# Which way is up?

Students will use their understanding of how to find the area of a rectangle to develop a formula and use it to solve problems. Students will consider the language we use when describing the dimensions of a rectangle.

## Visible learning

### Learning intention

* To develop the formula for the area of a rectangle.

### Success criteria

* I can explain how the formula for the area of a rectangle is obtained.
* I can use various terms to describe the dimensions of a rectangle.
* I can correctly substitute values into the formula for the area of a rectangle.
* I can solve equations involving the area of a rectangle.

### 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 area and composite area involving triangles, quadrilaterals and circles to solve problems **MA4-ARE-C-01**

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## Activity structure

The PowerPoint *Which way is up* accompanies this lesson.

### Launch

#### Blockout

This activity is an extension of the activity Blockout included in Unit 5 Multiplicative thinking in Lesson 3 ‘Area models and divisibility tests’ which was modified from the ‘Maths for love’ website ([bit.ly/MFLBlockout](https://bit.ly/MFLBlockout)). In this lesson, students will use a larger grid and 10-sided dice.

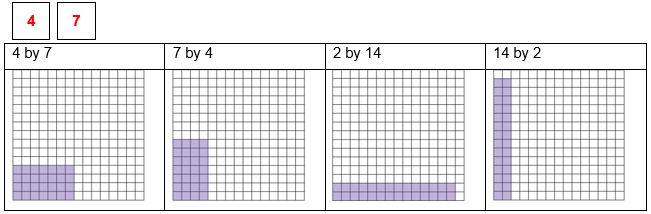
##### Equipment

* Two 10-sided dice per group of students. Virtual dice are available on Polypad ([mathigon.org/polypad](https://mathigon.org/polypad))
* Different coloured highlighter pens per group of students
* One copy of Appendix A ‘Blockout gameboard’ per group

##### Method

1. Players are to choose colours, then take turns rolling the dice and shading in a rectangle. If a player rolls a 4 and a 7, they can shade in 28 squares, either a 4 by 7 rectangle, or 2 by 14. They cannot shade a 1 by 28 rectangle as the grid is not large enough. The example, shown in Figure 1 below, is available on slide 2 of the *Which way is up* PowerPoint.

Figure 1 – a roll of 4 and 7



1. Players can place their rectangle anywhere in the grid on the gameboard.
2. No player can shade a square that is already shaded.
3. If a player cannot take their turn, they must pass. An example of a player that cannot take their turn is shown below in Figure 2, also available on slide 3 of the *Which way is up* PowerPoint.

Figure 2 – a roll that cannot be played

A screenshot of the blockout game

The numbers 4 and 9 are written in red, each in a black square.
A 15 by 15 black and white grid is shown with 3 purple rectangles and 2 green rectangles drawn on the grid.
The 5 rectangles are different shapes and are placed strategically on the grid with no overlapping.

1. If each player passes twice in a row, the game ends.
2. At the end of the game, players count the number of squares shaded in their colour. The winner is the player with the highest number of squares shaded.

Alternatively, students can play collaboratively, where the aim is to fill as many squares as possible as a team.

### Explore

1. Enlarge Appendix B *Finding Areas* onto A3 paper and slip into a plastic pocket, before placing them on walls around the room.
2. By working in visibly random groups of 3 ([bit.ly/visiblegroups](https://bit.ly/visiblegroups)) at the A3 plastic sheets ([bit.ly/VNPSstrategy](https://bit.ly/VNPSstrategy)), students will find the area of each rectangle and record their strategy for finding each area.

The rectangles increase in length, with the base dimension consistent at 5 units. The difficulty of the situation increases as the rectangles increase in size, the grid is removed and then dimensions begin to include decimals. The aim is for this to necessitate students moving away from counting squares to more efficient methods.

