

Investigating the maths inside:

Maths in 3D

Information for teachers



*Maths Inside* is a project funded by the Commonwealth Department of Education and Training under the Australian Maths and Science partnership Programme.

The aim of *Maths Inside* is to increase engagement of students in mathematics by using rich tasks that show the ways mathematics is used in real world applications.

# About this module

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This module consists of the video “Zebedee” and the following activities:

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| Activity 1 | Be a Zebedee | Years 8–10 |
| Activity 2 | Are we there yet? | Years 7–9 |
| Activity 3 | Scientific notation | Years 8–11 |

# Feedback

Feedback from teachers about these classroom activities would be appreciated. Please complete the form at <http://tiny.cc/mathsinsidefeedback>.

# Background

Zebedee is a handheld 3D mapping system, which consists of a lightweight scanner that measures distance by illuminating a target with a laser and analysing the reflected light. It has a maximum range of approximately 30m.

The measurement unit uses electrical and mechanical components built on the nanoscale. It is mounted on a simple spring mechanism. As an operator holding the device moves through the environment, the scanner loosely oscillates about the spring, thereby producing rotational motion that converts the 2D scanning plane into a local 3D field of view.

With the use of software, the sensor trajectory can be accurately and continuously calculated in real-time, and the range measurements can be projected into a common coordinate frame to generate a 3D point image.

There is more background information on Zebedee available at <https://wiki.csiro.au/display/ASL/Zebedee>.

Activity 1: Be a Zebedee

Students simulate how the Zebedee works in two dimensions. Instead of light, this simulation activity uses sound to identify the positions. Students cooperate as a team to lay out and then navigate a course. They then construct accurate scale diagrams and compare to the original.

# Why do this?

Develops skills in measuring angles and distances.

Promotes practical problem-solving when laying out the course.

Emphasises comparisons and acceptable degrees of error.

# Australian Curriculum links

**Year 9: Measurement and Geometry – Geometric reasoning**

Solve problems using [ratio](http://www.australiancurriculum.edu.au/glossary/popup?a=M&t=Ratio) and scale factors in [similar](http://www.australiancurriculum.edu.au/glossary/popup?a=M&t=Similar) figures [(ACMMG221)](http://www.australiancurriculum.edu.au/curriculum/contentdescription/ACMMG221)

# Getting started

How could you navigate in the dark? Students may be familiar with the navigation of bats and/or with other modes of echo-sounding.

## Be a Zebedee

This activity is designed to simulate how the Zebedee works in two dimensions. Instead of light, this simulation activity uses sound to identify the positions.

A student is blindfolded and walks along a straight line. Other students stand either side of the line at fixed distances from the line on the edge of a defined shape. The students at the boundary points call out to the blindfolded student to identify their positions relative to the straight line.

### Planning the course

Decide on your course. The points can form any shape. The transversal should be at least 10 metres long.

Draw your course to scale but do not record it on the drawing. This will be used to check the accuracy of students’ work. Include the necessary measurements.

A diagram of a sample course is included below.

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### Laying out the course

Students should lay out the course(s). This is a good activity to encourage accurate measurement of distances. Discuss practical ways of measuring right angles.

Give students the diagram of the course. They should first identify the transversal. They could use an existing straight line from a netball court or similar, or mark one out with either chalk or tape.

Then have the students measure off the boundary points at right angles to the transversal and label them A, B, C, etc. Locate these points by recording the distances along the transversal as well as the distances away from it.

### Running the activity

Ask students to stand at the boundary points.

The student acting as the Zebedee is blindfolded and is assisted by the Zebedee Helper to walk along the transversal line.

As the Zebedee moves closer to a boundary point, the student standing on that point calls out the distance they are away (e.g. “3 metres”). When the Zebedee has decided the student calling out is on a line perpendicular to the transversal, the Helper records the blindfolded student’s position on the transversal, by marking it with the appropriate letter.

The Zebedee continues along the transversal, stopping when closest to the next student and so on.

When the Zebedee has finished, the blindfold is removed and the information recorded on a sketch diagram.

### Mathematical follow-up activity

Each member of the group then draws an accurate scale diagram (ACMMG221) using the information that has been gathered. You can either give them the scale or ask them to work it out themselves.

Ask the students to compare their drawings. Do they look the same?

