THE WORKSHOPS RAIL MUSEUM
IPSWICH

EDUCATION

GEAR RATIO & SCALE

MATHS TRAIL

Years 8 to 10

QUEENSLAND MUSEUM NETWORK
Queensland Government

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open daily 9:30am-5:00pm
(except Good Friday, ANZAC Day & Christmas Day)

This program has been produced and published by The Workshops Rail Museum, North Street, North Ipswich, Qld, Australia 4305.

The Museum's Vision Statement is:

> *to be recognised as a creative, innovative and exciting journey of discovery into Australia's rail story.*

The Mission Statement is:

> *to harness the significance of the Workshops precinct by delivering international standard cultural and tourism related activities, education and public programs associated with the interaction of rail on people's lives.*

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Purpose and Overview

The following questions and activities are based on *Zone 6: Model Rail* and the *Science Stations* at The Workshops Rail Museum. They are aimed at helping students to develop an understanding of the mathematical concepts of ratio and scale and how they can be used in a real life rail-related context.

These activities are aligned with the Australian Curriculum: Mathematics content strands of *Number and Algebra* for Year 8, and *Measurement and Geometry* for Year 9.

Students will further develop their knowledge and understanding of the following areas:

Real Numbers – These activities contain examples of numbers, such as fractions and decimals, in everyday practical situations.

Patterns and Algebra – Students will be exposed to the correct use of variations and constants, and other symbols that help to express meaning in an efficient manner.

Measurement – The Science Stations at the Museum expose students to accurate measuring techniques. They will see how relationships are created between equivalent units of measure and how they can be used to make conversions.

Geometric Reasoning – These activities allow students to think about 2D and 3D shapes from the sketches and drawings provided and allow them to identify and show the geometric properties of what has been drawn.

General capabilities and cross-curriculum priorities

Number and Algebra	Measurement and Geometry	Cross-curricular priorities
YEAR 8 **Real Numbers** • Solve a range of problems involving rates and ratios, with and without digital technologies (ACMNA188) *Elaboration:* • Understanding that rate and ratio problems can be solved using fractions or percentages and choosing the most efficient form to solve a particular problem **Patterns and Algebra** • Simplify algebraic expressions involving the four operations (ACMNA192) *Elaboration:* • Understanding that the laws used with numbers can also be used with algebra	**YEAR 9** **Geometric Reasoning** • Solve problems using ratio and scale factors in similar figures (ACMMG221) *Elaboration:* • Establishing the relationship between areas of similar figures and the ratio of corresponding sides (scale factor)	**Literacy** Communicate using mathematical terminology **Numeracy** Understand scale and ratio in real-world applications **Critical and creative thinking** Evaluate approaches to problem solving

During their visit and activity participation, students will develop the proficiency standards of *Understanding*, *Fluency*, *Problem Solving* and *Reasoning* through:

- Analysing data to identify key mathematical features and conditions, using strategies, and generating solutions.
- Conducting investigations and applying learned knowledge in order to solve problems.
- Selecting and using mental and written computations, estimations, representations and technologies to generate solutions.
- Using mathematical interpretations and conclusions to generalise reasoning and make inferences.
- Communicating thinking and using mathematical language and representations.
- Identifying the contribution that mathematics has had on their lives and to the evolution of technology.

PROFICIENCIES	
Understanding **YEAR 8** *Understanding* includes identifying commonalities between operations with algebra and arithmetic **YEAR 9** *Understanding* includes simplifying a range of algebraic expressions	***Problem Solving*** **YEAR 8** *Problem Solving* includes formulating, and modelling practical situations involving ratios **YEAR 9** *Problem Solving* includes applying ratio and scale factors to similar figures,
Fluency **YEAR 8** *Fluency* includes calculating accurately with simple decimals, indices and integers, recognising equivalence of common decimals and fractions including recurring decimals, factorising and simplifying basic algebraic expressions	***Reasoning*** **YEAR 8** *Reasoning* includes justifying the result of a calculation or estimation as reasonable **YEAR 9** *Reasoning* includes following mathematical arguments

