INTRODUCTION

re(Solve) MATHS BY INQUIRY Phone Finding

Y9

Summary of learning goals

- Students apply Pythagoras’ theorem to explore practical technology that is reliant on mathematical concepts.

Australian Curriculum: Mathematics (Year 9)

ACMMG221: Solve problems using ratio and scale factors in similar figures.

ACMMG222: Investigate Pythagoras’ theorem and its application to solving simple problems using right-angled triangles.

Summary of lessons

Who is this sequence for?

- This sequence is for students who have been introduced to Pythagoras’ theorem and are able to complete routine calculations to find the length of the hypotenuse or of one of the short sides.

Lesson 1: Phone Finding

Students apply Pythagoras’ theorem to locate a lost mobile phone, using information about mobile phone towers in their local region. This task develops understandings of the functionality of Pythagoras’ theorem in three dimensions. Students also see the importance of precision when working in real-world contexts.

reSolve: Mathematics by Inquiry is funded by the Australian Government and is managed by the Australian Academy of Science.

Australian Academy of Science

Reflection on this sequence

Rationale

The concepts behind Pythagoras' theorem and its proofs are taught well in classrooms, and there are ample high-quality resources to assist teachers. This lesson is not intended to prove or teach the theorem for this reason. However, traditional applications are often shallow and uninteresting, and so the focus here is on providing explorative and atypical applications.

This task provides an exploration of practical real-world technology that relies on the theorem. In particular, it can serve as a useful assessment task due to its self-contained focus and emphasis on fluency exercises.

reSolve mathematics is purposeful

- This sequence provides an interesting application of Pythagoras' theorem that is aimed at building students' fluency with calculations in unorthodox contexts.

reSolve tasks are inclusive and challenging

- The task builds on foundational understanding of the theorem but pushes knowledge in new directions and relates to other mathematical principles.

reSolve classrooms have a knowledge-building culture

- The lesson relies on comparing and contrasting findings in order to reinforce the importance of justifying reasoning.

LESSON 1

re(Solve) MATHS BY INQUIRY Phone Finding

Phone Finding

Y9

About this lesson

Students apply Pythagoras' theorem to track and locate a lost mobile phone. Students also see the importance of precision when working in real-world contexts.

Australian Curriculum: Mathematics (Year 9)

ACMMG221: Solve problems using ratio and scale factors in similar figures.

ACMMG222: Investigate Pythagoras' theorem and its application to solving simple problems using right-angled triangles.

Mathematical purpose

- Students extend their knowledge of Pythagoras' theorem to contexts outside the classroom. The task uses scales and ratios to determine distances in real-life situations, and encourages precision in measurements, calculation and drawing.

Learning intention

- To track and locate a lost phone, using real-world data and Pythagoras' theorem.

Time

A lesson of approximately 1 hour.

Vocabulary

- ping

Resources

- Student Sheet 1 – Find My Phone (one per student) OR reSolve Excel Spreadsheet *1b Phone Finding*
- reSolve PDF *1a Phone Finding Map* (one per student, printed on A3 paper)
- Phone Finding GeoGebra app (optional)
- pair of compasses (one per student)

