# What’s that graph?

Students explore how linear, exponential and quadratic tile patterns grow to develop their understanding of the features of each relationship.

## Visible learning

### Learning intention

* To understand the similarities and differences between linear, exponential and quadratic relationships.

### Success criteria

* I can construct a table of values to graph relationships.
* I can identify graphs of linear, exponential and quadratic relationships.
* I can identify equations of linear, exponential and quadratic relationships.

Table 1: lesson summary

|  |  |  |  |
| --- | --- | --- | --- |
| Section | Summary of activity | Teaching strategies | Teaching points |
| Warm up | Students complete a concept map for terms related to linear and non-linear relationships and do a gallery walk to add to and modify their concept maps. | Visibly random groups of 3  Vertical non-permanent surfaces  Pose-Pause-Pounce-Bounce  Gallery walk | This activity acts as an opportunity to identify students’ prior knowledge and highlight the connections between prior learning and what students will be learning in this unit. |
| Launch | Students attempt to describe and create similar patterns to the tile patterns on slide 3 of the PowerPoint *What’s that graph?* and do a gallery walk to view the solutions of other groups. | Visibly random groups of 3  Vertical non-permanent surfaces  Pose-Pause-Pounce-Bounce  Gallery walk | Students associate each type of relationship with a visual representation and describe each pattern using common language. |
| Explore | Students complete the table in [Appendix A](#_Appendix_A), with each group starting with a different tile pattern. Groups present how they approached their starting pattern and describe its key features. | Visibly random groups of 3  Vertical non-permanent surfaces | Students connect each tile pattern with its table of values, equation and graph, to understand how each type of relationship is similar and unique. |
| Summarise | Display slides 10–13 of the PowerPoint for students to write notes about the key features of linear, exponential and quadratic relationships. Pairs complete a card sort using [Appendix B](#_Appendix_B). | Notes to future forgetful selves  Think-Pair-Share | Students summarise the features, similarities and differences of linear, exponential and quadratic relationships. |
| Apply | Students create their own tile patterns and challenge others to determine the equation of the pattern. | Visibly random groups of 3  Vertical non-permanent surfaces | The tile patterns created by the students will indicate their understanding of each type of relationship. |

### 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**
* identifies connections between algebraic and graphical representations of quadratic and exponential relationships in various contexts **MA5-NLI-C-01**
* identifies and compares features of parabolas and exponential curves in various contexts **MA5-NLI-C-02**

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## Activity structure

Please use the associated PowerPoint *What’s that graph?* (WTG PPT) to display images in this lesson.

### Warm up

1. Assign visibly random groups of 3 ([bit.ly/visiblegroups](https://bit.ly/visiblegroups)) at vertical non-permanent surfaces ([bit.ly/VNPSstrategy](https://bit.ly/VNPSstrategy)). Allocate each group a term from the following list:

* linear
* non-linear
* exponential
* graphs
* algebra
* patterns.

1. Groups are to create a concept map for their provided term.

Concept map templates could be provided ([bit.ly/conceptmapdls](https://bit.ly/conceptmapdls)).

1. After 5–10 minutes, students complete a gallery walk ([bit.ly/DLSgallerywalk](https://bit.ly/DLSgallerywalk)) to observe their peers’ concept maps, adding to each other’s maps.
2. Use a questioning strategy such as Pose-Pause-Pounce-Bounce (PDF 557 KB) ([bit.ly/posepausepouncebounce](https://bit.ly/posepausepouncebounce)), to facilitate a class discussion about the concept maps. Prompt students to draw connections between concept maps of different terms. For example, connecting that exponential relationships are non-linear.

This activity acts as an opportunity to identify students’ prior knowledge and highlight the connections between prior learning and what students will be learning in this unit.

### Launch

1. With students in the same groups of 3, on vertical non-permanent surfaces, display Figure 1, from slide 3 of the PowerPoint (WTG PPT).

Figure 1: tile patterns

Three different tile patterns as follows:
Tile pattern: 3, 4, 5, 6.
Tile pattern: 1, 2, 4, 8.
Tile pattern: 2, 3, 5, 11.

The tile patterns represent the relationships: , , and .  
Note that these tile patterns start at to make it easier for students to identify each relationship, whereas the tile patterns in Appendix A ‘Tile patterns’ start at to ensure students need to think more critically about how each pattern is growing.

1. Groups complete the following tasks, in any order:

* categorise each pattern as linear or non-linear
* determine an equation to represent each pattern
* create a pattern that grows in a similar way to each of the given tile patterns.

Hints may be provided to move students in the right direction. For example, ‘What shape is the same in each step of the pattern?’ or ‘Notice that the blue pattern has a square in the middle with a tile added on either side, how could you represent this algebraically?’

1. Students complete a gallery walk to observe how their peers completed the tasks.
2. Use a questioning strategy such as Pose-Pause-Pounce-Bounce to facilitate a class discussion. The following prompts could be used to guide discussion:

* How did you determine which patterns were linear or non-linear?
* What do the non-linear tile arrangements have in common?
* How did you find the equation for the pattern?
* What do you notice in the red and green patterns that is similar to the blue pattern?
* What makes the blue pattern different to the green pattern?

