# Simultaneous shopping

Students explore solving simultaneous equations through shopping scenarios. In this lesson they are introduced to bar models as a method to solve simultaneous equations.

## Visible learning

This lesson incorporates Path content.

### Learning intentions

* To be able to solve simultaneous linear equations using substitution.

### Success criteria

* I can draw a bar model to represent an equation.
* I can substitute a value into an equation.
* I can determine the solution to linear simultaneous equations by using a bar model.

### Syllabus outcomes

A student:

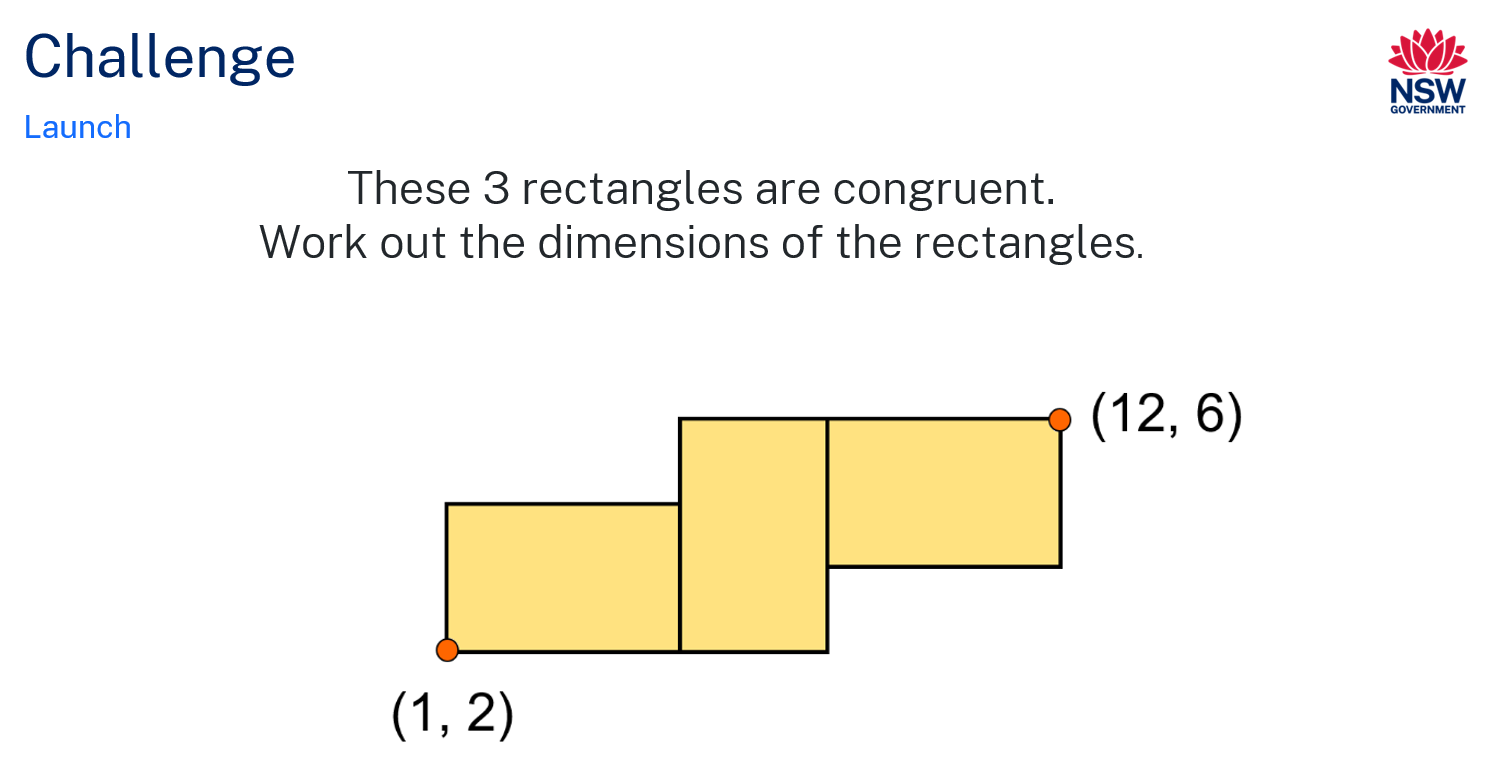
* develops understanding and fluency in mathematics through exploring and connecting mathematical concepts, choosing and applying mathematical techniques to solve problems, and communicating their thinking and reasoning coherently and clearly **MAO-WM-01**
* solves linear equations of more than 3 steps, monic and non-monic quadratic equations, and linear simultaneous equations **MA5-EQU-P-02**