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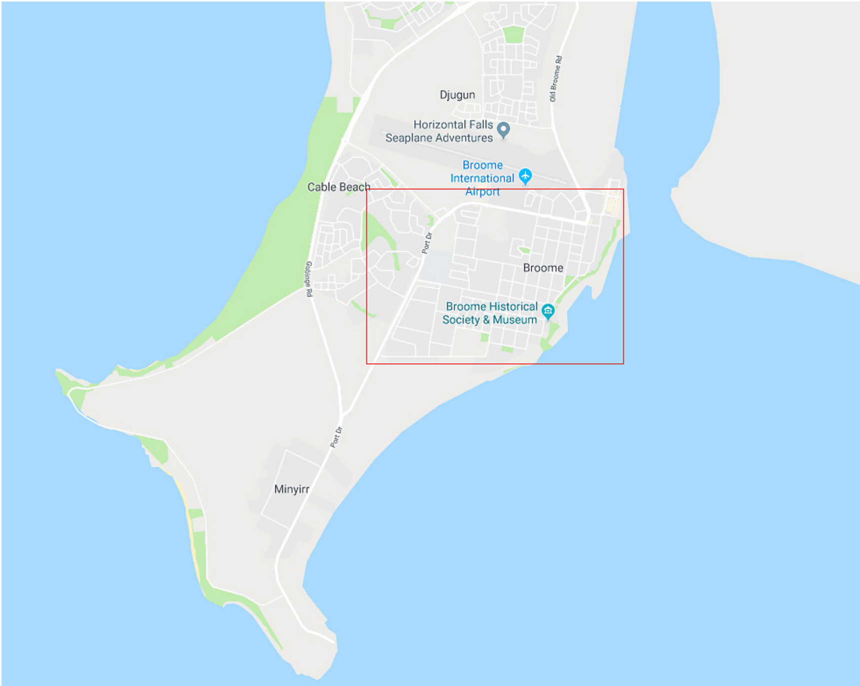
Teacher background information

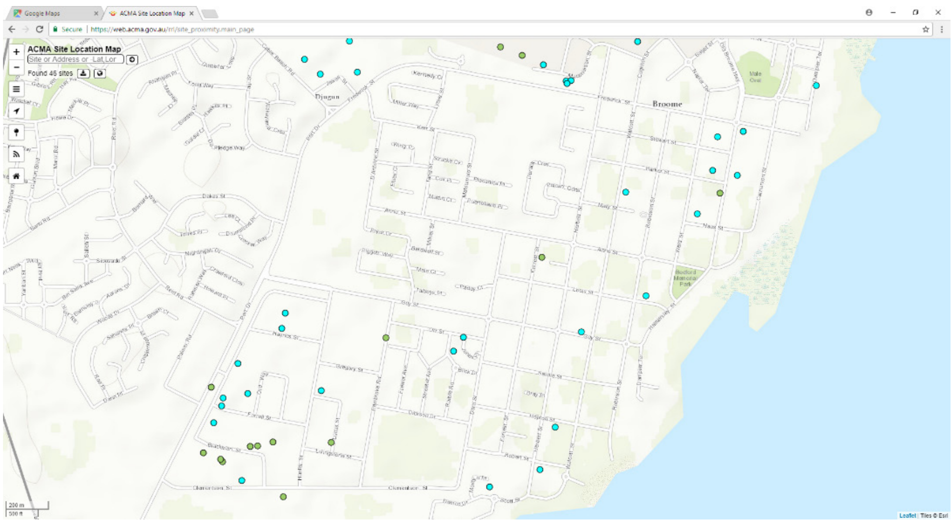
The map supplied in this task is from Broome, Western Australia.



Preparing your own map (optional)

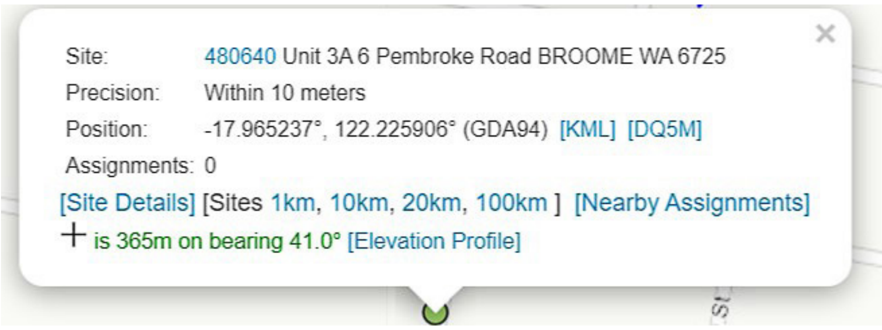
If you are interested in making your own map based on your location, this is how ours was made:

1. Find your location on the ACMA Site Location Map.

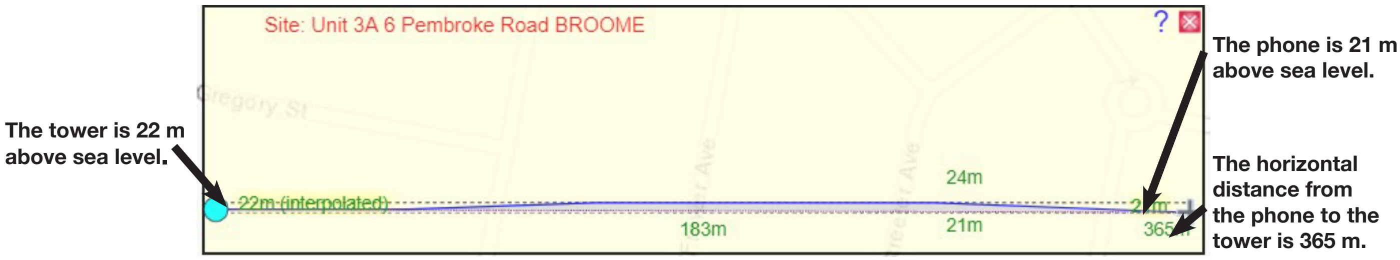


2. Click on the icon and then click on the map to place the lost phone at a location.

3. Select a nearby phone tower and click on 'Elevation Profile'.

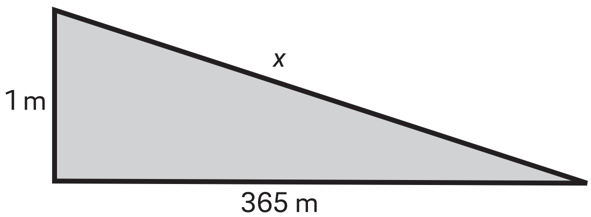


4. According to this particular elevation profile:



Significant height differences between the phone and tower will give better results; consider playing with numbers or using a location with more height variations.

5. Use the following values to calculate the direct distance from the tower to the phone. (The vertical height is the difference between the phone height and tower height.)



$$x^2 = 1^2 + 365^2$$

$$x = 365.001$$

6. **Resources:** Enter the tower and phone heights and the direct distance between them into a table, as in Student Sheet 1 – Find My Phone.

While selecting values, take into consideration the scale of the map and ensure that the circles will be large enough to draw with a pair of compasses.

If you do create your own map, we would love for you to share it with us at mbi@science.org.au!

Student sheet notes

Resources: reSolve PDF *1a Phone Finding Map* is an A3 map with a scale of 1 cm : 100 m. Students will need a copy of the map and a copy of Student Sheet 1 – Find My Phone, which has a table of information and space for students' working.

Extending prompt: Challenge students to change the scale by adjusting the size of the map.

Using the GeoGebra app

The included GeoGebra app allows students to place points on the map and generate circles with a given radius around the point. Notes for use:

- The map in the GeoGebra app has a scale of 1 cm : 200 m, which is half the size of the A3 map included in the lesson.
- The map is movable — ensure students do not move it out of the rectangle or the scale may be affected.
- Use the icon and then the 'Circle with Center and Radius' option to input a radius around a selected point.
- Make sure to click the icon before moving points around the map.

Pinging a phone

Introduce the task by discussing what technology students might have used to find their missing phones (e.g. a Find my iPhone app). How do these apps locate phones?

Explain how a mobile phone tower can ping a cell phone to ascertain the straight-line distance between the mobile phone and the top of the tower.

Before mobile phones had GPS technology, you could ask your service provider to ping your phone to find its location when you lost it.

Provide students with *1a Phone Finding Map* and either Student Sheet 1 – Find My Phone or reSolve Excel Spreadsheet *1b Phone Finding*. Explain: *I left my mobile phone in the back of a car/taxi/ride-sharing service vehicle. Because the car is constantly in motion, I can't locate its exact position. I've been pinging my phone every 4 minutes to find its distance to the closest mobile phone tower. What route has my phone travelled? How can I reclaim it?*

Teacher note:

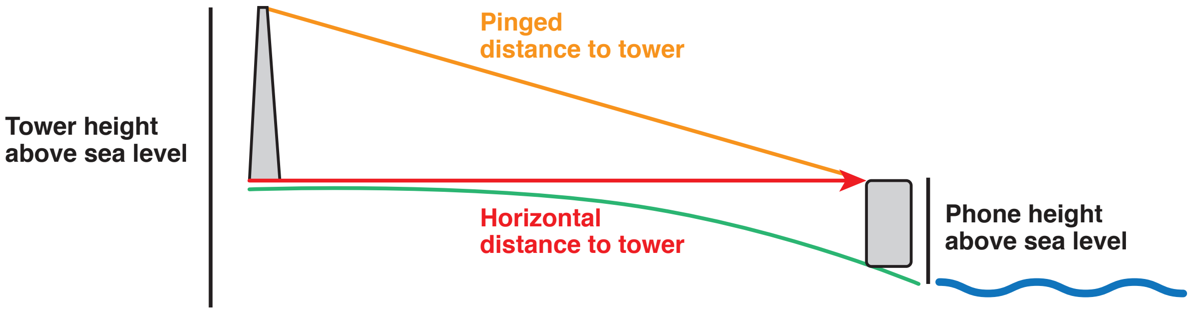
- The scenario given in this task is modelled on phone-locating strategies that were available pre-smartphone. These days we are more likely to locate our phones via GPS!

Tracking a route

Students begin by drawing a diagram modelling the phone tower, phone and pinged distance in order to work out what information is relevant and what needs to be investigated to solve the problem.

T Teacher note:

- An example diagram for teachers is shown. (Encourage students to create their own in the working space of their sheet, based on their understanding of the context.)



- Encourage students to independently work out how to use the information given to answer the problem. Resist the urge to explain the model and how Pythagoras' theorem applies!

Using the prepared worksheet and a pair of compasses, students work to accurately track the missing phone.

The key steps of this process (but allow students to discover this themselves!) are:

1. Finding the length of the *base* of the triangle in order to measure the distance on the map.
2. Applying a scale factor to mark distances on the map.
3. Because we know only how *far* the phone is from each tower (and not the direction), the closest we can get is an **arc** around each tower.
4. Once students have marked a radius around each tower that was pinged, they should mark the route that they think the phone has travelled, keeping in mind that each ping was 4 minutes apart.

Questioning to direct the investigation and challenge students' thinking and reasoning:

- Can we make a *precise* guess as to the location of the phone at 9:30 am? Why or why not?
- If I want to reclaim my phone, what will be the most reasonable course of action?
- Would information from *more* phone towers be useful? Is there any location where you would like more data?
- Between 9:23 am and 9:31 am, did the phone move? Why or why not?

Reflection

Discuss any variance in students' answers, comparing the different routes found by each student. Can they justify why they think the driver of the car might have travelled along this route?

How significant is the precision of the pinged distance reported by each mobile phone tower?

On reSolve PDF *1a Phone Finding Map*, the circles drawn around towers E, G and H all intersect on the corner of Barker St and Robinson St. Discuss the significance of this intersection.

Often, locating a mobile phone can be done through the process of *triangulation*, using the pinged distance from three different phone towers to accurately locate the phone. Why does triangulation require *three* phone towers? You can model the process by placing a student in the centre of the classroom and connecting ropes to the corners of the room. How many ropes do you need to attach to the student before their location can be fixed?

Further activities

Activity 1

Instead of giving students the straight-line distance from the tower to the phone, provide students with the time taken to receive a response from the tower. This will require student research into the speed of communications.

Activity 2

Students use the process described in the Teacher background information to create their own map and/or story for another student to solve.

LESSON 1

Find My Phone

Name: ________________________________

Each tower is accurate to within 10 metres.

Time	Tower	Tower height (above sea level)	Pinged distance to tower	Phone height (above sea level)
9:07 am	V	123 m	461 m	24 m
9:11 am	W	82 m	200 m	25 m
9:15 am	Q	50 m	280 m	31 m
9:19 am	K	3 m	341 m	30 m
9:23 am	H	227 m	305 m	20 m
9:27 am	E	53 m	303 m	18 m
9:31 am	G	169 m	296 m	19 m