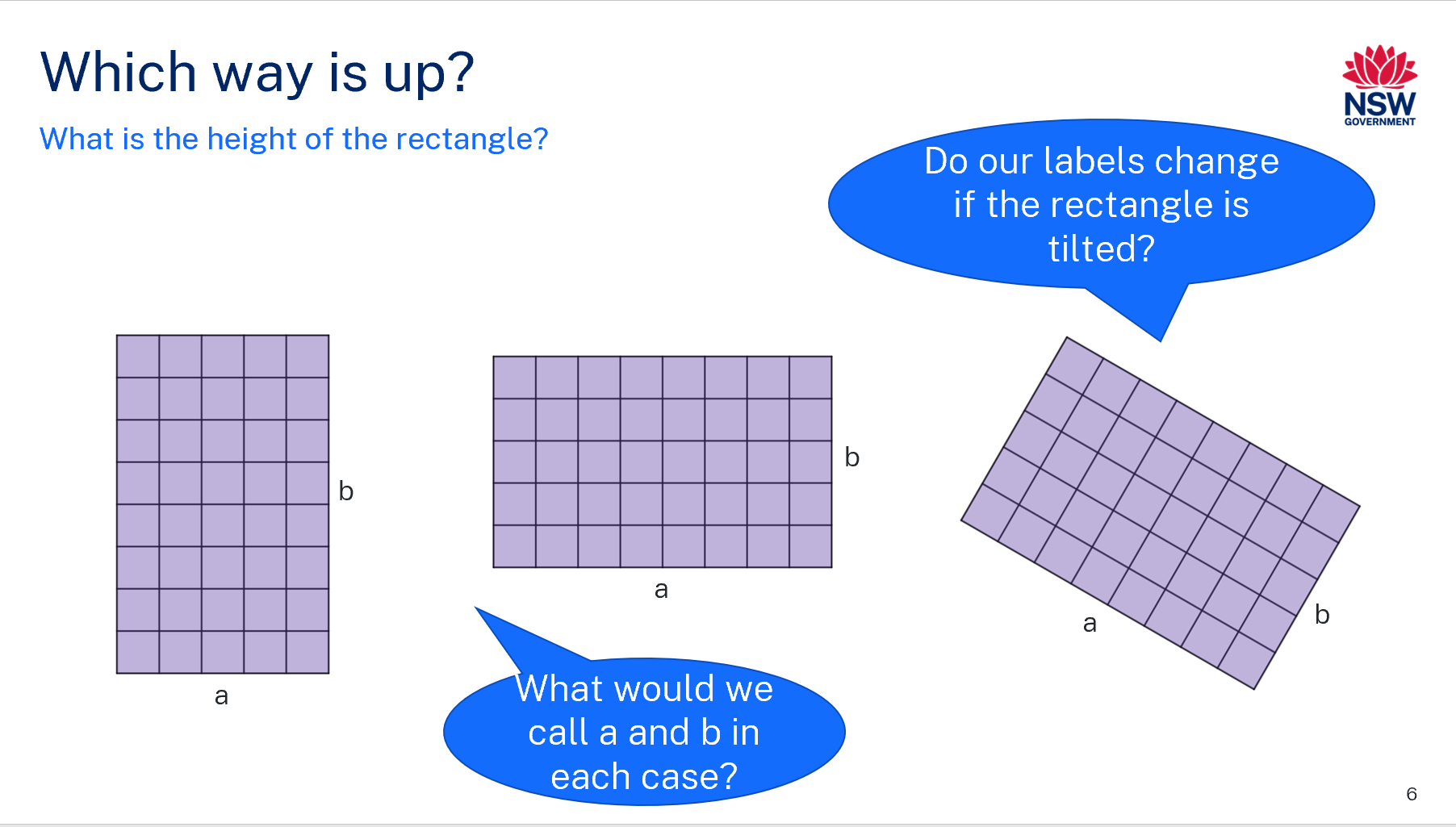
1. Use the Pose-Pause-Pounce-Bounce question strategy (PDF 557 KB) ([bit.ly/posepausepouncebounce](https://bit.ly/posepausepouncebounce)) to share the strategies that groups used to find the area.
2. As students share their strategies, make a list on the board of the terms they use to describe the dimensions of a rectangle.
3. Discuss the different terms used and brainstorm as a class, other words that are sometimes used to describe the dimensions of a rectangle. Add these new terms to the list on the board.

Teachers should add, if necessary, the following 5 terms: length, width, breadth, height and base.

Note that a discussion may be useful regarding the word ‘breadth’. The word breadth is derived from the word ‘broad’. To measure how broad something is, we measure the breadth.