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## Activity structure

### Launch

1. Display slide 2 of the *Simultaneous shopping* PowerPoint.

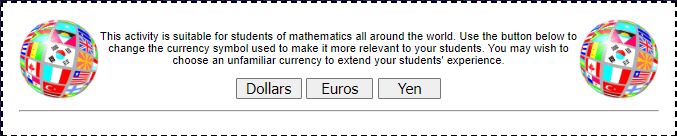


1. Students are to work in pairs to find the dimensions of the rectangles.
2. Use a Pose-Pause-Pounce-Bounce question strategy [PDF 200KB] ([bit.ly/pausepouncebouncestrategy](https://bit.ly/pausepouncebouncestrategy)) to get students to share their strategies for solving the problem without acknowledging the correct solution or correct or incorrect strategies.

Highlight the similarities and differences between the strategies that have been shared. The solution will be revealed in the Summarise section of the lesson.

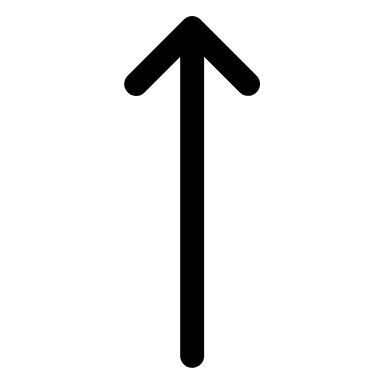
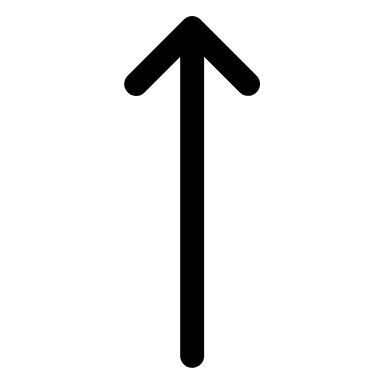
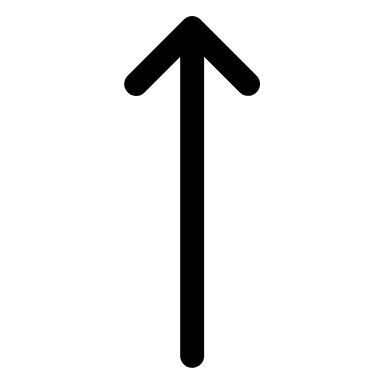
### Explore

1. Navigate to the website (<https://bit.ly/simultaneousshop>). If devices are not available, there is an alternate activity in Appendix A ‘Simultaneous shopping’.
2. Students are to work in pairs to solve each of the puzzles. They can move on to the next level when they are ready.

There is an option below the activity to change the units to dollars. 

1. Combine each pair of students with another pair of students so that they can explain the strategies they used to solve the puzzles to each other. If they used similar strategies, could they together come up with a different strategy? If they used different strategies, get them to play again using the other pair’s strategy.
2. Allow students time to discuss whether the new strategy was more or less efficient than their original approach.

### Summarise

1. Use a Think-Pair-Share ([bit.ly/thinkpairsharestrategy](https://bit.ly/thinkpairsharestrategy)) for students to consider if they could draw a diagram, similar to the ‘Simultaneous Shopping’ game, to represent the information they know from the challenge question in the Launch.   
   For instance,  = 11 and = 4.
2. Use a Pose-Pause-Pounce-Bounce question strategy to get students to share their representations and reasoning.
3. Show slide 3 from the *Simultaneous shopping* PowerPoint. Discuss with students how this representation can help us to determine the length and width of the rectangles.
4. Show slides 4–11 from the *Simultaneous shopping* PowerPoint to explicitly teach how to use a bar model to solve simultaneous linear equations.

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 give 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.

Review the notes section of the PowerPoint slides to find important considerations for teachers when engaging in class discussions.

