# Diameter and circumference

Students create number patterns to explore the relationship between the length of the line of symmetry of a shape and its perimeter, leading to the development of an equation to find the circumference of a circle.

Students will need at least one digital device per pair to interact with Desmos during this lesson.

## Visible learning

### Learning intention

* To understand the relationship between the diameter and circumference of a circle.

### Success criteria

* I can complete a table of values.
* I can create an equation to represent the relationship between the length of the line of symmetry and perimeter of a regular shape.
* I can define the terms ‘circumference’ and ‘diameter’.
* I can estimate an equation to represent the relationship between diameter and circumference.

### 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**
* represents and operates with fractions, decimals and percentages to solve problems   
  **MA4-FRC-C-01**
* applies knowledge of the perimeter of plane shapes and the circumference of circles to solve problems **MA4-LEN-C-01**

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Table 1: lesson summary

|  |  |  |  |
| --- | --- | --- | --- |
| Section | Summary of activity | Teaching strategies | Teaching points |
| Launch | Show the video ‘Polygons of increasing sides compared to a circle’ (0:14) ([bit.ly/regular-polygons-to-circle](https://bit.ly/regular-polygons-to-circle)) to start a class discussion. | Think-Pair-Share | Students discuss when a polygon could be assumed to be a circle. |
| Explore | Students complete tables of values to find an equation representing the relationship between the length of the line of symmetry of a shape and its perimeter ([Appendix A](#_Appendix_A)). Students discuss the pattern that happens each time we add a side. | Visibly random groups of 3  Vertical non-permanent surfaces  Turn and talk | Students explore how adding more sides affects the relationship between a shape’s line of symmetry and its perimeter. |
| Summarise | Define ‘perimeter’ and ‘circumference’ to students for them to write in their own words on a glossary page before they estimate the slope of an equation and write their equation using and . | Pose-Pause-Pounce-Bounce | Students define key terms in their own words. |
| Apply | Students complete the Desmos Classroom activity ‘Circumference Exploration’ ([bit.ly/circle-exploration](https://bit.ly/circle-exploration)) before discussing the accuracy of their equations.  Alternatively, students can measure a circular object’s diameter and circumference ([Appendix B](#_Appendix_B)) to attempt to create a better equation. | Pose-Pause-Pounce-Bounce  Turn and talk | Students apply their knowledge of surds to problems. |

## Activity structure

### Launch

Show the video ‘Polygons of increasing sides compared to a circle’ (0:14) ([bit.ly/regular-polygons-to-circle](https://bit.ly/regular-polygons-to-circle)) and in a Think-Pair-Share ([bit.ly/thinkpairsharestrategy](https://bit.ly/thinkpairsharestrategy)), ask students:

* As we increase the number of sides in a regular polygon, what happens to the shape?
* How many sides would we need for the shape to be considered a circle?

### Explore

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)).
2. Define ‘line of symmetry’ to students as a straight line that divides a shape into 2 equal parts.
3. Draw a square for students, and in a turn and talk ([bit.ly/classroomtalkmoves](https://bit.ly/classroomtalkmoves)), ask students to find an example or examples of the line of symmetry of a square.
4. Distribute Appendix A ‘Regular polygon relationships’ to each group.
5. Ask students to complete the table of values by finding the length of the vertical line of symmetry and perimeter of the squares provided and write an equation showing the relationship between the length and perimeter of a square.
6. Select groups randomly and ask them to share how they found their equation from the table of values.
7. Ask students to complete this process for the remaining shapes in Appendix A, noting how the equation changes each time we add a side.
8. Students are to compare their equations with another group and explain how they found their equations before randomly chosen groups share them with the class.
9. In a turn and talk, ask students to respond to the following questions and ask random students to share their responses:

* How does the equation change each time we add a side?
* What do you think will happen if we continued to increase the number of sides?

The co-efficient of approaches as we increase the number of sides. Students might not know about yet and will learn about this number more in Lesson 2 – irrational numbers.

Students might theorise that the coefficient of decreases each time you add a side. Noting that a circle does not have zero perimeter would aid students to realise it must be a certain number.

### Summarise

1. Define the perimeter of a circle to be the circumference and the diameter of a circle to be the line of symmetry that connects 2 points on the circumference and passes through the centre.
2. Ask students to create a glossary page for this unit of learning and write their own definitions for circumference and diameter.

The glossary page can be any page in their notes where they add new words during the unit.