1. Display Figure 3 for students, which is also available on slide 6 of the *Which way is up* PowerPoint.

Figure 3 – labelling sides of a rectangle



1. Out of the terms that the class brainstormed (and using others if they can now think of more), instruct students to consider in a Think-Pair-Share ([bit.ly/thinkpairsharestrategy](https://bit.ly/thinkpairsharestrategy)) which terms we would use to describe sides a and b in each rectangle.

Pairs should consider the following questions:

* Is the length always the longest side?
* If a rectangle is tilted at , which side is the length?
* As the rectangle is tilted more, do the labels ‘length’ and ‘breadth’, for example, change?

Students could be giving reasons which include that the length is always the longest side, the width and breadth are always the same side, the height is always vertical, or the base is always horizontal.

Students should recognise that the dimensions of the rectangle may be called different things and that both of the dimensions may be called the same thing.

**Fun fact:** the length is always measured along the grain of a piece of timber, even if it is not the longest side.

1. Have students verbalise a rule for finding the area of a rectangle using correct terminology.

Students should be able to recognise that although they may use different language, the process is still the same.

### Summarise

The formula is used in the syllabus.

1. Display slide 7 of the *Which way is up* PowerPoint.
2. Discuss with the class:

* Could the formula be written as ?
* What does mean?
* How could we write the formula for the area of a square?

1. Use slides 8–11 from the *Which way is up* PowerPoint for explicit teaching of the formula for the area of a rectangle.

The explicit teaching technique used in the PowerPoint is ‘Your turn’. The first slide is a worked example which should be displayed for the students before using the following steps.

1. Reveal the question to students and its solution.
2. Students read in silence.
3. Students individually explain to themselves what is happening in each step.
4. Students hold 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. Have students individually complete Appendix C, ‘Does the rule work?’

### Apply

1. During this section, students will work in visibly random groups of 3 ([bit.ly/visiblegroups](https://bit.ly/visiblegroups)) on vertical non-permanent surfaces ([bit.ly/VNPSstrategy](https://bit.ly/VNPSstrategy)) answering questions from Appendix D ‘Area maze’.
2. Provide groups with a copy of one question at a time. Allow them to compare and justify answers with other groups and to ‘steal’ questions from other groups when they have finished a question.

Students can be asked ‘Would you bet $100 on your answer?’ to assist them to justify how they know their answer is correct.

Groups with differing answers can also be placed together and asked to explain and justify their reasoning to each other.

More area mazes can be found on the Transum website ([bit.ly/areamazes](https://bit.ly/areamazes)).

## Assessment and differentiation

### Suggested opportunities for differentiation

**Launch**

* To enable students to participate, use a smaller grid and 6-sided dice.
* To challenge students, use the larger grid and 10-sided dice which includes a 0 or a 12-sided die with a 10-sided die.

**Explore**

* There are many strategies students could use to find the area of the rectangles. Teachers could support students by encouraging them to continue to utilise a grid drawn over the top of rectangles.
* There are many correct terms that can be used to describe the dimensions of a rectangle, so all students should feel they can participate in the discussion.

**Summarise**

* Students requiring support can continue to utilise a grid drawn over the top of rectangles to find the area.
* Students can continue to use their own strategies or terminology for finding the area of a rectangle.
* Bar models will help to support students when working backwards from the area to find the length of a side.

**Apply**

* To support students, add numbered circles to show students what values need to be calculated before they can find the required value in the area maze.
* Extend students by encouraging them to write equations which could be used to solve the area mazes.
* To challenge students, guide them to the Transum website, where they can find more challenging area mazes.
* Challenge students to make their own area maze and consider the least amount of information needed to solve it.

### Suggested opportunities for assessment

**Launch**

* **Monitor that students know how to construct a rectangle with specific dimensions.**

**Explore**

* Monitor responses in class and group discussions to check for student understanding that the labels of the dimensions are interchangeable.
* Check that students are able to formulate an appropriate rule to find the area of a rectangle.

**Summarise**

* **Collect Appendix C to check for understanding.**

**Apply**

* Monitor discussions and levels of participation of students whilst working in groups at the VNPS. Provide support where necessary.

## Appendix A

### Blockout gameboard

A 15 by 15 grid of squares with black squares.