1. Students are to complete Appendix B ‘Simultaneous equations – bar model’ either individually or in pairs.

### Apply

1. Students are to complete Appendix C ‘Making connections’. The first table has been completed as an example.
2. Students need to fill as many cells as possible using the given information.

## Assessment and differentiation

### Suggested opportunities for differentiation

**Explore**

* The website activity has different levels which allow for differentiation.

**Summarise**

* Students could be given manipulatives to assist in forming bar graphs.

**Apply**

* Students could be given the gradient intercept form of the equation rather than the general form of the equation.
* Students could find 2 equations that intersect at a given point.

### Suggested opportunities for assessment

**Summarise**

* The teacher could gauge understanding by listening to students’ responses during discussion as well as during the questioning.
* The teacher could check students’ equations and answers for Appendix B ‘Simultaneous equations – bar model’.

**Apply**

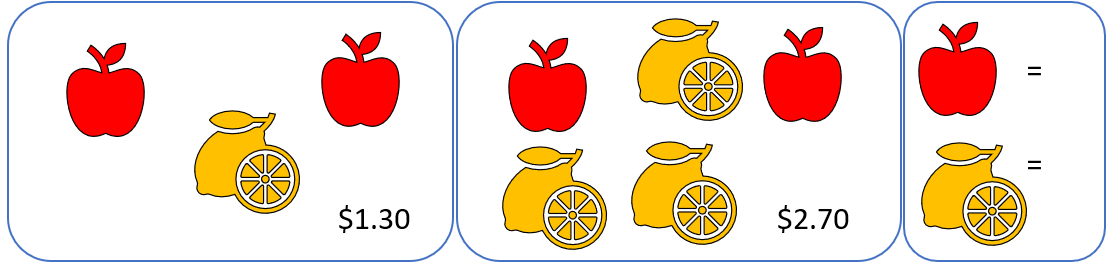
* The teacher could collect Appendix C as formative assessment for many of the concepts learnt previously in this topic as well as simultaneous equations.

## Appendix A

### Simultaneous shopping

Find the cost of each item in the baskets. The total cost of the items in each basket is shown.

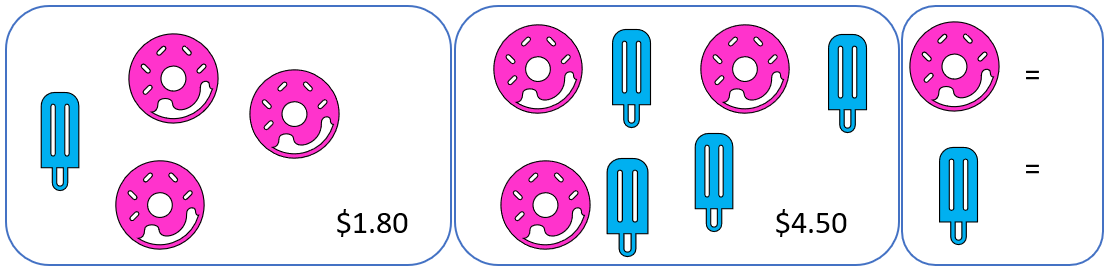
#### Set 1



#### Set 2

3 cards
Card one has 2 lollies and 3 bananas = $1.17.
Card two has 3 bananas and 7 lollies = $1.77
Card three has lolly = and banana =

#### Set 3



#### Set 4

3 cards
Card one has 2 croissants and 2 coffee mugs = $16
Card 2 has 3 croissants and 4 coffee cups = $31
Card 3 has a coffee mugs = and croissants =.


#### Set 5

3 cards
Card one has 3 eggplants and 2 pea pods = $5.40
Card two has 6 pea pods and 4 eggplants = $10.20
Card 3 has an eggplant = and a pea pod = .


#### Set 6

3 cards
Card one has 3 drumsticks and 2 drinks = $22.
Card 2 has 4 drumsticks and 3 drinks = $29.
Card 3 has a drink = and a drumstick =.

#### Set 7

3 cards
Card one has 3 pieces of cheese and 2 bread sticks = $19.40.
Card 2 has 2 pieces of cheese and 5 bread sticks = $21
Card 3 has a bread stick = and a piece of cheese =.

#### Set 8

3 cards
Card one has 2 bunches of grapes and 4 slices of watermelon = $1.36.
Card 2 has 4 bunches of graphs and 3 slices of watermelon = $1.47.
Card 3 has a bunch of grapes = and a slice of watermelon =.