Support materials and references

Educational Broadcasting Group, 2007, *"Gearing UP´ handout*, viewed 18 January 2013, http://pbs.panda-prod.cdn.s3.amazonaws.com/media/media_files/vtl07_doc_h1gears.doc

MicroMo Electronics, Inc., 2007, *Gearhead construction and use,* viewed 24 February 2013, http://www.micromo.com/Data/Sites/1/tech_gearhead_construction/gearhead_construction_use.pdf

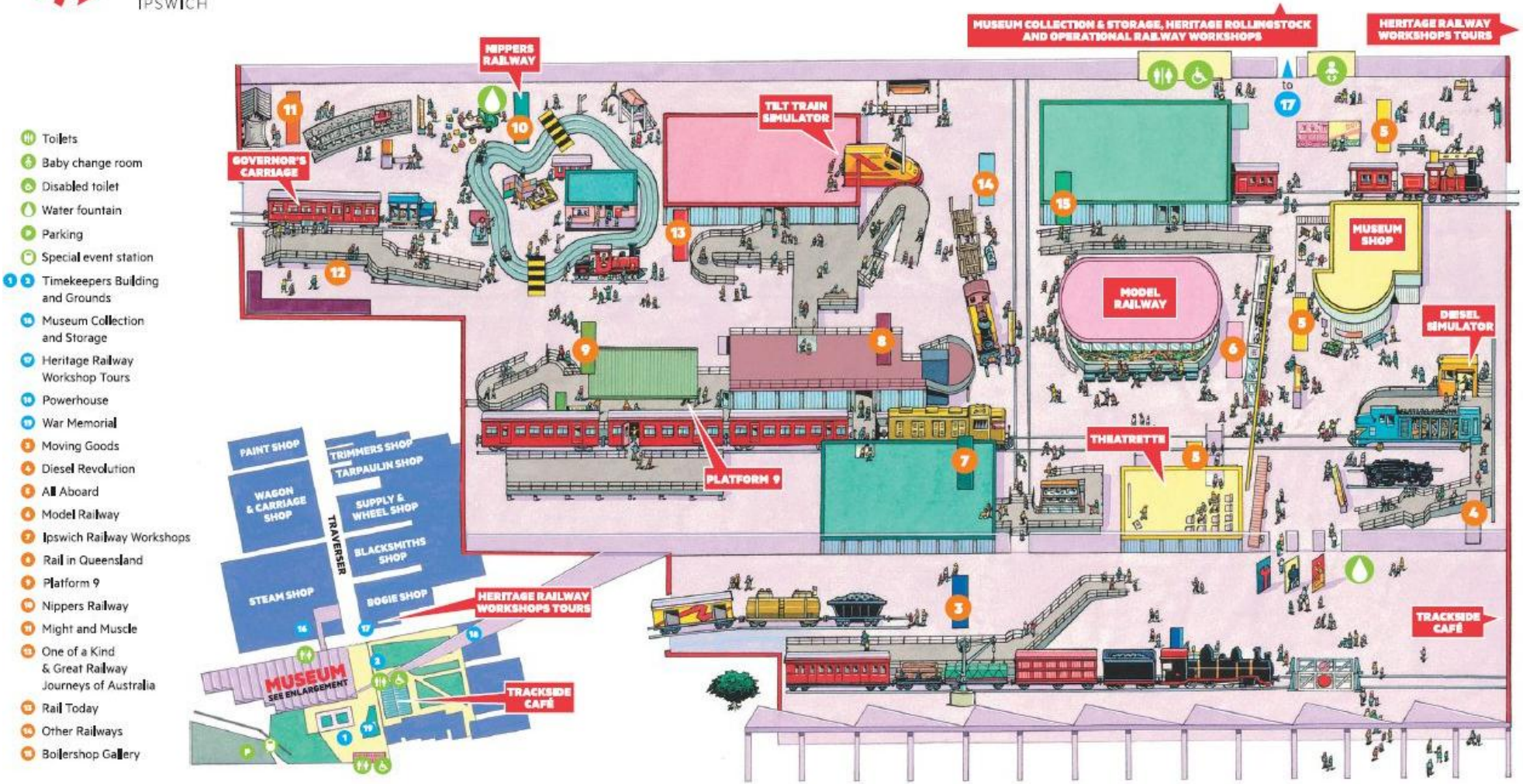
Mr B's Physics Plant, n.d., *Gears and gear ratios: Introduction to robotics*, viewed 18 January 2013, http://bowlesphysics.com/images/Robotics_-_Gears_and_Gear_Ratios.pdf

