# Laying the foundations of algebra

Students use algebra tiles to represent and simplify algebraic expressions.

## Visible learning

### Learning intentions

* To be able to simplify algebraic expressions.

### Success criteria

* I can identify like terms.
* I can represent terms using algebra tiles.
* I can simplify algebraic expressions by adding and subtracting like terms.

### 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**
* generalises number properties to operate with algebraic expressions including expansion and factorisation **MA4-ALG-C-01**

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## Activity structure

The activities in this lesson are based on ‘Collecting Like Terms – Sorting Terms’ by Chris McGrane (<https://startingpointsmaths.com/2018/09/20/collecting-like-terms-sorting-terms/>).

### Launch

#### Equipment

* Appendix A ‘Like term cards’, printed (one copy per pair)
* Scissors (one per pair)

#### Method

1. Assign pairs.
2. Issue the cards from Appendix A ‘Like term cards’ to pairs and ask them to cut out the cards.
3. Ask students to group the cards into categories that make sense to them. Explain that they will be asked to justify their groupings.
4. Select random pairs to explain how they have chosen to group the cards. Some students may group according to positives and negatives, others may put all the constants together, and hopefully some will group according to like terms.

These cards introduce some like terms that students did not encounter in the previous lesson. For instance, and It also asks them to consider if the order of the components in the term matter.

### Explore

#### Equipment

* Devices (optional)
* Class set of Appendix B ‘Polypad algebra tiles’, printed
* Class set of Appendix C ‘Algebra tiles practice’, printed

#### Method

1. Introduce students to Polypad Algebra Tiles (. The different tiles are shown in Appendix B, which students can have nearby as a guide for this activity.

A tutorial for teachers unfamiliar with Algebra Tiles is on the Mathigon website ([bit.ly/tutorialalgebra](https://bit.ly/tutorialalgebra)).

The tile has a length of and a width of 1. The tile has a length of and a width of , and so on.

Students need to understand that the names of the tiles are arbitrary and could easily have been labelled with and or any other letters.

There is also a negative version of each of these tiles.

1. Demonstrate, using slide 2 of the *Laying the foundations of algebra* PowerPoint, how can be modelled by joining 5, tiles together.
2. Complete the worked examples and ‘Your turn’ problems in the *Laying the foundations of algebra* PowerPoint (slides 3–13).

The explicit teaching technique used in the associated 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 hold up a thumbs up to the teacher when they have finished reading and have some sort of understanding.
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.
8. Students will model the scenarios from Appendix C ‘Algebra tiles practice’ using Polypad Algebra Tiles (or by drawing the tiles) and then writing a simplified expression.

Encourage students to rearrange the tiles to group for likeness, and use zero pairs to assist in simplifying the expressions.

The questions have been designed to remind students that is equivalent to .

Students could be encouraged to consider how many ways they could write each expression.

### Summarise

1. Using a Think-Pair-Share ([bit.ly/thinkpairsharestrategy](https://bit.ly/thinkpairsharestrategy)), students discuss any patterns that they noticed or strategies they used when simplifying the expressions in Appendix C ‘Algebra tiles practice’.
2. Using a questioning strategy such as Pose-Pause-Pounce-Bounce ([bit.ly/pausepouncebounce](https://bit.ly/pausepouncebounce)), ask students to share their patterns and strategies with the class.
3. Students will model the scenarios from Appendix D ‘Building on like terms’ using Polypad Algebra Tiles (or by drawing the tiles) and then writing a simplified expression.

This activity builds on from the previous ‘Algebra tiles practice’ by incorporating a larger variety of terms including terms.

The very last question cannot be modelled with algebra tiles and is designed to see if students have built enough conceptual understanding to move away from visual representations. Students should be encouraged to continue using algebra tiles for as long as they need them.

### Apply

1. Students can complete the ‘Algebra Pyramids’ from Appendix E.
2. Students requiring a further challenge can complete the ‘Algebraic Perimeters’ questions from the Transum website (<https://bit.ly/AlgebraicPerimeters>). There are a range questions at different levels for students to complete.

The Algebraic Perimeters activity links back to the previous lesson ‘Stepping through unknowns’ where students represented the perimeter of different areas using the length of their paces.

## Assessment and differentiation

### Suggested opportunities for differentiation

**Launch**

* Students might benefit from engaging with a concrete manipulative, such as counters, to first establish grouping and zero pairs.
* Encourage students to create their own algebraic expressions using the blank card, then challenge their peers to solve them.

