# Cooking for one

Students alter recipes, multiplying quantities by common fractions. They explore area models to represent fraction and decimal multiplication.

## Visible learning

### Learning intentions

* To be able to represent multiplication between fractions and decimals using area models.
* To be able to perform multiplication with fractions and decimals.

### Success criteria

* I can divide rectangles into equal parts to represent fractions and decimals.
* I can create area models to represent fraction and decimal multiplication.
* I can explain why multiplication between fractions can be performed by multiplying numerators and multiplying denominators.

### 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**
* **represents and operates with fractions, decimals and percentages to solve problems MA4-FRC-C-01**

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Please use the associated PowerPoint *Cooking for one* to display images in this lesson.

## Activity structure

### Launch

1. Explain to students that we are considering the situation of Andrew, a single person who wants to make a meal and dessert for himself.
2. Hand out Appendix A ‘Dinner and dessert recipes’ and explain that Andrew is hoping to make both recipes. He wants to make 2 servings of the stir-fry, one for tonight and one to keep in the fridge for dinner tomorrow. He wants to make 4 cupcakes, as he knows that after 4 days the cakes will go stale.
3. Have students engage in a Think-Pair-Share ([bit.ly/thinkpairsharestrategy](https://bit.ly/thinkpairsharestrategy)) to change the quantities of as many of the ingredients as possible to suit Andrew’s needs.

Teachers are advised to allow students to complete this without intervention, completing as much of the information as they know and allowing them to leave the measurements, they are unable to modify.

### Explore

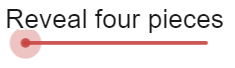
#### Paper folding to find fractions of fractions

##### Equipment

* Two A4 sheets of paper per student
* One copy of Appendix B ‘One quarter of everything’ per student

##### Method

1. Acknowledge with students that to modify the stir-fry recipe to serve 2 people instead of 8 people, we need to find one quarter of the quantity of each ingredient.
2. Display the Desmos graph ‘Cutting the cake’ ([bit.ly/DesmosCake1](https://bit.ly/DesmosCake1)) on the teacher screen. Inform students that the rectangle represents a chocolate cake.
3. Have a student drag the point at the bottom of the screen of the way along the cake. The rest of the class can give their opinion of where the cut should be made.
4. Drag the ‘Reveal four pieces’ switch to see the accuracy of the student’s estimate.



If technology is unavailable, steps 2–4 can be replicated by drawing a rectangle on a whiteboard and measuring with a metre ruler to determine how effectively a student estimated one quarter.

1. Hand each student one sheet of A4 paper.
2. Display Figure 1 and ask students to try to fold their paper of the way along the sheet.

Figure 1 – folding a sheet of paper one quarter of the way along the sheet

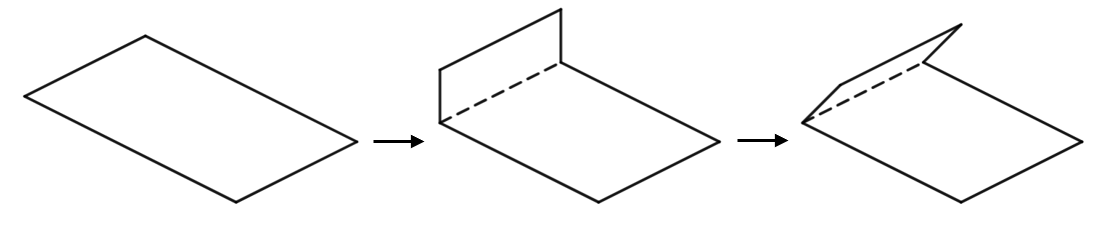


Image created using [Desmos](https://www.desmos.com/?lang=en) and is licensed under the [Desmos Terms of Service](https://www.desmos.com/terms?lang=en).