1. Ask pairs to create an equation they think would represent the relationship between the diameter () of a circle and its circumference () algebraically and in words.

For example, students might suggest as their equation, explaining in words that the circumference is 3 times the diameter.

1. Use the Pose-Pause-Pounce-Bounce questioning strategy (557 KB) ([bit.ly/posepausepouncebounce](https://bit.ly/posepausepouncebounce)) to share ideas and reasoning and discuss the accuracy of their equation.

This activity provides the opportunity for students to show their reasoning and justification skills and connect knowledge. Students who believe it is heading towards zero can be asked, ‘If the diameter of a circle is one, would the circumference be zero?’

Students can also be extended to graph their points to predict the coefficient of for the equation of the circumference of a circle, which is content from Stage 5 – Non-linear relationships B.

### Apply

1. With one device between each pair of students, have them complete the Desmos Classroom activity ‘Circumference exploration’ ([bit.ly/circle-exploration](https://bit.ly/circle-exploration)).

Before starting this activity, you will need to set up a Desmos Classroom ([bit.ly/createdesmosclassroom](https://bit.ly/createdesmosclassroom)).

In this activity, students use the line tool to draw the diameter of a circle, then use the pen tool to sketch the circumference. The length of each measurement will be displayed for students to explore the relationship between circumference and diameter.

1. In a turn and talk, ask students to compare the equation they created in this activity with the equation they created in the Summarise section.
2. Use the Pose-Pause-Pounce-Bounce questioning strategy to ask students which of their equations they believe is the most accurate equation to find the circumference of a circle based on their results and why.

#### Optional fieldwork

1. Supply groups of 3 students with some string, a ruler and Appendix B ‘Testing the equation’.
2. Ask students to find circular objects around the school and use them to complete the table in Appendix B. They will need to measure the diameter of each object, use their equation to estimate the circumference and then measure the circumference using the string.
3. Ask students to attempt to modify their equation to try and achieve a better estimate for the circumference.

## Assessment and differentiation

### Suggested opportunities for differentiation

**Launch**

* In a Think-Pair-Share, the ownership of answers is with a pair of students when sharing with the whole group, making students feel more comfortable and confident to contribute.

**Explore**

* Numbers on Appendix A can be modified so that the length of the line of symmetry is going up by regular intervals to make it easier to find the gradient for the question.
* Challenge students to compare if the length of the line of symmetry being the diagonal of a square would make a difference and have them calculate the length using Pythagoras’ theorem.
* Students might benefit from being reminded how to find the perimeter of a shape.
* Students might benefit from being reminded what a regular polygon is from Stage 3.
* Enable students by providing a list of equations to match to the tables of values for each shape.
* Students could be challenged to represent the relationship between the length of the line of symmetry and the perimeter of a shape as a ratio.

**Apply**

* An alternative activity has been provided for students who are unable to draw.
* There is no correct answer for the equation to find the circumference of a circle so all students should be encouraged to participate.

### Suggested opportunities for assessment

**Launch**

* Students give each other peer feedback, before sharing with the class in a Think-Pair-Share.

**Explore**

* Appendix A could be collected as evidence of learning towards Unit 14 – analysing patterns.
* When discussing with students, teachers can encourage students to think about their decisions.

**Summarise**

* Review students’ glossary pages for their understanding of diameter and circumference.

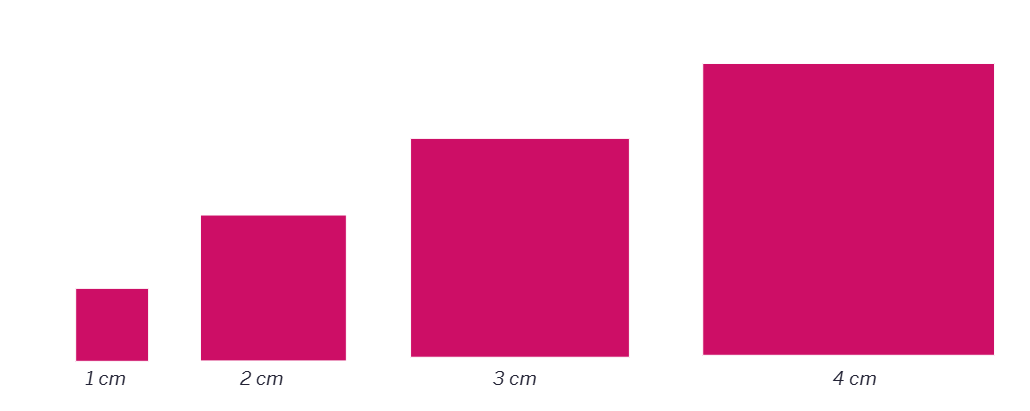
**Apply**

* Students will demonstrate their Working mathematically skills in discussions and justifications**.**

## Appendix A

### Regular polygon relationships

#### Squares (4 sides)



1. Complete the table for each of the shapes above.

|  |  |
| --- | --- |
| Length of the vertical line of symmetry | Perimeter |
|  |  |
|  |  |
|  |  |
|  |  |

1. Find an equation to represent the relationship between the length of the vertical line of symmetry () and perimeter ().