Then ask the students to compare their drawings with the original. How accurate are their drawings?

# Resources needed

A large flat area that can be marked out with chalk or masking tape or similar

A map of the course

Chalk or other form of marking material

Tape measure(s) at least 10 m in length

A blindfold

# Further ideas

To increase the interest of students, teams could be formed and performance judged by the accuracy of the final plans. This would require several different areas to be prepared for the activity.

You might also want to use this activity to review some of the properties of plane shapes (ACMMG202), explore areas of composite shapes (ACMMG216), the use of Pythagoras’ Theorem (ACMMG222) or the trigonometry of right angled triangles (ACMMG224).

Activity 2: Are we there yet?

Students perform calculations about speed, distance and time, emphasising estimation and correct units. They plan a driving trip of their own choice, taking into account practical factors.

# Why do this?

Sets a formula describing the relationship between speed, distance and time into a common context.

Establishes the importance of estimating an answer before calculating and encourages sensible decision making in terms of estimation.

Encourages creativity and personal research.

# Australian Curriculum links

Solve linear equations using algebraic and graphical techniques. Verify solutions by substitution (ACMNA194)

# Getting started

“Are we there yet?” The real question is “How long before we get there?” The question is about the time required to finish the trip.

It is important that students develop a good sense of an appropriate answer to a problem before doing a formal calculation.

This kind of proportional thinking can be difficult.

Sharing strategies is a way of understanding student thinking.

*One way of estimating the answer is to consider that the distance remaining is 70 km, and since the speed is 90 km per hour, the time must be less than one hour.*

*Proportionally, 70/90 is roughly three quarters. Expressed as time, 3/4 of an hour is 45 minutes.*

Using a formula will give an exact answer. Students may need some revision on the processes for solving an equation. Some will find it easier to rearrange the formula first before solving.

Students should be alerted to the need for the units to be the same (i.e. kilometres and hours). They should then know that their answer will be in hours but might more helpfully be expressed in minutes.

## Planning a trip

This is a good activity in which to involve families. The research part might be a take-home exercise.

# Answers

1. 0.17 seconds

2. 128.6 m/s = 462.96km/h

3. Light travels at 300 000 km/s. For each second, lightning is approximately 350 m or 0.35 km

# Resources needed

Paper and pencil

Access to internet (or other resources) for research

Activity 3: Scientific notation

Students explore the scientific notation used for very big and very small numbers, and use that knowledge in a variety of questions.

# Why do this?

Explains the need for scientific notation

Enables calculation practice in realistic contexts

# Australian Curriculum links

Express numbers in [scientific notation](http://www.australiancurriculum.edu.au/glossary/popup?a=M&t=Scientific+notation) [(ACMNA210)](http://www.australiancurriculum.edu.au/curriculum/contentdescription/ACMNA210)

Mathematical Methods Unit 2: Understand and use scientific notation and significant figures. (ACMMM063)

# Getting started

What is nanotechnology?

Nanotechnology is science, engineering, and technology conducted at the nanoscale, typically with sizes from 1 to 100 nanometres. Zebedee uses electrical and mechanical components built on the nanoscale with objects 1 to 100 nanometres in size.

## Scientific notation

You will probably need to review the use of negative indices.

One nanometre is a billionth of a metre, or 0.000 000 001 metre, or 10-9m.

For example, a sheet of newspaper is about 100 000 nanometres thick.

### Nanometres

A **millimetre** (mm) is 1000 times smaller than a metre

A **micrometre** (μ) is 1000 times smaller than a millimetre

A **nanometre** (nm) is 1000 times smaller than a micrometre.

A **nanometre** is 1000 × 1000 × 1000 = 1 000 000 000 times smaller than a metre.

### Scientific numbers

Very small and very large numbers are difficult to work with, even using scientific calculators. They cannot be entered into a basic calculator. We can write these numbers in a much more convenient form called scientific notation (so called, because scientists often deal with very large and very small numbers).

A number is in scientific notation if it is written in the form

 *a* × 10n

where *a* is a number between 1 and 10 and n is an integer.

# Answers

1. 2 × 10-7 seconds

2. 1337 seconds or 22 minutes and 16 seconds

3. 2414 hours = 100 days

4. 5.1648 × 1027 molecules

5. 186.7 seconds = 3.1 minutes

6. 9.46 × 1012 kilometres