1. Display Figure 2 and ask students to continue folding until they can fold no further.

Figure 2 – folding a sheet of paper into quarters

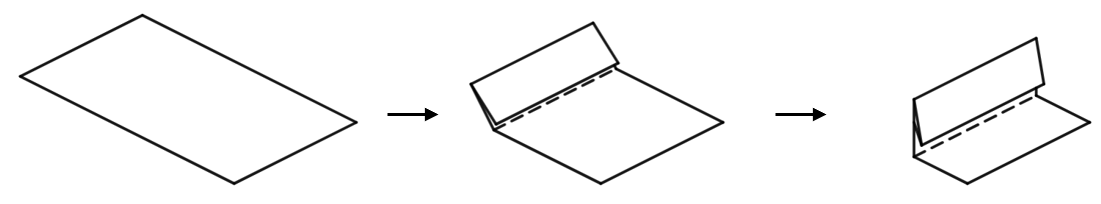


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1. Have all students unfold their paper and review the results.

It is likely that students will have made inaccurate, unequal sections, as this approach is not precise. If students have made quite accurate quarters, consider asking them to share any additional methods they used.

1. Display the Desmos graph ‘Cutting the cake 2’ ([bit.ly/DesmosCake2](https://bit.ly/DesmosCake2)) on the teacher screen.
2. Have a student drag the point at the bottom of the screen of the way along the cake. The rest of the class can again give their opinion of where the cut should be made.
3. Drag the switch to see the accuracy of the student estimate.

This method is far more likely to be accurate. If the first student does not improve upon the initial estimate with quarters, repeat step 9 with multiple students.

1. Conclude that a good way to make quarters is to halve once and then to halve again, as halves are reasonable to approximate.
2. Hand each student a new piece of A4 paper and display Figure 3. Have students halve their paper and then halve again to make quarters, shading one quarter when complete.

Figure 3 – folding a sheet of paper in half twice

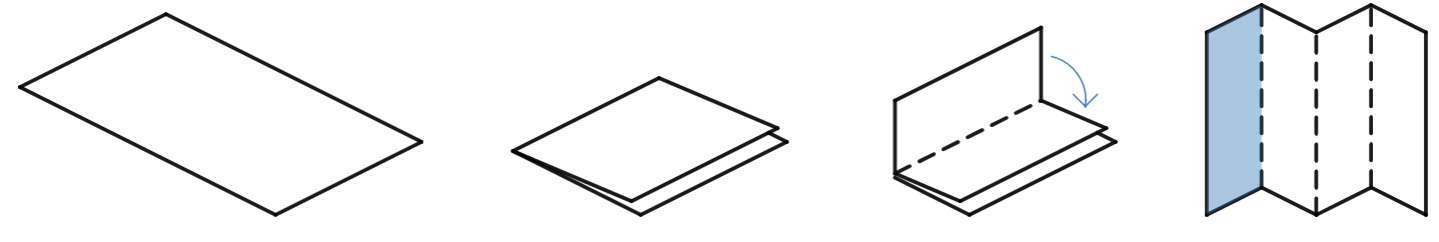


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1. Have students engage in a Think-Pair-Share to consider how we would find of this sheet of paper.
2. Demonstrate to students that folding the paper in the perpendicular direction to the original folds will help find of , as shown in Figure 4.

Figure 4 – one quarter of one quarter

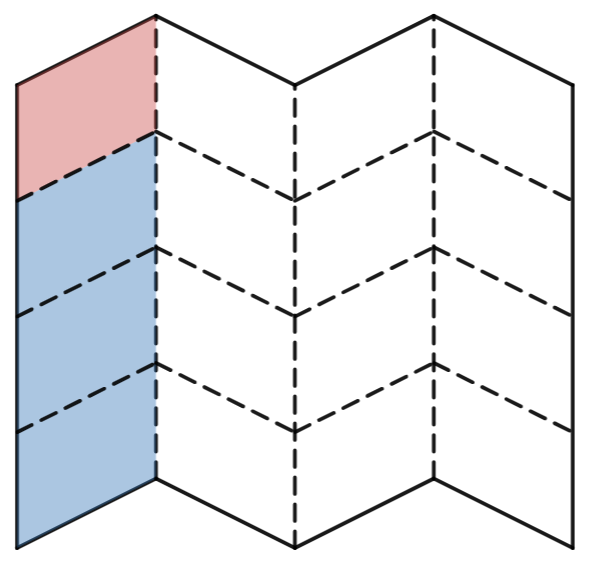


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1. Conclude that of is the same as and is equal to .