The purpose of this launch is to establish that not all non-linear relationships are alike and to begin drawing out the features of quadratic relationships.

### Explore

1. With groups remaining at vertical non-permanent surfaces, distribute Appendix A ‘Tile patterns’ to each group.
2. Assign each group a different tile pattern to start with. They will later be asked to explain this pattern to the class.

Groups will complete all tile patterns but will only report back on their starting tile pattern.

1. For each tile pattern, students are to complete the following tasks on vertical non-permanent surfaces, recording their final answers on Appendix A:

* fill in the table of values
* determine the equation
* sketch a graph of the relationship.

Each tile pattern starts at . In each pattern, represents the step in the pattern and represents the number of tiles in each step.

1. Groups present their starting tile pattern to the class. In their explanation, groups should:

* describe the tile pattern using words
* explain how they determined the equation of their tile pattern
* describe the shape and key features of the graph.

The equation of each tile pattern can be found on slides 5–9 of the PowerPoint (WTG PPT).

1. Use slide 10 of the PowerPoint to compare examples of linear, quadratic and exponential relationships, focusing on their graphs.
2. In a Think-Pair-Share ([bit.ly/thinkpairsharestrategy](https://bit.ly/thinkpairsharestrategy)), students discuss the similarities and differences between the 3 graphs.
3. Distribute Appendix B ‘Card sort’ to students and have them complete the matching activity.

The cards will need to be printed and cut prior to the lesson, as they are correctly ordered in Appendix B.

1. Use a questioning strategy such as Pose-Pause-Pounce-Bounce to facilitate a class discussion around the card matching activity. Question prompts could include:

* How does each graph behave for negative values?
* Which graphs are symmetrical?
* What could the tile pattern look like for ?

### Summarise

1. In a Think-Pair-Share, students discuss the differences between linear, exponential, and quadratic relationships. The following sample prompts could be used:

* Describe the differences between linear and non-linear relationships. Use examples from your tile patterns to explain.
* Describe how a quadratic relationship grows differently to an exponential relationship. Use examples from your tile patterns to explain.
* Which relationships grow more quickly? Use examples from your tile patterns to explain.

1. Use slides 12–14 of the PowerPoint (WGT PPT) to display a set of tile patterns, graphs and equations for linear, quadratic and exponential relationships. Whilst displaying each slide, have students write notes to their future forgetful selves ([bit.ly/notestofutureself](http://bit.ly/notestofutureself)), defining key features of linear, quadratic and exponential relationships.

### Apply

1. Assign new visibly random groups of 3 at vertical non-permanent surfaces.
2. Groups are to create their own new tile patterns for each of the following relationships:

* a linear tile pattern
* a quadratic tile pattern
* an exponential tile pattern
* a tile pattern that is not linear, quadratic or exponential.

1. Once a group has completed their tile patterns, they swap positions with another group and attempt to determine the equation of each tile pattern.

## Assessment and differentiation

### Suggested opportunities for differentiation

**Warm up**

* **Students could be provided with completed concept maps to discuss with their group as opposed to creating their own.**
* **Challenge students to include as many representations as they can think of. These could include tables, equations, graphs or patterns.**

**Launch**

* A table of values and/or equations could be provided for each tile pattern. The initial activity could then be completed as a notice and wonder ([bit.ly/noticewonderstrategy](https://bit.ly/noticewonderstrategy)).
* Rather than students creating their own pattern, the patterns from Appendix A could be printed and cut into cards for students to group according to their similarity to each of the patterns shown on slide 3.
* Challenge students to consider if they could find more than one equation to match each pattern.

**Explore**

* The group’s starting patterns could be strategically assigned at an appropriate level of challenge for each group.
* Students could be provided with devices to access Desmos graphing calculator, to observe the shape of each graph before sketching it in the table in Appendix A.
* Challenge students to label all important information about the graphs, including intercepts, turning points and asymptotes.
* By editing the sample solutions to Appendix A, mix up which columns are provided for students, requiring them to start from the table of values, equation or the graph, and draw a tile pattern representation.

**Summarise**

* **Student notes could be completed as a Venn diagram to emphasise the similarities and differences between each type of relationship.**
* **Key features of each type of relationship could be provided for students as opposed to students writing their own.**

**Apply**

* Challenge groups to graph another group’s tile pattern using Desmos and use the graph to determine the number of tiles that would be in the hundredth step of the pattern.
* Students could create just one tile pattern that is not linear, quadratic or exponential, as they would demonstrate their understanding of each type of relationship in verifying that the created pattern is none of these.

### Suggested opportunities for assessment

**Warm up**

* Student generated concept maps will indicate prior understanding of linear and non-linear relationships.

**Launch**

* The patterns that students create that are similar to the given patterns will indicate their understanding of the key features of each type of relationship.
* The gallery walk allows students to peer and self-reflect on their created patterns.