## Appendix B

### Finding areas

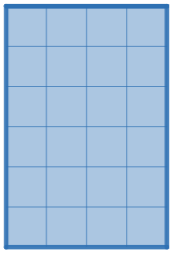
Find the area of each rectangle, explaining the strategy you used to find the area.

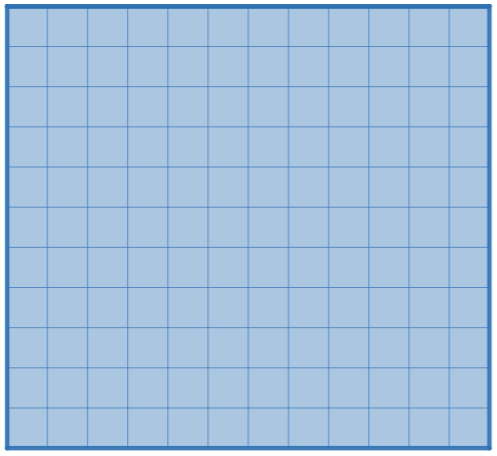
|  |  |  |
| --- | --- | --- |
| Rectangle | Area | Strategy used to find area |
| Rectangle grid measuring 5 squares wide by 1 square high. |  |  |
| Rectangle grid measuring 5 squares wide by 2 squares high. |  |  |
| Rectangle grid measuring 5 squares wide by 3 squares high. |  |  |
| Rectangle grid of 5 squares wide by 8 squares high. |  |  |
| Rectangular grid of 8 squares wide by 5 squares high. |  |  |
| Rectangle measuring 8 units high by 5 units wide. |  |  |
| Rectangle measuring 8.3 units high by 5 units wide. |  |  |

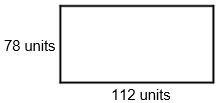
## Appendix C

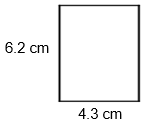
### Does the rule work?

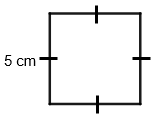
Write your rule for finding the area of a rectangle at the top of the writing space. Then, use your rule to find the area of each rectangle.











1. A rectangular driveway is being re-surfaced. The contractor needs to calculate the area of the driveway to order materials. The driveway is 3.1 metres by 5.2 metres. What is the area of the driveway?

## Appendix D

### Area maze

Find the value of the question marks in the following diagrams.

All the shapes are rectangles but are not drawn to scale.

Your working should only contain whole numbers.

