# Significant distances

In this activity, students learn about significant figures by calculating distances between the Earth and the stars using trigonometry, developing the need for a simpler way of expressing large distances.

This activity is designed to support students who have experience using trigonometry to find missing sides in right-angled triangles.

This lesson can be simulated via the Desmos activity [Significant distances](https://teacher.desmos.com/activitybuilder/custom/63fd74a9d2e16a2bfe16057c?collections=63d719e03c6fb65193e17a14) ([bit.ly/Desmos-significant-distances](https://bit.ly/Desmos-significant-distances)).

## Visible learning

### Learning intentions

* To appreciate the usefulness of significant figures in expressing very large measurements.
* To be able to round very large numbers to a specified number of significant figures for comparison.

### Success criteria

* I can compare two very large numbers expressed to two significant figures.
* I can round a very large number to any number of significant figures.

### Syllabus outcomes

A student:

* develops understanding and fluency in mathematics through exploring and connecting mathematical concepts, choosing and applying mathematical techniques to solve problems, and communicating their thinking and reasoning coherently and clearly **MAO-WM-01**
* applies trigonometric ratios to solve right-angled triangle problems **MA5-TRG-C-01**
* solves measurement problems by using scientific notation to represent numbers and rounding to give a number of significant figures **MA5-MAG-C-01**

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Please use the associated PowerPoint *Significant distances* to display images in this lesson.

## Activity structure

### Launch

1. Display Figure 1.

Figure 1 – stars in night sky



1. Explain to students that this is an image of the sky taken from Earth. Have students think about the following 2 questions individually.
2. Which star do you think is the closest to Earth?
3. How do you know?
4. Ask students to engage in a [Think-Pair-Share](https://bit.ly/thinkpairsharestrategy) ([bit.ly/thinkpairsharestrategy](https://bit.ly/thinkpairsharestrategy)) discussing their answers to the questions.

### Explore

If students have a device with access to the internet, send them to this [Desmos graph](https://bit.ly/DesmosDistancetoastar) ([bit.ly/DesmosDistancetoastar](https://bit.ly/DesmosDistancetoastar)) and have them follow along with the steps below.

If devices are unavailable, follow these steps to demonstrate the process and follow the steps in the ‘Paper-based activity’ section below.

1. Display the [Desmos graph](https://bit.ly/DesmosDistancetoastar) ([bit.ly/DesmosDistancetoastar](https://bit.ly/DesmosDistancetoastar)) on the screen.
2. Turn on folders A and B to display the solar system.
3. Turn on folder C to display some stars, each of which is numbered for reference.