**Explore**

* **Students’ working will demonstrate their communication and reasoning as they complete Appendix A.**
* **Appendix A could be collected as evidence that students can move between tile patterns, tables of values, equations and graphs.**

**Summarise**

* **Students’ notes to their future forgetful selves will demonstrate the understanding they will take away, such as the key features and similarities and differences of each type of relationship.**
* **The Desmos teacher dashboard can be used to monitor student responses to the card sort activity in real time or following the lesson.**

**Apply**

* **Student discussions will demonstrate their ability to reason and justify based on the types of relationships explored.**

## Appendix A

### Tile patterns

|  |  |  |  |
| --- | --- | --- | --- |
| Pattern | Table of values | Equation | Graph |
| Tile pattern: 2, 4, 6, 8. | Partially completed table. The 'x' values have been completed as follows: 1, 2, 3, 4. The 'y' values have been left blank. |  |  |
| Tile pattern: 4, 7, 10, 13. | Partially completed table. The 'x' values have been completed as follows: 1, 2, 3, 4. The 'y' values have been left blank. |  |  |
| Tile pattern: 5, 25, 125, 625. | Partially completed table. The 'x' values have been completed as follows: 1, 2, 3, 4. The 'y' values have been left blank. |  |  |
| Tile pattern: 2, 8, 26, 80. | Partially completed table. The 'x' values have been completed as follows: 1, 2, 3, 4. The 'y' values have been left blank. |  |  |
| Tile pattern: 1, 4, 9, 16. | Partially completed table. The 'x' values have been completed as follows: 1, 2, 3, 4. The 'y' values have been left blank. |  |  |
| Tile pattern: -4, -1, 4, 11. | Partially completed table. The 'x' values have been completed as follows: 1, 2, 3, 4. The 'y' values have been left blank. |  |  |
| Tile pattern: 3, 8, 13, 18. | Partially completed table. The 'x' values have been completed as follows: 1, 2, 3, 4. The 'y' values have been left blank. |  |  |
| Tile pattern: 1, 2, 4, 8. | Partially completed table. The 'x' values have been completed as follows: 1, 2, 3, 4. The 'y' values have been left blank. |  |  |
| Tile pattern: 3, 9, 19, 33. | Partially completed table. The 'x' values have been completed as follows: 1, 2, 3, 4. The 'y' values have been left blank. |  |  |
| Tile pattern: 3, 8, 15, 24. | Partially completed table. The 'x' values have been completed as follows: 1, 2, 3, 4. The 'y' values have been left blank. |  |  |

## Appendix B

### Card sort

|  |  |  |
| --- | --- | --- |
|  | Table with x and y values as follows: x: -1, 0, 1 y: -2, 0, 2. | Graph of y=2x. |
|  | Table with x and y values as follows: x: -1, 0, 1 y: 1/2, 1, 2. | Graph of y=2^x. |
|  | Table with x and y values as follows: x: -1, 0, 1 y: 2, 0, 2. | Graph of y=x^2. |
|  | Table with x and y values as follows: x: -1, 0, 1 y: -1, 0, 1. | Graph of y=-x^2. |

## Sample solutions

### Appendix A – tile patterns

|  |  |  |  |
| --- | --- | --- | --- |
| Pattern | Table of values | Equation | Graph |
| Tile pattern: 2, 4, 6, 8. | Table of x and y values as follows: x: 1, 2, 3, 4. y: 2, 4, 6, 8. |  | Graph of y=2x. |
| Tile pattern: 4, 7, 10, 13. | Table of x and y values as follows: x: 1, 2, 3, 4. y: 4, 7, 10, 13. |  | Graph of y = 3x+1. |
| Tile pattern: 4, 7, 10, 13. | Table of x and y values as follows: x: 1, 2, 3, 4. y: 5, 25, 125, 625. |  | Graph of y = 5^x. |
| Tile pattern: 2, 8, 26, 80. | Table of x and y values as follows: x: 1, 2, 3, 4. y: 2, 8, 26, 80. |  | Graph of y = 3^x-1. |
| Tile pattern: 1, 4, 9, 16. | Table of x and y values as follows: x: 1, 2, 3, 4. y: 1, 4, 9, 16. |  | Graph of y = x^2. |
| Tile pattern: -4, -1, 4, 11. | Table of x and y values as follows: x: 1, 2, 3, 4. y: -4, -1, 4, 11. |  | Graph of y = x^2 - 5. |
| Tile pattern: 3, 8, 13, 18. | Table of x and y values as follows: x: 1, 2, 3, 4. y: 3, 8, 13, 18. |  | Graph of y =5x - 2. |
| Tile pattern: 1, 2, 4, 8. | Table of x and y values as follows: x: 1, 2, 3, 4. y: 1, 2, 4, 8. |  | Graph of y = 1/2(2)^x. |
| Tile pattern: 3, 9, 19, 33. | Table of x and y values as follows: x: 1, 2, 3, 4. y: 3, 9, 19, 33. |  | Graph of y = 2x^2 + 1. |
| Tile pattern: 3, 8, 15, 24. | Table of x and y values as follows: x: 1, 2, 3, 4. y: 3, 6, 15, 24. |  | Graph of y = x^2 + 2x. |

## References

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