# Cylinders and water

Students investigate different problems involving cylinders and water including pools, tanks and sprinklers.

## Visible learning

### Learning intention

* To be able to solve problems involving the volume and capacity of cylinders.

### Success criteria

* I can use rates to solve problems with volume and capacity.
* I can convert between measurements in cubic metres and litres.
* I can use different units of measurement to calculate the volume of cylinders.

### 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 knowledge of volume and capacity to solve problems involving right prisms and cylinders **MA4-VOL-C-01**

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Table 1: lesson summary

|  |  |  |  |
| --- | --- | --- | --- |
| Section | Summary of activity | Teaching strategies | Teaching points |
| **Launch** | Students are shown a picture of a hose filling a pool and a graph on slide 3 of the PowerPoint Cylinders and water (CAW PPT) and discuss the rate at which the pool is being filled. | Think-Pair-Share  Pose-Pause-Pounce-Bounce | Students recognise that the rate indicates how much water is added to the pool each minute and that the depth of water is determined by the size of the pool and the amount of water in it at any moment. |
| **Explore** | Students calculate the amount of rain on a roof and in a water tank to see if the tank would be full. A picture of a sprinkler on slides 5 and 6 of the PowerPoint prompts investigation of how much water is used by the sprinkler. | Visibly random groups of 3  Vertical non-permanent surfaces  Assessing and advancing questions  Gallery walk  Notice and wonder  Pose-Pause-Pounce-Bounce | Students visualise rainfall in the shape of a rectangular prism and a cylinder and calculate the volume of the water. |
| **Summarise** | Using a scenario relating to irrigation of a crop on slides 8 and 9 of the PowerPoint (CAS PPT), students are asked to find and correct an incorrect solution in [Appendix A](#_Appendix_A). | Notice and wonder  Visibly random groups of 3  Vertical non-permanent surfaces  Pose-Pause-Pounce-Bounce | Students identify common errors, such as using the wrong dimensions and converting measurements incorrectly, when using the formula for volume of a cylinder and converting to litres. |
| **Apply** | Students solve practical problems relating to cylinders and water in [Appendix B](#_Appendix_B). | Visibly random groups of 3  Vertical non-permanent surfaces | Students calculate the volume of cylinders and rectangular prisms, converting between cubic metres and litres. |

## Activity structure

Please use the associated PowerPoint *Cylinders and water* (CAW PTT)to display images in this lesson.

### Launch

1. Display slide 3 of the PowerPoint (CAW PPT). In a Think Pair-Share ([bit.ly/thinkpairsharestrategy](https://bit.ly/thinkpairsharestrategy)) have students consider the following scenario by reading it aloud:

A children’s swimming pool, which is in the shape of a cylinder, is being filled with water from a hose. The pool has a radius of 60 cm. If the hose releases water at a rate of 16 L of waterper minute, how long will it take to fill the pool to a depth of 20 cm?

1. Use the Pose-Pause-Pounce-Bounce questioning strategy (PDF 557 KB) ([bit.ly/posepausepouncebounce](https://bit.ly/posepausepouncebounce)) to discuss the rate at which the pool fills. Some useful question prompts may include:

* How much water is in the pool after one minute?
* How much water is in the pool after 5 minutes?
* At what rate is the pool filling?
* How could we know how deep the water would be after 10 minutes?

Students can determine from both the information provided and the graph that after one minute, there are 16 L of water in the pool and that after 5 minutes there are 80 L of water in the pool.

Students should recognise that the rate at which the pool fills is 16 L per minute.

The volume of water required for a depth of 20 cm is 226 L.

Students were introduced to rates in Unit 13 – ratios and rates.

### Explore

1. Read the following scenario to students.

Jo’s roof is a rectangle with an area of 120 m2. Rainfall from the roof feeds into a water tank. There is 25 mm of rain predicted to fall. Jo’s tank has a capacity of 5000 L. Will the rain fill the empty tank?