**Explore**

* Students should continue modelling with algebra for as long as it takes them to develop a conceptual understanding of like terms.

**Apply**

* Students should be encouraged to create their own pyramids for other students to complete.
* The Transum ‘Algebraic Perimeter’ activity is self-checking and consists of several different levels of questions. Although it is an online activity, students should be encouraged to write an expression for the perimeter in their books, before simplifying it.

### Suggested opportunities for assessment

**Launch**

* Walk around the room and observe how students are grouping the cards. This will provide immediate feedback on their initial understanding of 'like terms'. You could also ask them to explain their grouping method for further insight into their thinking.

**Explore**

* Observe how students are approaching simplifying expressions, for example, do they begin by grouping like terms?
* Teachers could also create an exit ticket to check if students understand that .

## **Appendix A**

### **Like term cards**

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## **Appendix B**

### Polypad algebra tiles

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| Black square with the number 1 written inside |  |
| Green rectangle with the letter x written inside. |  |
| Aqua rectangle with the letter y written inside. |  |
| Mauve rectangle with width the same as the x tile and height the same as the y tile and labelled with xy in the middle. |  |
| Purple square with length y and the label y squared written inside. |  |
| Blue square with side length x and the label x squared written inside. |  |

Images created using the free virtual manipulatives at [Polypad.org](https://mathigon.org/polypad/).

## Appendix C

### Algebra tiles practice

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| Question | Drawing of model | Simplified expression |
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## Appendix D

### Building on like terms

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| Question | Drawing of model | Simplified expression |
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## Appendix E

### Algebra pyramids

Use the algebraic terms and expressions in the pyramids to fill in the blanks. The first one is an example to help you.

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| An image containing a table in a pyramid like structure with 3 rows. In the bottom row there are 3 cells with algebraic terms in each. The first cell has the term a, the second has 2a and the third has 3a. In the second row there are two cells. The first cell has 3a, the second has 5a. In the top row there is one cell with 8a in it. | An image containing a table in a pyramid like structure with 3 rows. In the bottom row there are 3 cells with algebraic terms in each. The first cell has the term m, the second has 3m and the third has 5m. In the second row there are two empty cells in the top row there is one empty cell. |
| An image containing a table in a pyramid like structure with 3 rows. In the bottom row there are 3 cells with algebraic terms in each. The first cell has the term 6m, the second has -3m and the third has 2m. In the second row there are two empty cells in the top row there is one empty cell. | An image containing a table in a pyramid like structure with 3 rows. In the bottom row there are 3 cells. The first cell is empty, the second has 3x in it and the third cell is empty. In the second row there are two cells. The first cell has 5x in it and the second cell is empty. In the top row there is one cell which has the term 12x in it. |
| An image containing a table in a pyramid like structure with 3 rows. In the bottom row there are 3 cells. The first cell is empty, the second has 5xy in it and the third cell is empty. In the second row there are two cells. The first cell has 3xy in it and the second cell is empty. In the top row there is one cell which has the term 7xy in it. | An image containing a table in a pyramid like structure with 3 rows. In the bottom row there are 3 cells. The first cell is empty, the second has 5 times a squared in it and the third cell is empty. In the second row there are two cells. The first cell has 2 times a squared in it and the second cell has 8 times a squared in it. In the top row there is one cell which is empty. |
| An image containing a table in a pyramid like structure with 4 rows. In the bottom row there are 4 cells with an algebraic term in each. The first cell has the term 7x, the second has negative 2x, the third has 5x and the fourth cell has negative 3x in it. In the second row from the bottom there are three empty cells, in the third row from the bottom there are 3 empty cells and in the top row there is one empty cell. | An image containing a table in a pyramid like structure with 4 rows. In the bottom row there are 4 cells. The second cell has the term 3 times x squared in it. The other 3 cells are empty. In the second row from the bottom there are 3 cells. The first cell has the term m squared in it. The other 2 cells are empty. The third row from the bottom has two cells. The first cell is empty. The second cell has the term 5 m squared in it. The top row has one cell. It has the term 3 times m squared in it. |