RSG ACES, 2013, *Simple machines: Gears, velocity ratio and mechanical advantage*, viewed 24 February 2013, http://darcy.rsgc.on.ca/ACES/.../Simple%20Machines%20and%20Gears.ppt

On the following page is a map of The Workshops Rail Museum. You can refer to this map to help orientate yourself throughout the activities.

THE WORKSHOPS RAIL MUSEUM
IPSWICH

MUSEUM MAP



Gear Ratios:

What is a rotation?

_____

_____

What is a ratio?

_____

_____

What is gear ratio?

_____

_____

What is the purpose of gears?

_____

_____

How do gears work?

_____

_____

Why are gears useful?

_____

_____

In the table below, list some objects that have gears:

Home	School

Find three objects in the Museum which use gears and complete the following table:

What is it?	Where is it? (i.e. which zone?)	What is its purpose or use?

Gears are wheels with teeth and are used to transfer motion or power from one moving part to another. The primary gear is called the *Driver Gear* and it causes the secondary gear, the *Follower*, to move in the opposite direction.

Gear ratio is the ratio of the rotational speeds of two meshing gears or of rotational speeds of the first and last gear in a gear chain. Gear ratio is expressed as a fraction and can be written as:

- 1 to 3
- 1/3
- 1:3

Gear ratio is determined by the number of teeth on each gear wheel. A simple way to work out the gear ratio of two meshing gears is by using the following formula:

$$\frac{\text{Number of teeth of Follower Gear}}{\text{Number of teeth of Driver Gear}}$$

For example if Gear A is the Driver with 10 teeth and Gear B is the Follower with 30 teeth, the equation is:

$$B/A = 30/10 = 3/1 \text{ or } 3:1$$

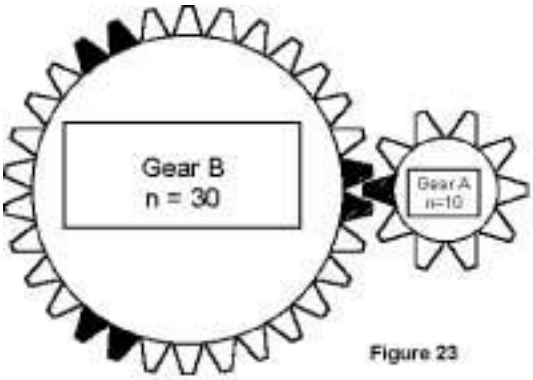


Figure 23

(MicroMo Electronics, Inc. 2007)

This means that for every 3 rotations of the Driver Gear, the Follower Gear makes 1 rotation.

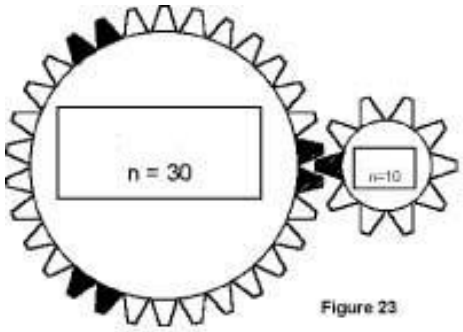
Activities:

Work out the gear ratio for the following sets of gears:

1. Driver: 32 teeth; Follower: 24 teeth. Gear ratio = _____
2. Driver: 8 teeth; Follower: 24 teeth. Gear ratio = _____
3. Driver: 25 teeth; Follower: 75 teeth. Gear ratio = _____

Working out revolutions per minute (rpm):

When the Driver Gear is *larger* than the Follower Gear, *multiply* the gear ratio by the rpm of the first gear. The Driver Gear has 30 teeth and the Follower Gear has 10 teeth. The Driver Gear has an rpm of 60. What is the rpm of the Follower Gear?



