# Let’s power down

Students investigate the dividing and zero index laws to apply them to algebraic bases.

## Visible learning

This lesson incorporates small amounts of Path content.

### Learning intentions

* To be able to use the division index law to simplify algebraic expressions.
* To be able to simplify algebraic expressions that involve the zero index.

### Success criteria

* I can simplify fractions by dividing by a common factor.
* I can simplify algebraic expressions using the division index law.
* I can simplify algebraic expressions using the zero index law.

### 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**
* simplifies algebraic expressions involving positive-integer and zero indices, and establishes the meaning of negative indices for numerical bases **MA5-IND-C-01**

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## Activity structure

### Launch

#### Which one doesn’t belong?

1. Use slide 2 of the *Let’s power down* PowerPoint to display the ‘Which one doesn’t belong?’ activity below.

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1. Have students justify which one doesn’t belong in a Think-Pair-Share ([bit.ly/thinkpairsharestrategy](https://bit.ly/thinkpairsharestrategy)).
2. Propose the following questions for discussion.
3. What do you notice about the base of each expression?
4. Which of the expressions are equal?
5. What do you notice about the indices?

Students may notice that:

* one of the expressions doesn’t equal one
* one of the expressions has different bases
* one expression is only a single term
* one expression has the same terms in it.

### Division of indices

#### Explore

1. Begin the lesson by writing the fraction on the board.
2. Pose the following questions:
3. What can you see?
4. What do you know?
5. What do you wonder?
6. Write the fraction on the board.
7. Under the fraction , write the following 4 fractions.
8. Have students engage in a Think-Pair-Share ([bit.ly/thinkpairsharestrategy](https://bit.ly/thinkpairsharestrategy)) to identify any patterns in these expressions.
9. After a short time, divide by the common factor(s) in each fraction and pose the following questions:
10. What has happened?
11. How did the fraction change?
12. Why can the numbers be cancelled?

There are 4 fractions. Each fraction has some cancelling of common factors. The first fraction has a numerator of 2 times 3 and a denominator of 2 times 5. The 2 from the numerator and the 2 from the denominator have been cancelled. The second fraction has a numerator of 2 times 2 times 3 and a denominator of 2 times 2 times 5. The 2s from the numerator and the 2s from the denominator have been cancelled. 
The third fraction has a numerator of 3 times x and a denominator of 5 times x. The x from the numerator and the x from the denominator have been cancelled. The fourth fraction has a numerator of 4 times 3 times 2 and a denominator of 5 times 4 times 2. the 4 and the 2 from the numerator and the 4 and the 2 from the denominator have been cancelled. After the cancelling in each fraction, the fractions are all left with a 3 in the numerator and a 5 in the denominator.

It is important that students understand that dividing the numerator and denominator by a common factor is called ‘cancelling’.

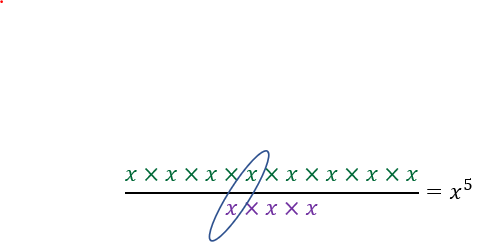
It is possible because it creates a value of one (not zero) and that it does not change the value of the original fraction.

A discussion about the impact of multiplying or dividing something by one may also be useful.

1. Write these 4 expressions on the board:
2. Have students engage in a Think-Pair-Share ([bit.ly/thinkpairsharestrategy](https://bit.ly/thinkpairsharestrategy)) to identify any patterns in these expressions.
3. After a short time, reveal the solutions below and ask for further contributions from students.

It is important at this stage that students recognise that the base of each exponent is the same within each question.

1. Model writing each number in expanded form. Use different coloured whiteboard markers to indicate different values rather than brackets.
2. Prompt student thinking by asking if there is a better way of expressing division.
3. Rewrite the question in expanded form, this time as a fraction using the colours again, and show the common factors being cancelled.



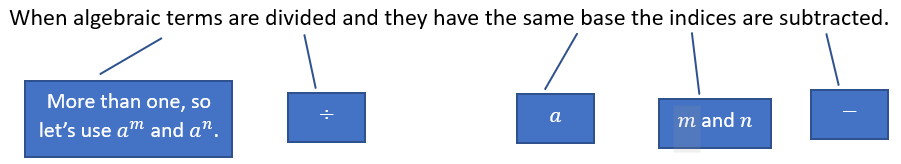
1. Have students develop a process, in pairs, to explain what is happening and apply this process to the other 3 examples.