Figure 2 – Solar system

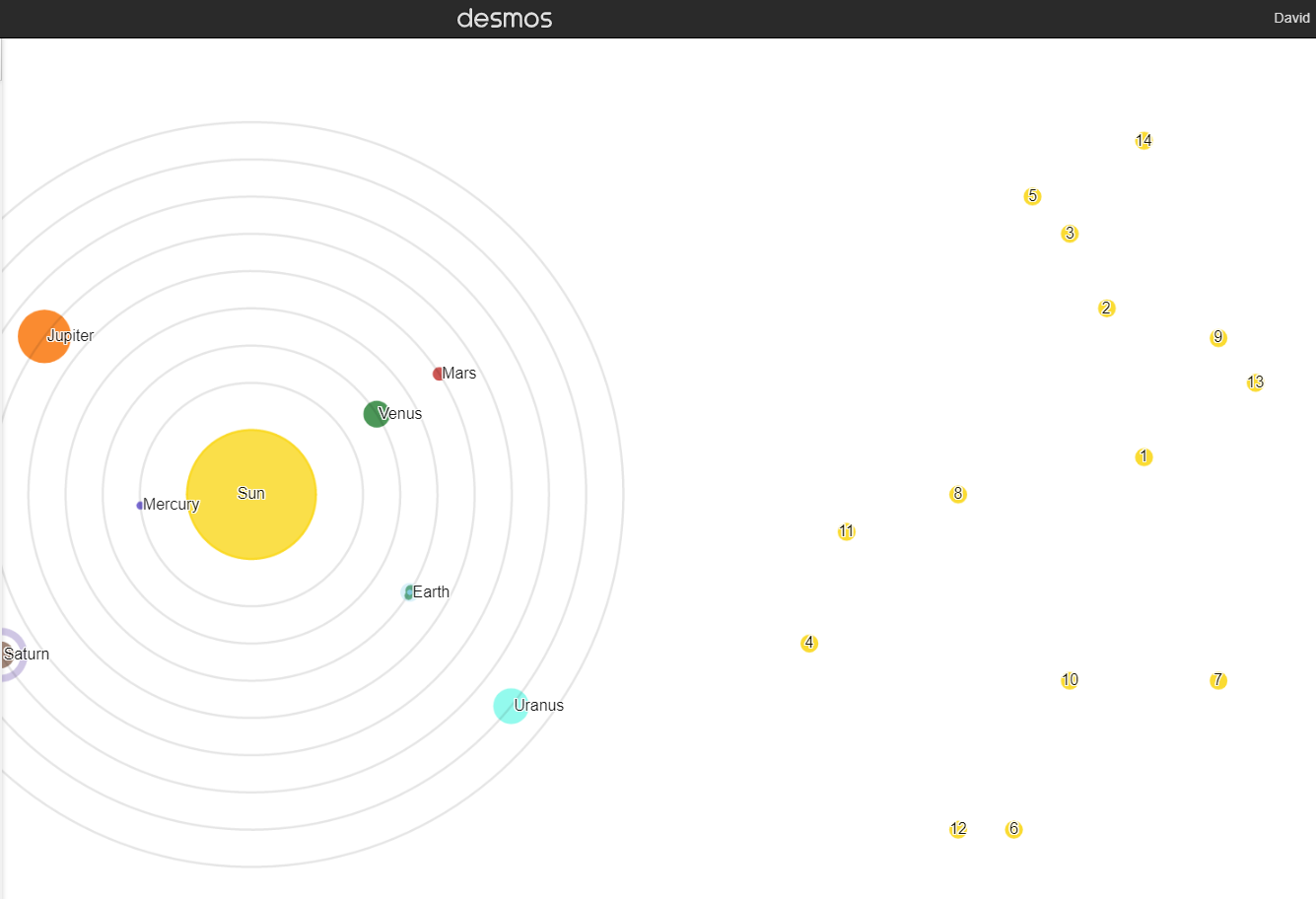


Image created using [Desmos](https://www.desmos.com/?lang=en) and is licensed under the [Desmos Terms of Service](https://www.desmos.com/terms?lang=en).

1. Have students complete a [Notice and Wonder](https://bit.ly/noticewonderstrategy) table ([bit.ly/noticewonderstrategy](https://bit.ly/noticewonderstrategy)) and discuss some shared wonderings.

Teachers may wish to acknowledge that this diagram is not to scale, and that the closest star to Earth and our solar system is over 50,000 times further away than these stars. Additionally, the orbit of the planets around the Sun is not circular.

1. Turn off folder A and B to avoid the distraction of the other planets. Leave on folder C only.
2. Inform students that we know the approximate distance from the Earth to the Sun, being 149,600 000 km. Turn on folder D to display this.
3. Press the pause button next to A (line 75), to stop the Earth from spinning.
4. Display Figure 3, where the Earth is directly in between the Sun and the star with number 1. This figure is in the associated PowerPoint file.