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| An image containing a table in a pyramid like structure with 4 rows. In the bottom row there are 4 cells. The second cell has the term negative 3 a b in it and the last cell has the term negative 2 a b in it. The other two cells are empty. In the second row from the bottom there are three cells. The first cell is empty. The second cell has the term negative 4 a b in it and the last cell has the term negative 3 a b in it. The third row from the bottom has two cells. The first cell has the term negative 5 a b in it. The second cell is empty. The top row has one cell which is empty. | An image containing a table in a pyramid like structure with 3 rows. In the bottom row there are 3 cells. The first cell has the term 3b, the second cell has the term 2a and the third cell has the term b in it. The second row from the bottom has two cells which are empty. The top row has one cell which is empty. |
| An image containing a table in a pyramid like structure with 3 rows. In the bottom row there are 3 cells. The first cell is empty. The second cell has the term 2m and the last cell has the term 4p in it. In the second row from the bottom there are two cells. In the first cell is the algebraic expression 3p plus 2m. The second cell is empty. In the top row there is 1 cell which is empty. | An image containing a table in a pyramid like structure with 3 rows. In the bottom row there are 3 cells. The first cell and second cells are empty. The last cell has the algebraic expression 2ab minus 4b in it. In the second row from the bottom there are two cells. In the first cell is the algebraic expression 5ab plus 2b. The second cell is empty. In the top row there is 1 cell which has the algebraic expression 11ab-4b in it. |
| An image containing a table in a pyramid like structure with 3 rows. In the bottom row there are 3 cells. The first cell has the algebraic expression 4a plus 2 times a squared, the second cell has the algebraic expression 2a plus 5 times a squared and the third cell has the algebraic expression 6a plus 3 times a squared in it. The second row from the bottom has two cells which are empty. The top row has one cell which is empty. | An image containing a table in a pyramid like structure with 3 rows. In the bottom row there are 3 cells. The first cell has the algebraic expression negative 5a plus 1 in it. The second cell is empty. The last cell has the algebraic expression negative 4a minus 2 in it. In the second row from the bottom there are two cells. In the first cell is the algebraic expression negative 3a minus 2. The second cell is empty. In the top row there is 1 cell which is empty. |
| An image containing a table in a pyramid like structure with 3 rows. In the bottom row there are 3 cells. The first cell is empty. The second cell has the algebraic expression 3a minus 2b in it. The last cell has the algebraic expression negative 4a minus 5b in it. In the second row from the bottom there are two cells which are empty. In the top row there one cell which has the algebraic expression 3a minus 6b in it. | An image containing a table in a pyramid like structure with 4 rows. In the bottom row there are 4 cells. The first cell is empty. The second cell has the algebraic expression 2x minus 2y in it. The third cell is empty. The last cell has the algebraic expression negative x +3y in it. In the second row from the bottom there are three cells. The first cell has the algebraic expression negative 3x minus 5y in it. The second cell is empty. The last cell has the algebraic expression x plus 2y in it. The third row from the bottom has two cells which are both empty. The top row has one cell which has the algebraic expression 6x minus 9y in it. |
| 1. Create your own. Fill in some cells with single algebraic terms and leave some blank.   An image containing a table in a pyramid like structure with 3 rows. In the bottom row there are 3 cells which are empty. In the second row from the bottom there are two cells which are empty. In the top row there one cell which is empty. | 1. Create your own. Fill in some cells with algebraic expressions and leave some blank.   An image containing a table in a pyramid like structure with 4 rows. In the bottom row there are 4 cells which are empty. In the second row from the bottom there are 3 cells which are empty. In the third row from the bottom there are 2 cells which are empty. In the top row there one cell which is empty. |