#### Summarise

1. Ask the students to think about how they might write the process in words so that it is like an instruction and would make sense to someone reading it. Have students work in pairs to write the instruction.
2. Ask students to read out their instructions and use the student responses to create a written version on the board. Ask students the question ‘Are there any words we used that can be represented by a mathematical symbol?’.

An example of the instructions written on the board may be ‘When algebraic terms are divided and they have the same base the indices are subtracted’. Whilst the wording may be slightly different, the intention should be the same.

1. Discuss how components of the instruction can be substituted with mathematical symbols to make it more compact. An example is shown below.



1. Write the formal law on the board: .
2. Propose the following questions for discussion:
3. What do you think?
4. Which is easier to remember, the law or the written instruction?
5. Which is easier to write, the law or the instruction?
6. How does this law compare with the multiplying law?

Discussion points may include the idea that the words may be easier to remember, but the algebra is easier to write.

Students may need to be prompted to recall the multiplying law and recognise that when they multiply, they add and when they divide, they subtract.

1. Have students write notes to their future forgetful self ([bit.ly/notesstrategy](https://bit.ly/notesstrategy)). These should include the rule, where it came from and some typical examples that are found.
2. Provide students with the 5 ‘your turn’ questions to consolidate their learning.

Simplify:

These 5 ‘your turn’ questions increase in difficulty moving from numbers to pronumerals and introducing multiple pronumerals and numbers.

### Zero Index Law

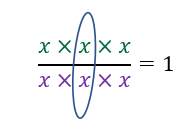
#### Explore

1. Write these 4 expressions on the board:
2. Have students engage in a Think-Pair-Share ([bit.ly/thinkpairsharestrategy](https://bit.ly/thinkpairsharestrategy)) to discuss what they notice about these expressions.
3. After a short time, simplify the 4 questions showing the 2 ways of writing the solution for each question, on the board without discussion.
4. and
5. and
6. and
7. and

Students should recognise that there are 2 solutions for each question because one shows the subtraction of the indices and the other uses a division process.

It is important to focus student attention on the solutions and recognising that an index of zero makes a term equal to one.

1. Model writing the expanded expression. Again, use different colour whiteboard markers to indicate different parts.
2. Prompt student thinking by asking if they have investigated a better way of expressing division and ask them if they think it still applies. Rewrite the question in expanded form, this time as a fraction using colours as shown.



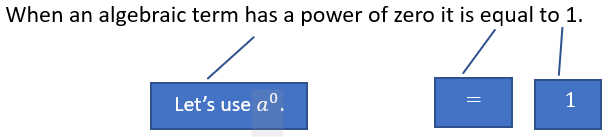
1. In pairs, have students develop a process to explain what is happening and apply this process to the other 3 examples.

#### Summarise

1. Ask the students to think about how they might write the process in words so that it is like an instruction and would make sense to someone reading it. Have students work in pairs to write the instruction.
2. Ask students to read out their instructions and use the student responses to create a written version on the board.
3. Ask students the question ‘Are there any words we used that can be represented by a mathematical symbol?’

An example of the instructions written on the board may be ‘When an algebraic term has a power of zero it is equal to 1’. Whilst the wording may be slightly different, the intention should be the same.

1. Discuss how components of the instruction can be substituted with mathematical symbols to make it more compact. An example is shown below.



1. Write the formal law on the board:
2. Propose the following questions for discussion:

* What do you think?
* Which is easier to remember, the law or the written instruction?
* Which is easier to write, the law or the instruction?
* How is this law different to the other laws?

Discussion points may include the idea that the words may be easier to remember, but the algebra is easier to write and that this law has less information in it.

1. Have students write notes to their future forgetful self ([bit.ly/notesstrategy](https://bit.ly/notesstrategy)). These should include the rule, where it came from and some typical examples that are found.
2. Provide students with these 6 ‘your turn’ questions to consolidate their learning.