#### Quarters of ingredients

1. Hand students copies of Appendix B ‘One quarter of everything’.
2. Organise students into visibly random groups of 3 ([bit.ly/visiblegroups](https://bit.ly/visiblegroups)).
3. Have students read the first example on the worksheet before attempting to find and describe one quarter of each quantity.
4. Use a Pause-Pose-Pounce-Bounce question strategy [PDF 200KB] ([bit.ly/pausepouncebounce](https://bit.ly/pausepouncebounce)) to gather and review student responses.

#### Thirds of ingredients

1. Hand students copies of Appendix C ‘One third of everything’.
2. Have students read the first example on the worksheet before attempting to find and describe one third of each quantity, working in their groups from the previous activity.
3. Use a Pause-Pose-Pounce-Bounce question strategy to gather and review student responses.

### Summarise

1. Use slides 6–17 from the *Cooking for one* PowerPoint for explicit teaching of multiplying fractions and decimals.

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. Have students complete Appendix D ‘Representing multiplication of fractions and decimals’ where they draw representations of each multiplication before solving.
9. Students can use the Desmos graphs ‘Fraction multiplication’ ([bit.ly/DesmosFracMult](https://bit.ly/DesmosFracMult)), ‘Decimal multiplication’ ([bit.ly/DesmosDecMult](https://bit.ly/DesmosDecMult)) and ‘Fraction and decimal multiplication’ ([bit.ly/DesmosFDMult](https://bit.ly/DesmosFDMult)) to assist their representations.
10. Write the operation on the whiteboard. Have students engage in a Think-Pair-Share to discuss the following reflection questions.
11. How can we predict the value of the numerator and denominator of the solution without drawing a representation?
12. How does a representation explain these predictions?

When sharing, the teacher can establish rules for multiplying fractions, including that we can multiply the denominators to obtain the denominator of the solution. Such rules should be introduced by drawing connection to the representation and the reason these rules apply. For example, when evaluating , the denominator of the solution will be , because the result can be shown as a square divided horizontally into 7 equal parts and vertically into 9 equal parts, making a grid of 63 equal parts.

1. Have students write notes to their future forgetful self ([bit.ly/notesstrategy](https://bit.ly/notesstrategy)).

### Apply

#### Open middle problem

* Challenge students to complete the open middle problem displayed on slides 18 and 19 of the *Cooking for one* PowerPoint. This problem is also displayed in Figure 5 and is inspired by the problem at the ‘Open middle’ website ([bit.ly/OMFractionMult](https://bit.ly/OMFractionMult)).