Figure 3 – image 1 of Sun, Earth and star

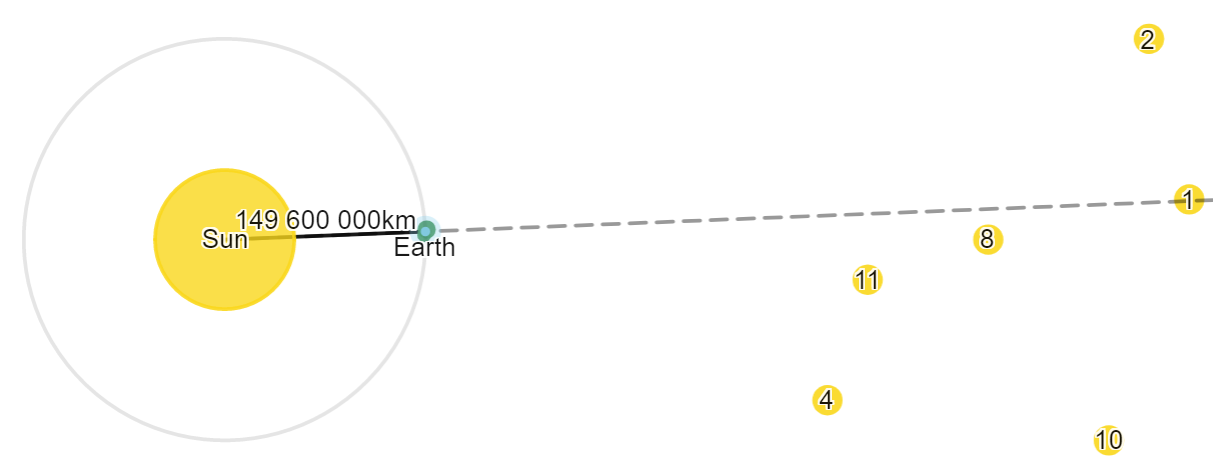


Image created using [Desmos](https://www.desmos.com/?lang=en) and is licensed under the [Desmos Terms of Service](https://www.desmos.com/terms?lang=en).

1. Challenge students to consider how we can know when the Earth, Sun and star form a right angle if we know the Earth is directly between the Sun and star right now.

If we know the Earth is directly between the Sun and a star right now, in 3 months, exactly a quarter of a year, the Earth, Sun and star will form a right angle.

1. Demonstrate to students how we can form a right-angled triangle with the Earth, the Sun and a star as the 3 vertices, by taking the following steps.
2. Turn on folder E to see measurements.
3. Select the Earth and drag it around its orbit until the dotted line goes through a star, as shown in Figure 4 below. This is equivalent to us waiting until the right time of year, when the Earth, Sun and star form a right angle.

Figure 4 – image 2 of Sun, Earth and star

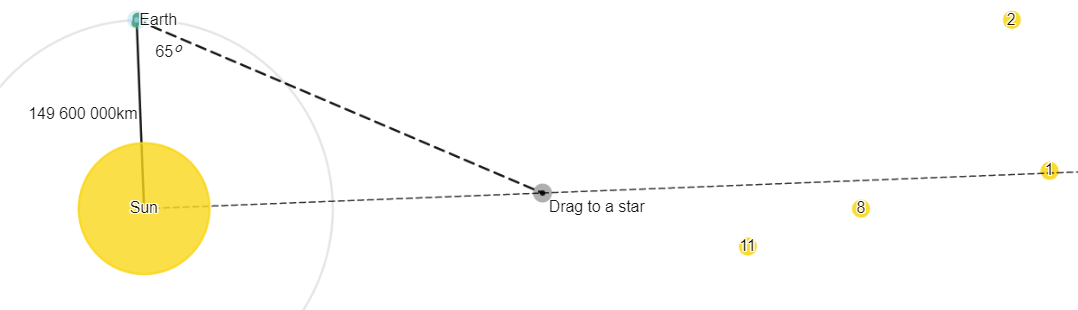


Image created using [Desmos](https://www.desmos.com/?lang=en) and is licensed under the [Desmos Terms of Service](https://www.desmos.com/terms?lang=en).