1. Assign students to visibly random groups of 3 ([bit.ly/visiblegroups](https://bit.ly/visiblegroups)) at vertical non-permanent surfaces ([bit.ly/VNPSstrategy](https://bit.ly/VNPSstrategy)) to solve the problem.

Students will need to decide which unit of measurement they will use to complete their calculations and then convert some measurements to be able to calculate the volume of water from the roof and compare it with the capacity of the tank.

1. Ask students assessing and advancing questions ([bit.ly/supportingstrategies](https://bit.ly/supportingstrategies)) to further student thinking. Some suggestions are provided in the following table.

Table 2: assessing and advancing questions

|  |  |
| --- | --- |
| Assessing questions | Advancing questions |
| What units of measurement have you decided to use? | Could you convert some of the measurements? |
| How did you use the 25 mm measurement? | How could the formula for the volume of a prism be used? |
| How do you convert cubic units to litres? | How much rain is needed to fill the tank? |

1. Students are to do a gallery walk ([bit.ly/DLSgallerywalk](https://bit.ly/DLSgallerywalk)) to view the solutions of other groups.
2. Discuss with the class how the formula for the volume of a prism was useful for solving the problem and how the volume of rain that fell on the roof was calculated.

Students may benefit from being encouraged to visualise the rain being collected on the roof in the shape of a rectangular prism.

1. Display slide 5 from the PowerPoint (CAW PPT). The slide shows water being distributed from a sprinkler head in a circle formation to water a lawn.
2. Ask students what they notice and wonder ([bit.ly/noticewonderstrategy](https://bit.ly/noticewonderstrategy)).

Students may notice that the water is spread in the shape of a circle. They might wonder what sized circle the sprinkler can water and how much water the sprinkler uses.

1. With students continuing in their random groups of 3 at their vertical non-permanent surfaces, read the following information out to students. This is also displayed on slide 6 of the PowerPoint (CAW PPT).

The sprinkler distributes water in the shape of a circle with a radius of 3 m at a rate of 16 L per minute (L/min). The lawn needs 10 mm of water to soak the lawn. How much water is used by the sprinkler and for how long should the sprinkler be on, before it is moved?

1. Ask students assessing and advancing questions ([bit.ly/supportingstrategies](https://bit.ly/supportingstrategies)) to further student thinking. Some suggestions are provided in the following table:

Table 3: assessing and advancing questions

|  |  |
| --- | --- |
| Assessing questions | Advancing questions |
| How did you use the 10 mm measurement? | How could the formula for volume of a cylinder be used? |
| How is the problem similar to the problem of filling a pool? | How would you solve the problem if the water was filling a pool? |
| Can you show me the important information from the question that will help to calculate the water used by the sprinkler? | What information do you need to calculate the amount of water? |
| How did you determine the time needed? | What information is needed to calculate the amount of time? |
| Did you draw a diagram? | Could you draw a diagram? |
| How did you use the radius of a circle? | Could you create a table of values or draw a graph to find the amount of water? |

1. Students are to do a gallery walk ([bit.ly/DLSgallerywalk](https://bit.ly/DLSgallerywalk)) to view the solutions of other groups.
2. Discuss with the class how they calculated the amount of water used by the sprinkler and the amount of time the sprinkler needs to be on for.
3. Use the Pose-Pause-Pounce-Bounce questioning strategy to help students draw a connection between how they solved the problem involving rainfall on the roof and how they solved the sprinkler problem. Useful question prompts may include:

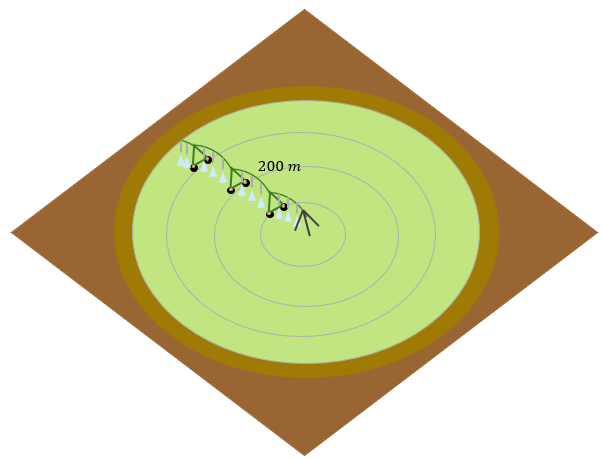
* Why can we use a formula for a 3-dimensional solid to help us calculate rainfall on a roof?
* Why can we use the formula for the volume of a cylinder to calculate the volume of water coming out of the sprinkler?

Encourage students to recognise the similarity between visualising the rainfall on the roof as a rectangular prism and the water coming out of the sprinkler as a cylinder.

### Summarise

1. Display slide 8 of the PowerPoint (CAW PPT). It shows a picture of a pivot irrigation system being used to irrigate crops.

Figure 1: a diagram of a pivot irrigation system



1. Ask students to consider what they notice and wonder ([bit.ly/noticewonderstrategy](https://bit.ly/noticewonderstrategy))about the picture.

Students might notice that the field is a circle and that the watering system, which is the radius of the largest circle, is 200 m long.

They might wonder how it moves and where the water comes from.

The diagram represents a pivot irrigation system. There are differences between systems, but generally the water is supplied in some way, possibly by an underground pipe, to the centre and is distributed along the hoses which extend out from the centre. The wheels may be automated to move the hoses around, but other methods to move the arm of the watering system, such as using a tractor on the outside of the arm, may be used.

1. Teachers may like to show students the video ‘What is a Center Pivot?’ (2:37) ([bit.ly/centre\_pivot](https://bit.ly/centre_pivot)) until the 1:05 mark if they wish to enhance student understanding of how centre pivot irrigation works.
2. Display slide 9 of the PowerPoint (CAW PPT). It shows the picture of the pivot irrigation system with some information and a question about the system. The slide also says that Luca has attempted to answer the question but has made some errors.
3. Ask students to read the information, then distribute Appendix A ‘Farm irrigation’ to each student. Students should study Luca’s attempt to solve the problem, displayed in Appendix A, and then find the error and create a correct solution.
4. Use the Pose-Pause-Pounce-Bounce questioning strategy to discuss the mistakes and the solution.

### Apply

1. Distribute Appendix B ‘How much water?’
2. Students are to return to their group of 3 at their vertical non-permanent surfaces to solve the problems.

## Assessment and differentiation

### Suggested opportunities for differentiation

**Launch**

* Students could determine the equation of the line shown on slide 3 of the PowerPoint (CAW PPT).
* Students could be challenged to consider how long it would take to fill an Olympic-sized swimming pool.
* Students might find it useful to create a table of values from the graph to determine the amount of water used at any time.

**Explore**

* Students could consider why Smart Water Choices require watering of lawns to occur before 10 am and after 4 pm.

**Apply**

* Students may be supported by providing a scaffold for the questions.
* Sprinkler systems can be adjusted to distribute water in sectors. Ask students to compare the amount of water used by sprinklers set to distribute water in different arc lengths, including in a semicircle.

### Suggested opportunities for assessment

**Launch**

* Observe students' reasoning skills when discussing how deep the water is after 10 minutes.

**Explore**

* Students working at vertical non-permanent surfaces means the teacher can assess student progress and provide support where appropriate.
* When placed in groups of 3, students provide and receive peer feedback on their understanding.

**Summarise**

* A gallery walk allows students to self- and peer-assess following the activity.

**Apply**

* Students working at vertical non-permanent surfaces means the teacher can assess student progress and provide support where appropriate.
* Student work from Appendix B could be collected as evidence of being able to calculate the volume of cylinders.

## Appendix A

### Farm irrigation

Explain the mistakes made in Luca’s incorrect solution and write the correct solution.