## Sample solutions

### Appendix C – algebra tiles practice

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| --- | --- | --- |
| Question | Drawing of model | Simplified expression |
|  | 7x tiles stacked vertically. |  |
|  | 4 negative x tiles stacked vertically. |  |
|  | 4 negative x tiles stacked vertically. |  |
|  | 3x tiles stacked vertically and 4 zero tiles stacked vertically. |  |
|  | 3x tiles stacked vertically and 4 zero tiles stacked vertically. |  |
|  | 5x tiles stacked vertically and 4 one tiles. |  |
|  | 7x tiles stacked vertically and 4 one tiles. |  |
|  | 2x tiles stacked vertically, 2 zerp to;es stacked vertically and 4 one tiles. |  |
|  | 2x tiles stacked vertically, 3 zero tiles stacked vertically and 4 one tiles. |  |
|  | 4x tiles stacked vertically, 1 zero tile stacked vertically and 7 negative one tiles. |  |
|  | 4x tiles stacked vertically, 1 zero tile stacked vertically and 7 negative one tiles. |  |
|  | 1 x tile stacked vertically, 1 y tile stacked vertically and 7 negative one tiles. |  |
|  | 1 x tile stacked vertically, 1 y tile stacked vertically and 7 negative one tiles. |  |
|  | 5x tiles stacked vertically and 1 y tile stacked vertically. |  |
|  | 7x tiles stacked vertically , 2 negative y tiles stacked vertically and 1 zero tile stacked vertically. |  |
|  | 7x tiles stacked vertically , 2 negative y tiles stacked vertically and 1 zero tile stacked vertically. |  |
|  | 4 negative x tiles stacked vertically , 2 zero tiles stacked vertically and 1 negative y tile stacked vertically. |  |
|  | 4 negative x tiles stacked vertically , 2 zero tiles stacked vertically and 1 negative y tile stacked vertically. |  |
|  | 3 zero tiles stacked vertically, 3 zero unit tiles (normally ones) and 3 negative 1 tiles. |  |
|  | 3 zero tiles stacked vertically, 3 zero unit tiles (normally ones) and 3 negative 1 tiles. |  |

Image created using the free virtual manipulatives at [Polypad.org](https://mathigon.org/polypad/).

### Appendix D – building on like terms

|  |  |  |
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| Question | Drawing of model | Simplified expression |
|  | Two x squared tiles and two y squared tiles |  |
|  | Seven x squared tiles and two y squared tiles |  |
|  | Seven x squared tiles and six y squared tiles |  |
|  | Ten x squared tiles and six y squared tiles |  |
|  | Ten x squared tiles and eight y squared tiles |  |
|  | Students will initially add 6 tiles and then remove 4 of them. |  |
|  | Students will initially add 6 tiles and then remove 4 of them and add 5 tiles and remove 3 of them. |  |
|  | Students will need to add zero pairs to have enough tiles to subtract.  Alternatively, they can think of this as: | or |
|  | Students will need to add zero pairs to have enough tiles to subtract.  Alternatively, they can think of this as: |  |
|  | Students will need to add zero pairs to have enough tiles to subtract.  Alternatively, they can think of this as: |  |
|  | Students need to realise that is equivalent to and that the question is a repeat of the one above. |  |
|  | Students should realise that there are no like terms in this question |  |
|  | There are no algebra tiles to model the term . Students will hopefully have built enough conceptual knowledge to complete this question without the aid of the tiles |  |