1. Drag the black point until it is on top of the star, to measure the angle to the star, as shown in Figure 5 below.

Figure 5 – image 3 of Sun, Earth and star

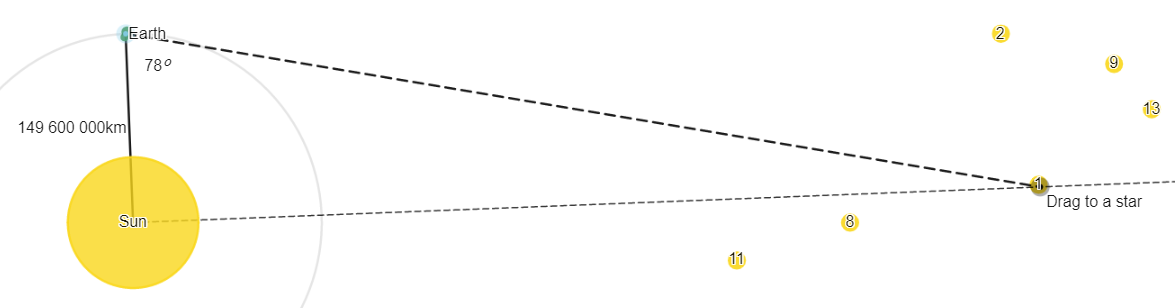


Image created using [Desmos](https://www.desmos.com/?lang=en) and is licensed under the [Desmos Terms of Service](https://www.desmos.com/terms?lang=en).

1. We now have a right-angled triangle, with one angle and a side length known. We can use this to find the distance from the Earth to the star, and the Distance from the Sun to the star, using trigonometry.
2. Display [Appendix B](#_Appendix_B) for students and have them review the worked example individually.
3. Students indicate to the teacher when they have read the example by using a thumbs up.
4. Students discuss the worked example with a peer, explaining what is happening at each step.
5. Pairs should then adjust the triangle in Desmos to aim at Star 2 and complete the calculations for themselves.
6. Alternatively, students could be handed [Appendix A](#_Appendix_A) to measure the distance of the stars from the Earth and Sun using a protractor, ruler and pencil.
7. Hand students a copy of [Appendix C](#_Appendix_C) and have them record the distances of all 14 stars both from the Earth, and from the Sun, and answer the question about which star they believe is the furthest from us. They will leave the third and fifth columns empty for the moment.

It is likely that [Appendix A](#_Appendix_A) will become difficult to work with after finding a few stars. Students could rub out existing working, be given multiple copies of the map, or work with peers. [Appendix A](#_Appendix_A) could also be laminated and used with a whiteboard marker.

#### Significant figures

1. Express to students that comparing the measurements found and recorded in [Appendix C](#_Appendix_C) is challenging.
2. Use the Significant distances PowerPoint for explicit teaching of the skills required for interpreting and rounding to significant figures. This includes:
3. Identifying the number of significant figures of a measurement.
4. Rounding a measurement to a specified number of significant figures.

The explicit teaching technique used in the PowerPoint is Your turn. The first slide is a worked example which should be displayed for the students and then use the following steps.

1. Reveal the question to students and its solution.
2. Students read in silence.
3. Students individually think and explain to themselves what is happening in each step.
4. Students give a thumbs up to the teacher when they have finished reading.
5. Think, pair, share. Students explain the solution to their partner.
6. In pairs, students then answer the self-explanation questions.
7. Finally, randomly select students to share their answers with the whole class.

### Summarise

1. Students are to complete column 3 and 5 of [Appendix C](#_Appendix_C), rounding all of their measurements to 3 significant figures.
2. Teacher to lead a discussion around significant conclusions from this investigation:
3. Rounding to a number of significant figures, where we simplify measurements to show their most significant digits, improves the ease of understanding and comparison.

### Apply

Students are to attempt the Goal free problem in [Appendix D](#_Appendix_D). Students are to round each measurement to 2 significant figures as they calculate.

## Assessment and Differentiation

### Suggested opportunities for differentiation

**Explore**

* Challenge students to consider the closest and furthest distances that the Earth will be from a star. Can this be calculated from what we know?
* Challenge students to consider how we might know when the Earth, the Sun, and a star form a right angle.
* Challenge students to investigate the scenario ‘What if all 0's could not be significant figures?’

**Apply**

* A goal free problem allows students to find what they are capable of. For students who find incorrect measurements via trigonometry, they will not be restricted from applying their learnt skills with rounding to a number of significant figures.
* Challenge students to investigate the differences in the final measurements if you did not round to 2 significant figures after each calculation.