#### Set 9

3 cards.
Card one has 4 lollypops and 2 peaches = $19.20
Card 2 has 7 lollypops and 3 peaches = $33.20
Card 3 has a lollypop = and a peach =.

#### Set 10

3 cards
Card one has 3 footballs and 1 cap = $41.
Card 2 has 5 footballs = $55.
Card 3 has a football = and a cap =. 

#### Set 11

#### 3 cards Card one has 4 frogs and 7 chicks = $89.80 Card 2 has 3 frogs and 5 chicks = $64.90 Card 3 has a frog = and a chick =.

## Appendix B

### Simultaneous equations – bar model

|  |  |  |
| --- | --- | --- |
| Bar model | Equations | Solution |
| 2 bars. Bar one has 2 x's the same length as 20. Bar two has 2 x's and 4 y's the same length as 140. |  |  |
| 2 bars. Bar one has 2 x's the same length as 60. Bar two has 2 x's and 4 y's the same length as 200. |  |  |
| 2 bars. Bar one has an x the same length as 30. Bar two has 2 x's and 4 y's the same length as 100. |  |  |
| 2 bars. Bar one has 2y's and  2 x's the same length as 16. Bar two has 2 x's and 4 y's the same length as 20. |  |  |
| 2 bars. Bar one has 2 y's and 2 x's the same length as 16. Bar two has an x and 2 y's the same length as 10. |  |  |
| 2 bars. Bar one has 2 y's and 2 x's the same length as 12. Bar two has an x and 2 y's the same length as 6. |  |  |
| 2 bars. Bar one has 2 y's and 2 x's the same length as 12. Bar two has an x and 2 y's the same length as 12. |  |  |
| 2 bars. Bar one has 2 y's and 2 x's the same length as 12. Bar two has an x and a y the same length as 12. |  |  |
| 2 bars. Bar one has 4 y's and 2 x's the same length as 100. Bar two has an x and y the same length as 40. |  |  |
| 2 bars. Bar one has 4 y's and 2 x's the same length as 20. Bar two has an x and y the same length as 8. |  |  |

## Appendix C

### Making connections

For each table, fill in as much information as possible. The first one has been completed for you as an example.

|  |  |
| --- | --- |
| **Equations**  **Line 1:** or  **Line 2:** or | **Solutions/Point of intersection**  6  2  ( |
| **Bar model** 2 bars. Bar one has 2 y's and 2 x's the same length as 16. Bar two has an 2 x's and 4 y's the same length as 20. | **Graph** Graph with two lines drawn. The first line intercepts the y axis at 5 and the x axis at 10. The second line intercepts the y-axis at 8 and the x-axis at 8. They intercept at (6,2) |
| **Intercepts**  Line 1: (8  Line 1: y(0,8  Line 2: (10  Line 2: y(0 | **Gradients**  Line 1:  Line 2: |

|  |
| --- |
| **Table of Values**  **Line 1**  Table of values for Line 1. The first row labelled x contains the numbers 0 to 6 in ascending order. The second row labelled y contains the digits 8 to 3 in descending order.  **Line 2**  **Table of values for Line 2.  The first row labelled x contains the numbers 0 to 6 in ascending order. The second row labelled y contains the digits 5 to 2, descending by a .5 increment.** |

|  |  |
| --- | --- |
| **Equations**  Line 1: or  Line 2: or | **Solution/Point of intersection**  ( |
| **Bar model** | **Graph**  Blank cartesian plane |
| **Intercepts**  Line 1: (  Line 1: y(  Line 2: (  Line 2: y( | **Gradients**  Line 1:  Line 2: |