(MicroMo Electronics, Inc. 2007)

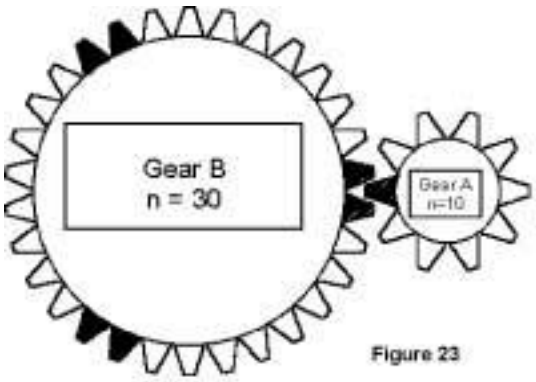
Divide 30 teeth by 10 teeth to find the gear ratio (3:1) which is simplified to 3.

Multiply this number (3) by the rpm (60).
This gives an answer of 180rpm.

$$\frac{30}{10} = \frac{3}{1} = 3$$

$$3 \times 60 = 180$$

When the Driver Gear is *smaller* than the Follower Gear, *divide* the gear ratio by the rpm of the first gear. If Gear A, the Driver Gear, has 10 teeth and has an rpm of 75, and Gear B, the Follower Gear, has 30 teeth, what is the Follower Gear's rpm?



(MicroMo Electronics, Inc. 2007)

Divide 30 teeth by 10 teeth to find the gear ratio of 3:1, which can be simplified to 3. Then divide the 75rpm by the gear ratio of 3. The answer is 25rpm.

$$\frac{30}{10} = \frac{3}{1} = 3$$

$$75 \div 3 = 25$$

Activities:

Find the *Gears Science Station* in the Museum and complete the activities below.

1. Turn the left hand gear wheel (marked 40) in a clockwise direction. What direction does the next gear wheel turn?

   _____

   _____

2. Now turn the large middle gear wheel (marked 80) in an anticlockwise direction. What direction does the next gear wheel on the right turn?

   _____

   _____

3. Turn the left hand gear wheel again in an anticlockwise direction. What direction does each of the following gear wheels turn?

   Gear 1 (marked 40) : anticlockwise

   Gear 2 (marked 80) : _____

   Gear 3 (marked 40) : _____

   Gear 4 (marked 120) : _____

4. Turn the left hand gear wheel one revolution. How many revolutions does the large gear wheel (marked 120) make? (Hint: the answer is a fraction)

   _____

   _____

5. Turn the middle gear wheel one revolution. How many revolutions does the large gear wheel (marked 120) make? (Hint: the answer is a fraction)

   _____

   _____

6. If you turn the small gear wheel once in a minute, its speed would be one revolution per minute or 1 rpm. In the same time, the largest gear wheel would turn only a fraction of that. Express the speed of the large gear wheel in rpm.

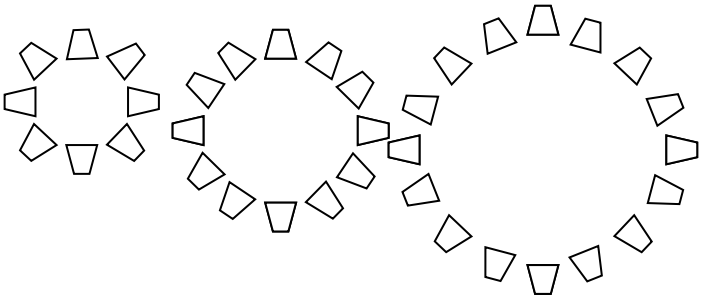
_____

_____

Multiple Gears:

When there are more than two gears in a gear chain, you can work out gear ratio by breaking it down into its parts: Work out the gear ratio of each pair of gears and multiply the gear ratios together to get the total gear ratio.