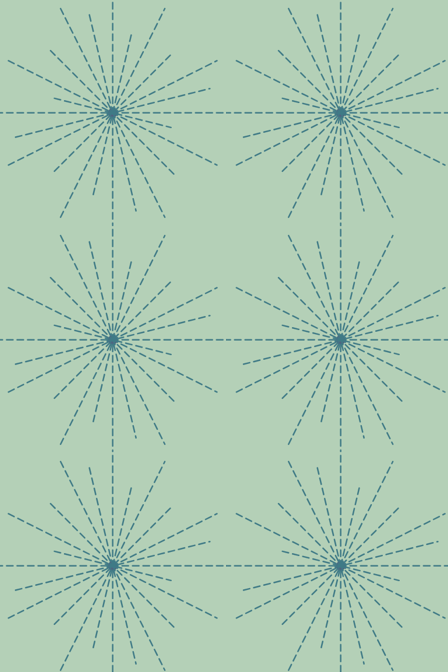
|  |  |  |
| --- | --- | --- |
| Luca’s incorrect solution | Explain mistakes made | Correct solution |
| A diagram of a blue cylinder with diameter 200 metres and height 12 millimetres.  The system uses 3770 litres. |  |  |

## Appendix B

### How much water?

1. Morgan has a small sprinkler that distributes water using a radius of 1.2 m at a rate of 16 L per minute. For how long should Morgan have the sprinkler on for it to deliver 10 mm of water to the lawn?
2. Kai’s cylindrical water tank has a diameter of 4.6 m. Kai measured the side of the tank to discover that the tank only had water up to a height of 60 cm. Kai’s watering system has 6 sprinkler heads, each distributing water at a radius of 3 m at a rate of 16 L per minute.

Will Kai have enough water for the lawn, if the lawn needs 10 mm of water?



1. Nori has planted tomatoes in the garden. The garden has a sprinkler that distributes water in a circle with a radius of 2 m. Use the table below to determine the total number of litres of water the tomatoes need over the period from germination to harvesting.

|  |  |  |
| --- | --- | --- |
| Growth stage | Water requirement | Duration |
| Germination and early growth | 6 mm/day | 30 days |
| Growing and flowering | 9 mm/day | 40 days |
| Fruiting and harvesting | 7 mm/day | 20 days |

1. Olly has a plastic water tank in the garden which is in the shape of a cube with dimensions of 1.2 m and a metal watering can in the shape of a cylinder, which is 40 cm tall and has a diameter of 30 cm. If the plastic water tank is full, how many times will Olly be able to fill the watering can using the tank water before the tank is empty?

## Sample solutions

### Explore

Volume of rain:

The rain won’t fill the empty tank.

Sprinkler calculations:

The lawn would need 280 L of water and the sprinkler should be on for 17.5 minutes.

### Appendix A – farm irrigation

|  |  |  |
| --- | --- | --- |
| Incorrect solution | Explain mistake made | Correct solution |
| A diagram of a blue cylinder with diameter 200 metres and height 12 millimetres.  The system uses 3770 litres. | * The incorrect radius was used. * The 12 mm height was converted incorrectly. * The answer for cubic metres was used for the number of litres. | A diagram of a blue cylinder with diameter 200 metres and height 12 millimetres.  The system uses 1508 kilolitres. |

### Appendix B – How much water?

|  |  |
| --- | --- |
|  | Morgan needs to have the sprinkler on for 3 minutes. |
|  | Amount of water in tank:  A cylinder with a height of 60 centimetres and a diameter of 1.6 metres.  The sprinkler system needs 10 mm of water for each sprinkler and there are 6 sprinklers:  A cylinder layered with lines. Each layer is 10 millimetres in height and there are 6 layers. The radius is 3 metres.  There will not be enough water in the tank. |
|  | Total depth of water needed:  Volume of water used by sprinkler:  Nori needs 8545 litres of water for the tomatoes. |
|  | Volume of water tank:  Volume of watering can:  Olly will be able to fill the watering can 61 times. |

## References

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