Simplify:

#### Apply

##### Indices Bingo

**Equipment**

* Appendix A ‘Bingo game cards’ (printed and cut in half to make 30 bingo game cards)
* A printout of Appendix B ‘Indices bingo answer key’
* Counters (9 per student)
* *Indices bingo* PowerPoint displayed on a screen

**Method**

1. Distribute a bingo game card and 9 counters to each student.
2. Project the *Indices bingo* PowerPoint on a screen, starting at slide 3.
3. Play the slideshow, moving from one slide to the next.

**Note:** to improve random selection of the questions, before you begin you may wish to move the slides around without looking at the questions to change the order of the slides.

1. When each slide is shown, the students will need to simplify the expression shown on the slide and then check if their answer is on the bingo game card. If the answer is there, the students should place a counter on that square of the game card.
2. When a student covers all 9 squares of their game card, they call ‘Bingo’.
3. After the game is finished, direct discussion to the questions which involved a negative index.

* What is different about these questions?
* How did the negative sign change the way the expression was simplified?

The questions on the slides are numbered. Each number corresponds to the number on Appendix C ‘Indices Bingo answer key’.

## Assessment and differentiation

### Suggested opportunities for differentiation

**Explore and summarise**

* There are regular checkpoints for teachers where specific realisations and conclusions are identified as being essential before progressing. Teachers should use questioning techniques to verify student understanding of each of these points before continuing.
* Students who have difficulty working with algebraic notation should continue to work with numerical bases.

**Apply**

* The PowerPoint *Indices Bingo* contains an answer with a negative index which touches on Path content. This question can be changed to remove the negative index.
* Teachers could also adjust the *Indices Bingo* PowerPoint to incorporate more questions which involve more operations with negative indices as well as fractional indices.

### Suggested opportunities for assessment

**Launch**

* Student responses to the ‘Which one doesn’t belong?’ activity can demonstrate their understanding of multiple index laws.

**Summarise**

* Use the consolidation questions in step 7 of each section to verify student understanding of the key ideas in each generalisation.

**Apply**

* Monitor students when playing the bingo game, watching for incorrect placement of counters and omitting valid answers.

## **Appendix A**

### Bingo game cards

The game cards should be printed, one side only, and cut in half to distribute to each student.

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| --- | --- | --- |
|  |  |  |
|  |  | 3 |
|  | 2 |  |

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|  |  | 3 |
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|  |  |  |
| --- | --- | --- |
|  |  | 2 |
|  |  | 3 |
| 1 |  |  |
|  |  |  |
|  |  | 3 |
|  |  | 2 |

|  |  |  |
| --- | --- | --- |
|  |  |  |
|  |  |  |
|  |  |  |
|  | 2 | 7 |
|  |  | 3 |
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|  |  | 3 |
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|  |  | 7 |
|  |  | 3 |
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|  |  |  |
|  |  | 3 |
|  | 1 |  |
|  | 1 |  |
|  |  | 7 |
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| --- | --- | --- |
|  |  | 7 |
|  |  |  |
|  | 1 |  |
|  |  |  |
|  | 1 |  |
|  |  | 3 |

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|  | 2 |  |
|  |  | 3 |
|  |  |  |
|  |  | 3 |
|  |  |  |
|  | 7 |  |

|  |  |  |
| --- | --- | --- |
|  | 1 |  |
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| 3 |  |  |
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|  | 2 |  |
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| 1 |  |  |
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|  |  | 3 |
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| --- | --- | --- |
|  |  | 3 |
| 2 |  |  |
| 1 |  |  |
|  |  |  |
|  |  | 7 |
|  | 2 | 1 |

|  |  |  |
| --- | --- | --- |
|  |  | 7 |
|  | 2 | 3 |
|  |  |  |
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|  |  |  |

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| --- | --- | --- |
|  |  | 7 |
|  | 2 |  |
|  |  |  |
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|  | 1 | 7 |
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|  | 2 |  |
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|  |  | 7 |

## **Appendix B**

### Indices Bingo answer key

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| --- | --- | --- |
| Question number | Question | Answer |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |
| 6 |  |  |
| 7 |  | 1 |
| 8 |  |  |
| 9 |  |  |
| 10 |  | 2 |
| 11 |  |  |
| 12 |  |  |
| 13 |  |  |
| 14 |  |  |
| 15 |  | 7 |
| 16 |  | 3 |
| 17 |  |  |
| 18 |  |  |

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