What is the gear ratio for each of the following gear chains?
(Don't forget to show your working out)



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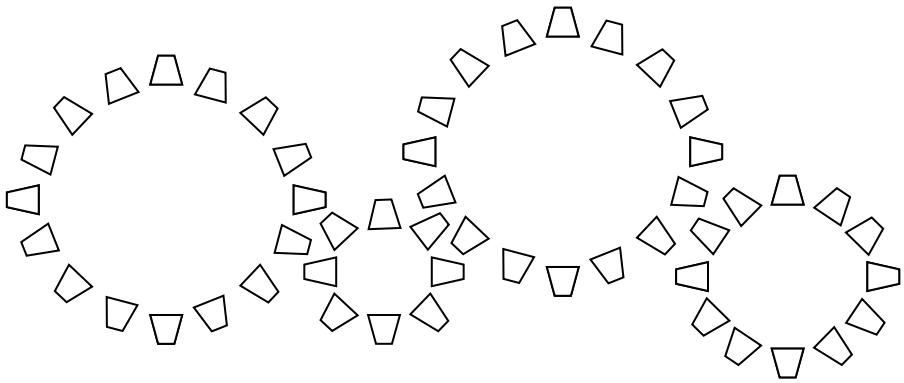

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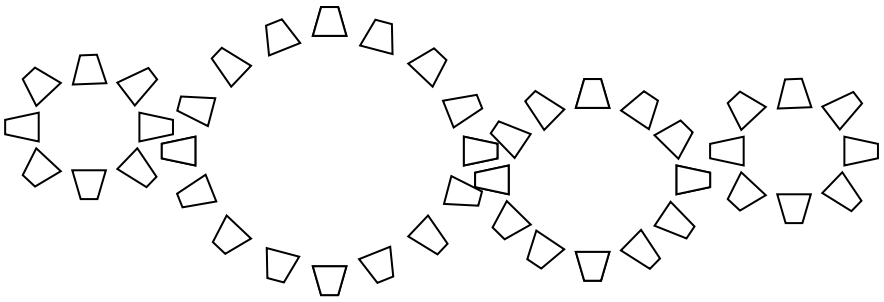
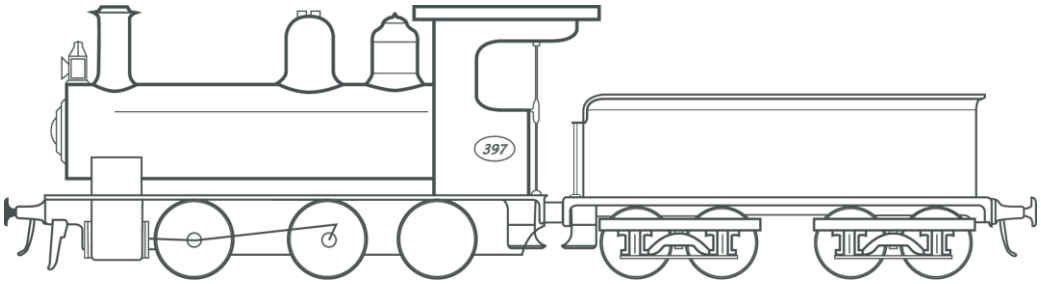


_____

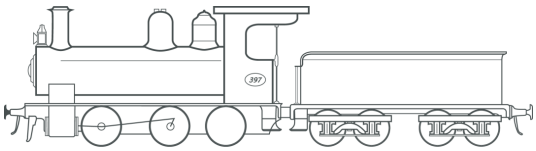
Built to Scale:

Model trains are can be made in a variety of sizes. Model trains are built to scale. This means that they are the same as real trains but reduced in size. The proportions remain the same. For example, train B is half the size of train A.