### Appendix E – algebra pyramids

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| --- | --- | --- |
| An image containing a table in a pyramid like structure with 3 rows. In the bottom row there are 3 cells with algebraic terms in each. The first cell has the term m, the second has 3m and the third has 5m. In the second row there are two cells. The first cell has the term 4m, the second cell has the term 8m. The top row has one cell which has the term 12m in it. | An image containing a table in a pyramid like structure with 3 rows. In the bottom row there are 3 cells with algebraic terms in each. The first cell has the term 6m, the second has -3m and the third has 2m. In the second row there are two cells. The first cell has the term 3m, the second cell has the term negative m. The top row has one cell which has the term 2m in it. | An image containing a table in a pyramid like structure with 3 rows. In the bottom row there are 3 cells with algebraic terms in each. The first cell has the term 2x, the second has 3x and the third has 4x. In the second row there are two cells. The first cell has the term 5x, the second cell has the term 7x. The top row has one cell which has the term 12x in it. |
| An image containing a table in a pyramid like structure with 3 rows. In the bottom row there are 3 cells with algebraic terms in each. The first cell has the term negative 2xy, the second has 5xy and the third has negative xy. In the second row there are two cells. The first cell has the term 3xy, the second cell has the term 4xy. The top row has one cell which has the term 7xy in it. | An image containing a table in a pyramid like structure with 3 rows. In the bottom row there are 3 cells with algebraic terms in each. The first cell has the term negative 3 times a squared, the second has 5 times a squared and the third has 3 times a squared. In the second row there are two cells. The first cell has the term 2 times a squared, the second cell has the term 8 times a squared. The top row has one cell which has the term 10 times a squared in it. | An image containing a table in a pyramid like structure with 4 rows. In the bottom row there are 4 cells with algebraic terms in each. The first cell has the term 7x, the second has negative 2x, the third has 5x and the fourth has negative 3x. In the second row there are 3 cells. The first cell has the term 5x, the second cell has the term 3x and the third cell has the term 2x. The third row has 2 cells. The first call has the term 8x and the second cell has the term 5x. The top row has one cell which has the term 13x in it. |
| An image containing a table in a pyramid like structure with 4 rows. In the bottom row there are 4 cells with algebraic terms in each. The first cell has the term negative 2 times m squared, the second has the term 3 times m squared, the third has negative 6 times m squared and the fourth has negative 14 times x squared. In the second row there are 3 cells. The first cell has the term m squared, the second cell has the term negative 3 times m squared and the third cell has the term 8 times m squared. The third row has 2 cells. The first call has the term negative 2 times m squared and the second cell has the term 5 times m squared. The top row has one cell which has the term 3 times m squared in it. | An image containing a table in a pyramid like structure with 4 rows. In the bottom row there are 4 cells with algebraic terms in each. The first cell has the term 2ab, the second has negative 3ab, the third has negative a b and the fourth has negative 2ab. In the second row there are 3 cells. The first cell has the term negative a b, the second cell has the term negative 4ab and the third cell has the term negative 3ab. The third row has 2 cells. The first call has the term negative 5ab and the second cell has the term negative 7ab. The top row has one cell which has the term negative 12ab in it. | An image containing a table in a pyramid like structure with 3 rows. In the bottom row there are 3 cells with algebraic terms in each. The first cell has the term 3b, the second has 2a and the third has the term b in it. In the second row there are two cells. The first cell has the algebraic expression 2a+3b, the second cell has the algebraic expression 2a+b. The top row has one cell which has the algebraic expression 4a+4b in it. |
| An image containing a table in a pyramid like structure with 3 rows. In the bottom row there are 3 cells with algebraic terms in each. The first cell has the term 3p, the second has 2m and the third has the term 4p in it. In the second row there are two cells. The first cell has the algebraic expression 3p+2m, the second cell has the algebraic expression 4p+2m. The top row has one cell which has the algebraic expression 7p+4m in it. | An image containing a table in a pyramid like structure with 3 rows. In the bottom row there are 3 cells with algebraic expressions in each. The first cell has the algebraic expression ab+4b, the second has 4ab-2b and the third has the algebraic expression 2ab-4b in it. In the second row there are two cells. The first cell has the algebraic expression 5ab+2b, the second cell has the algebraic expression 6ab-6b. The top row has one cell which has the algebraic expression 11ab-4b in it. | An image containing a table in a pyramid like structure with 3 rows. In the bottom row there are 3 cells with algebraic expressions in each. The first cell has the algebraic expression 4a+2 times a squared, the second has 2a+5 times a squared and the third has the algebraic expression 6a plus 3 times a squared in it. In the second row there are two cells. The first cell has the algebraic expression 6a plus 7 times a squared, the second cell has the algebraic expression 8a plus 8 times a squared. The top row has one cell which has the algebraic expression 14a plus 15 times a squared in it. |
| An image containing a table in a pyramid like structure with 3 rows. In the bottom row there are 3 cells with algebraic expressions in each. The first cell has the algebraic expression negative 5a plus 1, the second has 2a-3 and the third has the algebraic expression negative 4a-2 in it. In the second row there are two cells. The first cell has the algebraic expression negative 3a-2, the second cell has the algebraic expression negative 2a-5. The top row has one cell which has the algebraic expression negative 5a-7 in it. | An image containing a table in a pyramid like structure with 3 rows. In the bottom row there are 3 cells with algebraic expressions in each. The first cell has the algebraic expression negative 7a+3b, the second has 3a-2b and the third has the algebraic expression negative 4a-5b in it. In the second row there are two cells. The first cell has the algebraic expression negative 4a+b, the second cell has the algebraic expression 7a-7b. The top row has one cell which has the algebraic expression negative 3a-6b in it. | An image containing a table in a pyramid like structure with 4 rows. In the bottom row there are 4 cells with algebraic expressions in each. The first cell has the algebraic expression negative 5x-3y, the second has the algebraic expression 2x-2y, the third has the algebraic expression negative x+3y. In the second row there are 3 cells. The first cell has the algebraic expression negative 3x-5y, the second has 4x-3y and the third has the algebraic expression x+2y in it. In the second row there are two cells. The first cell has the algebraic expression negative x-8y, the second cell has the algebraic expression 5x-y. The top row has one cell which has the algebraic expression negative 6x-9y in it. |

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