### Suggested opportunities for assessment

**Explore**

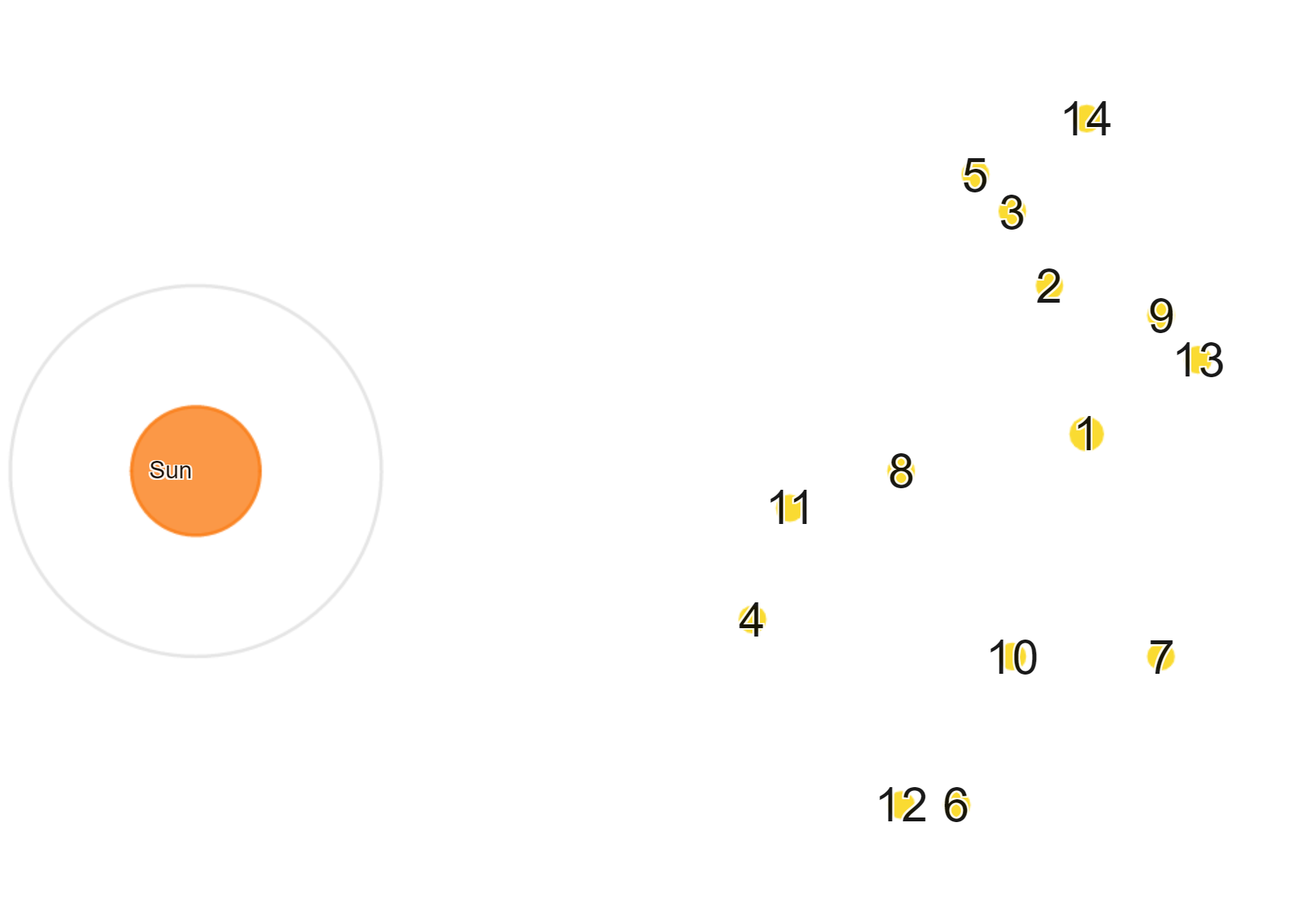
* The Desmos activity allows the teacher to record, review, and give feedback on student responses. There are multiple opportunities for students to express their thinking.