Train A

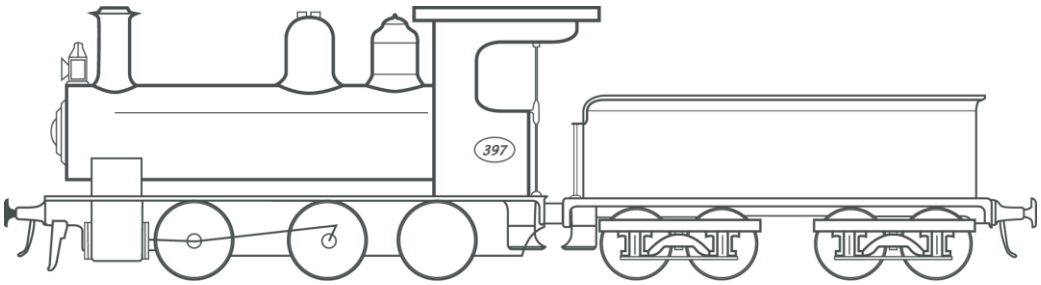


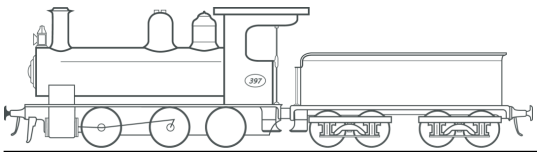
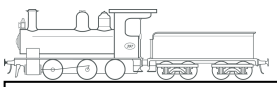
Train B



Train B is 2 times smaller than train A.

Write the correct scale in the box:



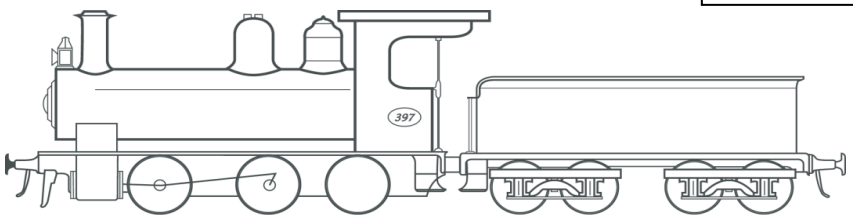
Train A	**1:1**
 This train is 2 times smaller than Train A	**1:**
 This train is 4 times smaller than Train A	**1:**
 This train is 8 times smaller than Train A	**1:**

Real Scales:

Model trains are built in a variety of different scales. These scales include the G Scale, O Scale, HO Scale and the N scale.

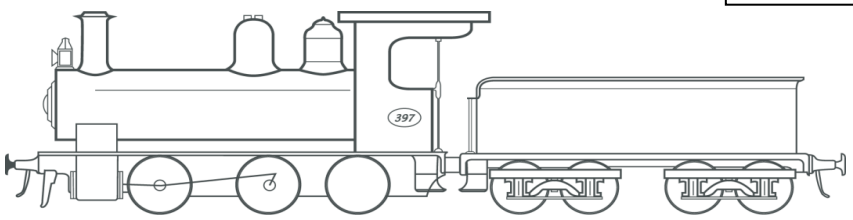
Find the following model train scales information in *Zone 6: Model Rail*. Then convert the ratio into a sentence. The first one is done for you.

G Scale 1:22.5

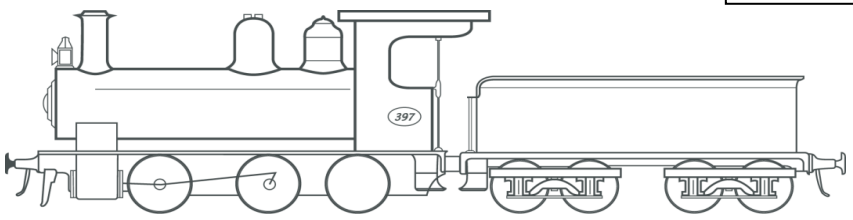


G Scale train is 22.5 times smaller than a real train.

O Scale 1: _____



HO Scale 1: _____



N Scale 1:_____