|  |  |
| --- | --- |
|  | A rectangle split into two sections, one orange and one green. The dimensions are 2 centimetres and 9 centimetres. The area of the orange rectangle is 8 square centimetres and the area of the green rectangle is unknown. |
|  | A rectangle split into two sections, one yellow and one blue. The dimensions are 3 centimetres and the other is unknown. The area of the yellow rectangle is 6 square centimetres and the area of the blue rectangle is 12 square centimetres. |
|  | A composite shape with two rectangles in an l shape. The top rectangle is split into two sections, one green and one blue. The area of the green rectangle is unknown. The width of the blue rectangle is 5 centimetres and the area of the blue rectangle is 20 square centimetres. The bottom rectangle is yellow. Its height is 3 centimetres. The area of the yellow rectangle is 18 square centimetres. |
|  | A composite shape with two rectangles in an l shape. The top rectangle is split into two sections, one blue and one green. The width of the blue rectangle is unknown. The area of the blue rectangle is 36 square centimetres. The the area of the green rectangle is 24 square centimetres. The bottom rectangle is rust. Its height is 2 centimetres. The area of the rust rectangle is 12 square centimetres. |
|  | A composite shape with two rectangles in an l shape. The taller rectangle on the left rectangle is blue. Its width is 4 centimetres and its area is 32 square centimetres. The shorter rectangle on the right is green. Its width is 5 centimetres and its area is 25 square centimetres. The vertical length on the right side of the taller rectangle, above the shorter rectangle is unknown. |
|  | A composite shape with one longer rectangle and two smaller rectangles below, with a gap between them. The top rectangle is 3 centimetres tall and has an area of 60 square centimetres. The rectangle on the bottom left is dark blue. It has a height of 3 centimetres and an area of 18 square centimetres. The rectangle on the bottom right is also dark blue. It has a hieght of 4 centimetres and its area is unknown. There is a 9 centimetre gap between the two lower rectangles. |
|  | A rectangle split into 2 rows of 2 rectangles. The top left rectangle is orange. It has a height of 3 centimetres and an area of 30 square centimetres. The top right rectangle is blue. It has an area of 24 square centimetres. The bottom right rectangle is green and has an area of 32 square centimetres. The bottom left rectangle is yellow. Its area is unknown. |
|  | A rectangle with a height of 15 centimetres, split horizontally into two rectangles. The top rectangle is green. It has a height of 7 centimetres and an area of 175 square centimetres. The bottom rectangle is blue. Its area is unknown. |
|  | A rectangle split into 4 rectangles, 2 rows of 2. The top left rectangle is orange. It has a height of 6 centimetres and an area of 30 square centimetres. The top right rectangle is grey. It has a height of 6 centimetres and an area of 42 square centimetres. The bottom left rectangle is blue. It has a height of 8 centimetres and an area of 72 square centimetres. The bottom right rectangle is yellow. It has a height of 8 centimetres. Its area is unknown. |
|  | A rectangle, with a height of 15 centimetres and a width of 12 centimetres, is split into 4 rectangles, 2 rows of 2. The top left rectangle is green and has an area of 45 square centimetres. The bottom left rectangle is red and has an area of 25 square centimetres. The bottom right rectangle is blue and has an area of 80 square centimetres. The top right rectangle is yellow. Its area is unknown. |
|  | A composite shape that is 12 centimetres wide is split into 3 adjacent rectangles. The tallest rectangle, which is on the left, is yellow. It has a height of 11 cm and an area of 33 square centimetres. The bottom right of this rectangle, below the adjacent rectangle, is 7 centimetres in length. The shortest rectangle is the middle rectangle. It is pink and its area is 16 square centimetres. The rectangle on the right is grey. Its area is 35 square centimetres. The bottom left of this rectangle, below the adjacent rectangle, has a length which is unknown. |
|  | A composite shape, split into 3 horizontal rectangles, with the bottom rectangle longer than the one above it, which is longer than the one above it. The top rectangle is blue. It has a height of 4 centimetres and an area of 24 square centimetres. The middle rectangle  has an area of 34 square centimetres and the top left of the rectangle, beside the top rectangle, has a length of 2 centimetres. The bottom rectangle is yellow. It has an area of 44 square centimetres. The top left of the rectangle, beside the green rectangle, has a length of 3 centimetres. The height of the bottom rectangle is unknown. |
|  | A composite shape with a height of 15 centimetres, split into 3 horizontal rectangles, with the bottom rectangle longer than the one above it, which is longer than the one above it. The top rectangle is green. Its area is unknown. The middle rectangle is blue. It has a height of 5 centimetres and an area of 40 square centimetres. The top right of the rectangle, beside the top rectangle, has a length of 3 centimetres. The bottom rectangle is purple. It has an area of 60 square centimetres. The top right of the rectangle, beside the blue rectangle, has a length of 2 centimetres. |
|  | A large rectangle split into 4 rectangles. The top right rectangle is grey. It has an area of 40 square centimetres. The bottom right rectangle is pink. It has a height of 3 centimetres and an area of 15 square centimetres. The bottom left rectangle is tan. It has an area of 54 square centimetres. The top left rectangle is yellow. It has an area of 45 square centimetres. Its height is unknown. |
|  | A rectangle split into 5 rectangles. The bottom rectangle extends across the large rectangle. It is orange, has an area of 72 square centimetres. Its height is unknown. A green rectangle is on the right, extending from the orange rectangle up to the top of the large rectangle. Its area is 48 square centimetres. There is a purple rectangle in the middle, extending from the left along to the green rectangle. It area is 32 square centimetres. Above it are two rectangles. The left rectangle is pink. It has an area of 40 square centimetres. The rectangle on the right, which is at the top middle of the large rectangle, is peach. It has an area of 24 square centimetres and a width of 6 centimetres. |

## Sample solutions

### Appendix C – Does the rule work?

### Appendix D – area maze

1. 10
2. 6
3. 24
4. 9
5. 3
6. 20
7. 40
8. 200
9. 24
10. 30
11. 3
12. 4
13. 20
14. 5
15. 3

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