**Summarise and Apply**

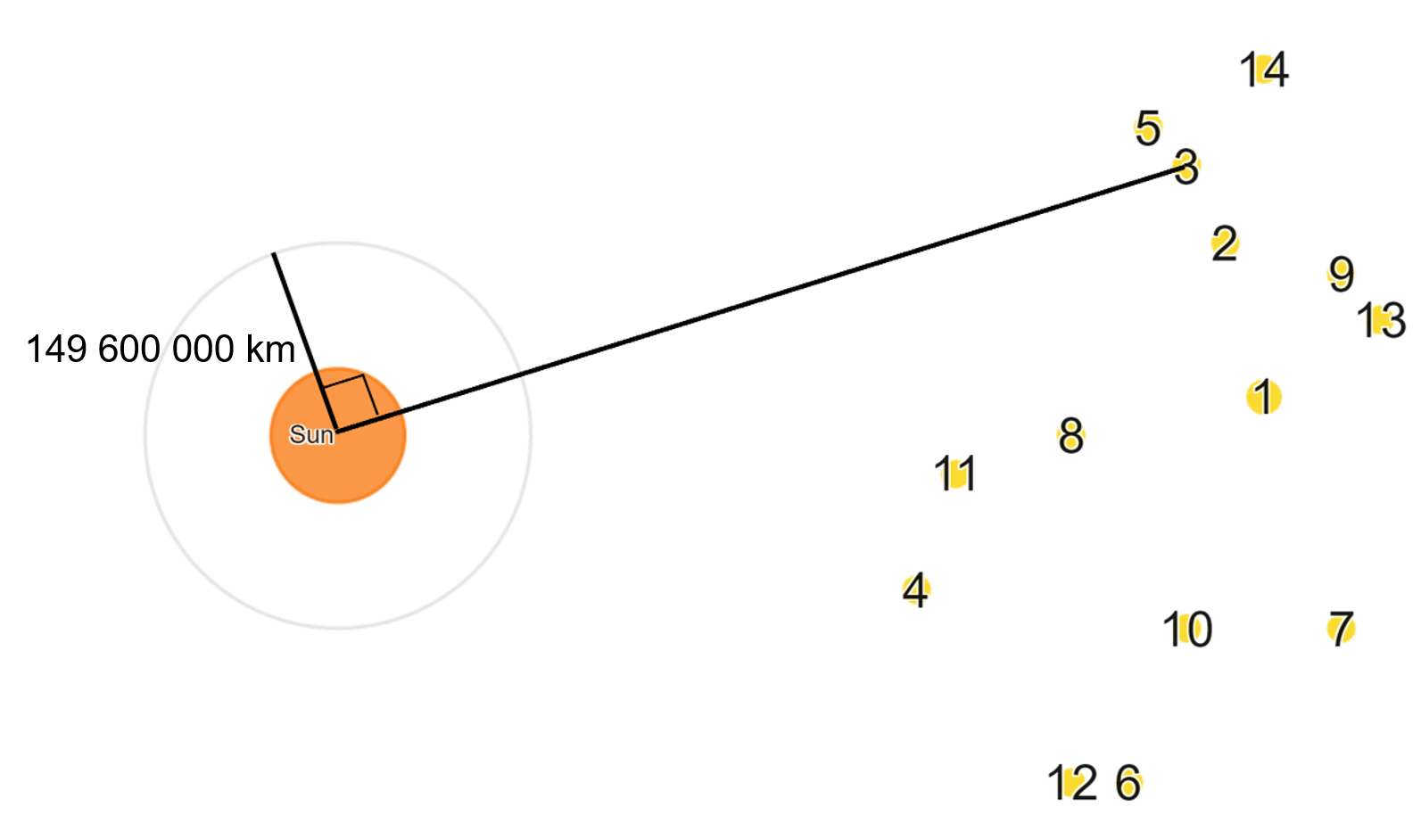
* Collect [Appendix C](#_Appendix_C) and/or [Appendix D](#_Appendix_D) to act as an exit ticket, both to assess student's continuing development of trigonometry skills, as well as their newly developed concept of significant figures.

