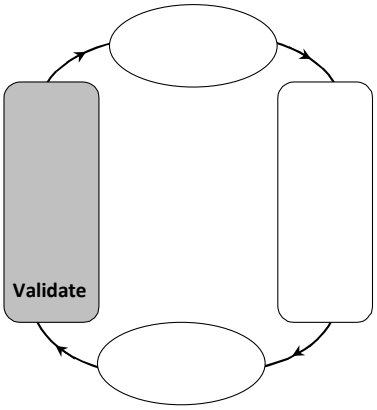
Use your function $x = f(t)$ to predict how long it will take to travel a distance that you didn't test.



4 Validate

Check your prediction using the apparatus:

x	
t_1	
t_2	
t_3	
t_4	
t_5	
Average t	



Think about what your graph and function are telling you.

How have your assumptions affected the model?

For example, what do they suggest about the position or speed of the trolley when $t = 0$?

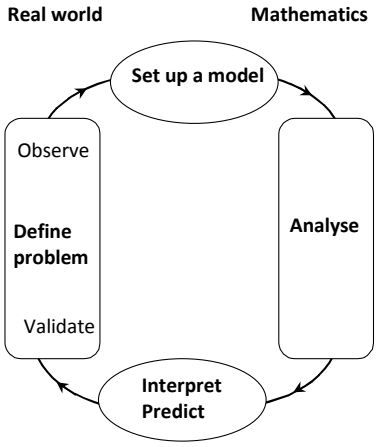
Can you explain this?

Sometimes results in the real world do not validate the model that has been used. In such cases the modelling should be tackled again using fewer or different assumptions. The modelling cycle then starts again.

Revise the model

How appropriate is the model?

What are the limitations of the model?



Extension

Read the introduction to this activity again.
It said that accident investigators might ask the question
'How fast was the train going when it hit the crash barrier?'

How could an accident investigator use your model to answer this question?
Think about the calculations they might make.

How can you adapt your experiment so that the speed of the trolley can be calculated directly from the data you collect?

Reflect on your work

Can you describe the different stages of the modelling process?

How has this activity helped you to understand them?