#### Regular pentagons (5 sides)

Four pentagons of varying sizes with black lines bisecting the shapes vertically.
1. Side length 1 cm and bisector 1.7 cm.
2. Side length 2 cm and bisector 3.4 cm.
3. Side length 3 cm and bisector 5.1 cm.
4. Side length 4 cm and bisector 6.8 cm.

1. Complete the table for each of the shapes above.

|  |  |
| --- | --- |
| Length of the line of symmetry | Perimeter |
|  |  |
|  |  |
|  |  |
|  |  |

1. Find an equation to represent the relationship between the length of the line of symmetry () and perimeter ().

#### Regular octagons (8 sides)

Four regular octagons.
1. Side length 1 cm and bisector 1.6 cm.
2. Side length 1.5 cm and bisector 3.92 cm.
3. Side length 2 cm and bisector 5.23 cm.
4. Side length 2.5 cm and bisector 6.5 cm.

1. Complete the table for each of the shapes above.

|  |  |
| --- | --- |
| Length of the line of symmetry | Perimeter |
|  |  |
|  |  |
|  |  |
|  |  |

1. Find an equation to represent the relationship between the length of the line of symmetry () and perimeter ().

#### Regular decagons (10 sides)

Four regular decagons.
1. Side length 1 cm and bisector 3.27 cm.
2. Side length 1.2 cm and bisector 3.88 cm.
3. Side length 1.4 cm and bisector 4.53 cm.
4. Side length 1.6 cm and bisector 5.18 cm.

1. Complete the table for each of the shapes above.

|  |  |
| --- | --- |
| Length of the line of symmetry | Perimeter |
|  |  |
|  |  |
|  |  |
|  |  |

1. Find an equation to represent the relationship between the length of the line of symmetry () and perimeter ().

#### Regular icosagons (20 sides)

Four regular isocagons.
1. Side length 0.2 cm and bisector 3.28 cm.
2. Side length 0.4 cm and bisector 2.56 cm.
3. Side length 0.6 cm and bisector 3.84 cm.
4. Side length 0.8 cm and bisector 5.11 cm.

1. Complete the table for each of the shapes above.

|  |  |
| --- | --- |
| Length of the line of symmetry | Perimeter |
|  |  |
|  |  |
|  |  |
|  |  |

1. Find an equation to represent the relationship between the length of the line of symmetry () and perimeter ().

## Appendix B

### Testing the equation

**Equation:**

|  |  |  |
| --- | --- | --- |
| Measured diameter | Estimated circumference | Measured circumference |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

## Sample solutions

### Appendix A – regular polygon relationships

#### Squares (4 sides)

|  |  |
| --- | --- |
| Length of the vertical line of symmetry | Perimeter |
| 1 | 4 |
| 2 | 8 |
| 3 | 12 |
| 4 | 16 |

#### Regular pentagons (5 sides)

|  |  |
| --- | --- |
| Length of the line of symmetry | Perimeter |
| 1.7 | 5 |
| 3.4 | 10 |
| 5.1 | 15 |
| 6.8 | 20 |

#### Regular octagons (8 sides)

|  |  |
| --- | --- |
| Length of the line of symmetry | Perimeter |
| 1.6 | 8 |
| 3.92 | 12 |
| 5.23 | 16 |
| 6.5 | 20 |

#### Regular decagons (10 sides)

|  |  |
| --- | --- |
| Length of the line of symmetry | Perimeter |
| 3.27 | 10 |
| 3.88 | 12 |
| 4.53 | 14 |
| 5.18 | 16 |

#### Regular icosagons (20 sides)

|  |  |
| --- | --- |
| Length of the line of symmetry | Perimeter |
| 3.28 | 4 |
| 2.56 | 8 |
| 3.84 | 12 |
| 5.11 | 16 |

## References

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