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| --- |
| **Table of values**  **Line 1**  **Table of values for Line 1. The first row labelled x contains the numbers 8 to 14 in ascending order. The second row labelled y has been left blank for students to respond.**  **Line 2**  **Table of values for Line 2. The first row labelled x contains the numbers 8 to 14 in ascending order. The second row labelled y has been left blank for students to respond.** |

|  |  |
| --- | --- |
| **Equations**  Line 1:  Line 2: | **Solution/Point of intersection**  ( |
| **Bar model** | **Graph**  Graph with two lines drawn. The first line intercepts the y axis at 4.5 and the x axis at 9. The second line intercepts the y-axis at 15 and the x-axis at 7.5. They intercept at (7,1) |
| **Intercepts**  Line 1: (  Line 1: y(  Line 2: (  Line 2: y( | **Gradients**  Line 1:  Line 2: |

|  |
| --- |
| **Table of values**  **Line 1**  **Table of values for Line 1. The first row labelled x contains the numbers zero in the second cell and the remaining 6 cells have been left blank for students to respond. The second row labelled y has been left blank for students to respond.**  **Line 2**  **Table of values for Line 2. The first row labelled x contains the numbers zero in the second cell and the remaining 6 cells have been left blank for students to respond. The second row labelled y has been left blank for students to respond.** |

|  |  |
| --- | --- |
| **Equations**  Line 1:  Line 2: | **Solution/Point of intersection**  ( |
| **Bar model** | **Graph**  Blank cartesian plane |
| **Intercepts**  Line 1:  Line 1: y  Line 2:  Line 2: y | **Gradients**  Line 1:  Line 2: |

|  |
| --- |
| **Table of values**  **Line 1**  **Table of values for Line 1**  **Line 2**  **Table of values for Line 2** |