## Appendix A

### Map of the Earth, Sun and stars



#### How to use this map

1. Draw a line from the centre of the Sun to any star.
2. Use your protractor to draw another line from the Sun to the Earth's orbit, making a right angle as shown below. Mark this new side with the distance between the Earth and the Sun, 149,600,000 km. 
3. Connect the final side and use a protractor to measure the angle on the Earth's orbit (we can only measure the angle from Earth).This is an image of the sun, surrounded by a circle representing the Earth's orbit, all built and copied from Desmos. There are then 14 numbered stars in the distance. There is also now a right angle at the sun, with the distance of 149 600 000 km extending to the Earth's orbit, and another arm extending to star number 3.
   There is now also an additional arm joining star number 3 to the Earth, and a 75 degree angle at the Earth. 
4. Use trigonometry to find the length of the 2 remaining sides of the right-angled triangle.

## Appendix B

### Worked examples

This is an image of the sun, surrounded by a circle representing the Earth's orbit, all built and copied from Desmos. There are then 14 numbered stars in the distance. There is also now a right angle at the sun, with the distance of 149 600 000 km extending to the Earth's orbit, and another arm marked with an S extending to star number 1.
There is also an additional arm marked with an E, extending from the Star to the Earth, forming a 78 degree angle at the Earth. 

#### Distance from the Sun to the star

#### Distance from Earth to the star

## Appendix C

### The distance of 14 stars

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Star | Distance from the Sun | 3 significant figures | Distance from the Earth | 3 significant figures |
| 1 | 703,812,664 km | 704,000,000 km | 719,536,257 km | 720,000,000 km |
| 2 |  |  |  |  |
| 3 |  |  |  |  |
| 4 |  |  |  |  |
| 5 |  |  |  |  |
| 6 |  |  |  |  |
| 7 |  |  |  |  |
| 8 |  |  |  |  |
| 9 |  |  |  |  |
| 10 |  |  |  |  |
| 11 |  |  |  |  |
| 12 |  |  |  |  |
| 13 |  |  |  |  |
| 14 |  |  |  |  |

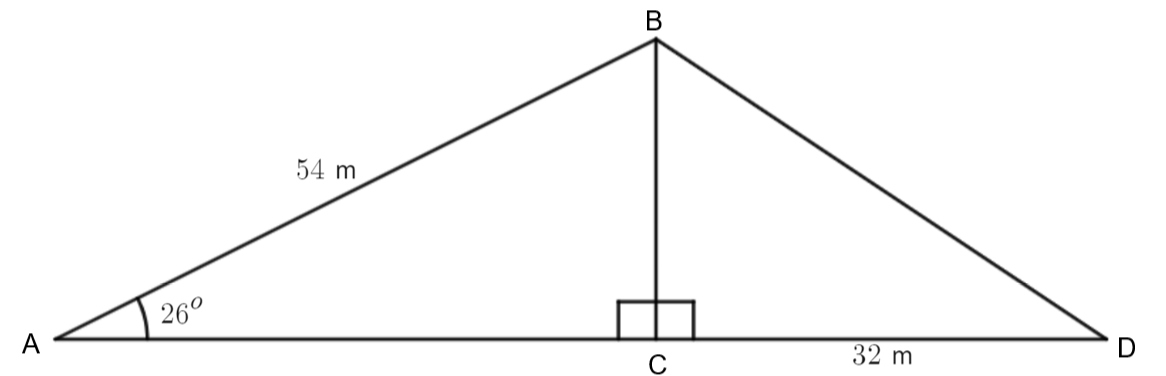
Which star do you think is the closest to the Sun?

Which star do you think is the closest to the Earth?

## Appendix D

### Goal free problem

Find all the information you can in this diagram. Round each measurement to 2 significant figures.



## Sample solutions

### Appendix D

This is an image of two right-angled triangles, ABC and DBC, which are joined by the side BC. Both triangles have their right angle at the vertex C. DC = 32 m and AB = 54 m, while the angle BAC is known to be 26 degrees. 
Additional solutions show that AC = 49 m, BC = 24 m and BD = 40 m, while angles ABC = 64 degrees, CBD = 53 degrees, and BDC = 37 degrees. 

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