## Sample solutions

### Appendix A – simultaneous shopping

#### Set 1

2 apples + 1 lemon = $1.30

2 apples + 3 lemons = $2.70

2 lemons = $1.40

1 lemon = $0.70

1 apple = $0.30

#### Set 2

2 lollies + 3 bananas = $1.17

7 lollies + 3 bananas = $1.77

5 lollies = $0.60

1 lolly = $0.12

1 banana = $0.31

#### Set 3

1 ice block + 3 donuts = $1.80

4 ice block + 3 donuts = $4.50

3 ice blocks = $2.70

1 ice block = $0.90

1 donut = $0.30

#### Set 4

2 croissants + 2 coffees = $16

3 croissants + 4 coffees = $31

4 croissants + 4 coffees = $32

1 croissant = $1

1 coffee = $7

#### Set 5

3 eggplants + 2 pea pods = $5.40

4 eggplants + 6 pea pods = $10.20

9 eggplants + 6 pea pods = $5.40 x 3 = $16.20

5 eggplants = $6.00

1 eggplant = $1.20

1 pea pod = $0.90

#### Set 6

3 drumsticks + 2 drinks =$21

4 drumsticks + 3 drinks =$29

12 drumsticks + 8 drinks = 21 x 4 = $84

12 drumsticks + 9 drinks = 29 x 3 = $87

1 drink = $3

1 drumstick = $5

#### Set 7

2 breadsticks + 3 cheese = $19.40

5 breadsticks + 2 cheese = $21

10 breadsticks + 15 cheese = 19.40 x 5 = $97

10 breadsticks + 4 cheese = 21 x 2 = $42

11 cheese = $55

1 cheese = $5

1 breadstick = $2.20

#### Set 8

2 grapes + 4 watermelon = $1.36

4 grapes + 3 watermelon = $1.47

4 grapes + 8 watermelon = 1.36 x 2 = $2.72

5 watermelon = $1.25

1 watermelon = $0.25

1 grape = $0.18

#### Set 9

4 lollypops + 2 peaches = $19.20

7 lollypops + 3 peaches = $33.20

12 lollypops + 6 peaches = 19.20 x 3 = $57.60

14 lollypops + 6 peaches = 33.20 x 2 = $66.40

2 lollypops = $8.80

1 lollypop = $4.40

1 peaches = $0.80

#### Set 10

3 footballs + 1 cap = $41

5 footballs = $55

1 football = $11

1 cap = $8

#### Set 11

4 frogs + 7 chicks = $89.80

3 frogs + 5 chicks = $64.90

12 frogs + 21 chicks = 89.80 x 3 = $269.40

12 frogs + 20 chicks = 64.90 x 4 = $259.60

1 chick = $9.80

1 frog = $5.30

### Appendix B – simultaneous equations – bar model

|  |  |  |
| --- | --- | --- |
| Bar model | Equations | Solution |
| 2 bars. Bar one has 2 x's the same length as 20. Bar two has 2 x's and 4 y's the same length as 140. |  |  |
| 2 bars. Bar one has 2 x's the same length as 60. Bar two has 2 x's and 4 y's the same length as 200. |  |  |
| 2 bars. Bar one has an x the same length as 30. Bar two has 2 x's and 4 y's the same length as 100. |  |  |
| 2 bars. Bar one has 2y's and  2 x's the same length as 16. Bar two has 2 x's and 4 y's the same length as 20. |  |  |
| 2 bars. Bar one has 2 y's and 2 x's the same length as 16. Bar two has an x and 2 y's the same length as 10. |  |  |
| 2 bars. Bar one has 2 y's and 2 x's the same length as 12. Bar two has an x and 2 y's the same length as 6. |  |  |
| 2 bars. Bar one has 2 y's and 2 x's the same length as 12. Bar two has an x and 2 y's the same length as 12. |  |  |
| 2 bars. Bar one has 2 y's and 2 x's the same length as 12. Bar two has an x and a y the same length as 12. |  | No solution  Parallel lines |
| 2 bars. Bar one has 4 y's and 2 x's the same length as 100. Bar two has an x and y the same length as 40. |  |  |
| 2 bars. Bar one has 4 y's and 2 x's the same length as 20. Bar two has an x and y the same length as 8. |  | 6 |

### Appendix C – making connections

|  |  |
| --- | --- |
| **Equations**  Line 1:  Line 2: or | **Solution/Point of intersection** |
| **Bar model**  2 bars. First bar, y and x is equal to 14. Second bar 2 y's and an x is equivalent to 16 | **Graph**  Graph with two lines drawn. The first line intercepts the y axis at 14 and the x axis at 14. The second line intercepts the y-axis at 8 and the x-axis at 16. They intercept at (12,2) |
| **Intercepts**  Line 1:  Line 1: y  Line 2:  Line 2: y | **Gradients**  Line 1:  Line 2: |

|  |
| --- |
| **Table of values**  **Line 1**  **Table of values for Line 1. The first row labelled x contains the numbers 8 to 14 in ascending order. The second row labelled y contains the numbers 6 to 5 in descending order.**  **Line 2**  **Table of values for Line 2.  The first row labelled x contains the numbers 8 to 14 in ascending order. The second row labelled y contains the digits 4 to 1, descending by a .5 increment.** |

|  |  |
| --- | --- |
| **Equations**  Line 1:  Line 2: or | **Solution/Point of intersection** |
| **Bar model**  2 bars. First bar, y and 2 x's is equal to 15. Second bar 2 y's and an x is equivalent to 9. | **Graph**  Graph with two lines drawn. The first line intercepts the y axis at 4.5 and the x axis at 9. The second line intercepts the y-axis at 15 and the x-axis at 7.5. They intercept at (7,1) |
| **Intercepts**  Line 1:  Line 1: y  Line 2:  Line 2: y | **Gradients**  Line 1:  Line 2: |

|  |
| --- |
| **Table of values**  **Line 1**  Table of values for Line 2.  The first row labelled x contains the number zero and increases by 2 until it reaches 12. The second row labelled y contains the digits 4.5 to -1.5, descending by 1 increment.  **Line 2**  **Table of values for Line 2.  The first row labelled x contains the numbers 0 to 6 in ascending order. The second row labelled y contains the odd digits between 15 and 3 in a descending order.** |

|  |  |
| --- | --- |
| **Equations**  Line 1:  Line 2: | **Solution/Point of intersection** |
| **Bar model**  2 bars. First bar, y and 6 x's is equal to 18. Second bar a y and 4 x's is equivalent to 14. | **Graph**  Graph with two lines drawn. The first line intercepts the y axis at 14  and the x axis at 3.5. The second line intercepts the y-axis at 18 and the x-axis at 3. They intercept at (2,6) |
| **Intercepts**  Line 1:  Line 1: y  Line 2:  Line 2: y | **Gradients**  Line 1:  Line 2: |

|  |
| --- |
| **Table of values**  **Line 1**  **Table of values for Line 2.  The first row labelled x contains the numbers -1 to 5 in ascending order. The second row labelled y contains the digits 24 to -12, descending by 6 each time.**  **Line 2**  **Table of values for Line 2.  The first row labelled x contains the numbers -1 to 5 in ascending order. The second row labelled y contains the even digits from 18 and descending by 4 each time to reach -4.** |

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