Figure 5 – open middle problem

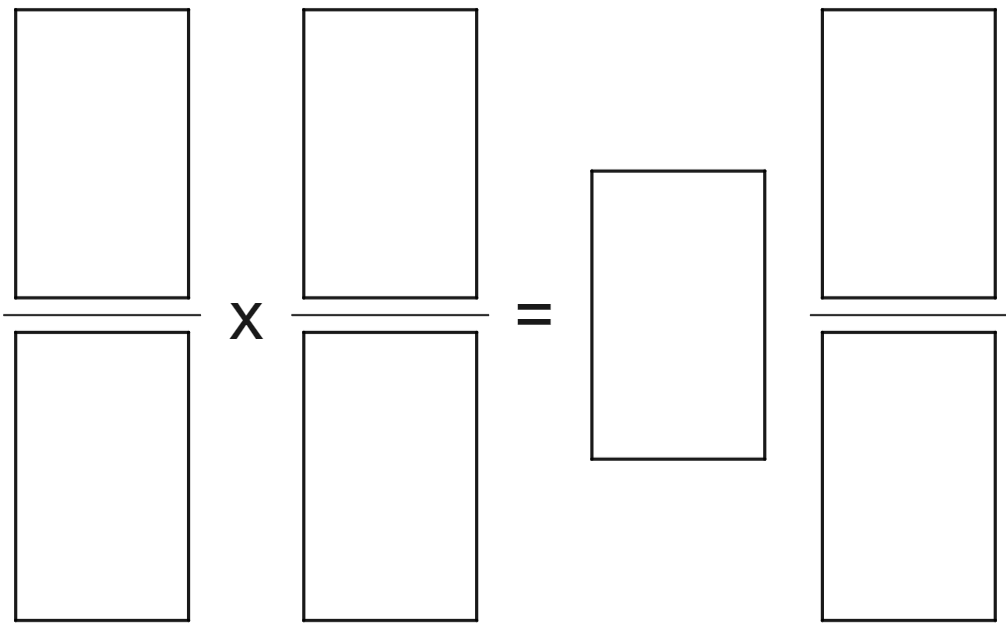


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* Students are to use the integers from 1 to 9 at most once to try to obtain the largest possible result. Teachers can print this from Appendix E ‘Open middle problem’ if desired.
* Similar open middle problems can be found at the ‘Open middle’ website ([bit.ly/OMMultFrac](https://bit.ly/OMMultFrac)).

## Assessment and Differentiation

### Suggested opportunities for differentiation

**Explore**

* The Desmos graph to simulate cake cutting and the paper folding activity support students to attempt, reflect and improve. These activities also support students to enter the concept of fraction multiplication by first manipulating concrete materials.
* Challenge students to consider what fractions of paper would be difficult to represent using the paper folding method shown. We hope students will conclude that given we create the fractions using multiplication, prime numbers are especially difficult to create in the denominator.

**Summarise**

* The use of Desmos graphs for fraction multiplication supports more students to have access to these activities and the ability to reflect on trends in results.

**Apply**

* The general link to the ‘Open middle’ website ([bit.ly/OMMultFrac](https://bit.ly/OMMultFrac)) includes a range of further problems, improving access for students furthering the challenge available.

### Suggested opportunities for assessment

**Launch**

* Student responses to the initial activity can serve as a pre-test to determine students’ abilities with fraction interpretation.

**Explore**

* Teachers can collect Appendices B and C as evidence of students’ ability to interpret and work with fraction representations to support multiplications.

**Summarise**

* Appendix D provides evidence of students’ understanding of fraction multiplication.

## **Appendix A**

### Dinner and dessert recipes

#### Vegetarian stir-fry



‘[vegetable stir-fry](https://www.flickr.com/photos/30478819@N08/36308432714)’ by [wuestenigel](https://www.flickr.com/photos/30478819@N08) is licensed under [CC BY 2.0](https://creativecommons.org/licenses/by/2.0/?ref=openverse).

Table 1 – ingredients for the full recipe serving 8 people

|  |  |
| --- | --- |
| Ingredients | Modified quantities |
| red capsicum |  |
| cup of water |  |
| cup of oyster sauce |  |
| 2 teaspoons of honey |  |
| bunch of celery |  |
| grams of green beans |  |
| carrots |  |
| cups of mushrooms |  |
| cups of jasmine rice |  |

#### Chocolate cupcakes



Photo by [Mike Meeks](https://unsplash.com/@mikemeex?utm_source=unsplash&utm_medium=referral&utm_content=creditCopyText) on [Unsplash](https://unsplash.com/photos/zk-fclJdGas?utm_source=unsplash&utm_medium=referral&utm_content=creditCopyText)

Table 2 – ingredients for the full recipe making 12 cupcakes

|  |  |
| --- | --- |
| Ingredients | Modified quantities |
| cups flour |  |
| cup of caster sugar |  |
| cup of butter |  |
| 2 eggs |  |
| cup of milk |  |
| 2 teaspoons of vanilla extract |  |
| cups of soft icing sugar |  |
| cup cocoa powder |  |

## Appendix B

### One quarter of everything

Use representations to multiply each quantity of ingredient by .

Table 3 – one quarter of the vegetarian stir-fry ingredients

|  |  |  |
| --- | --- | --- |
| Original ingredient quantity | Representation | One quarter quantity |
| red capsicum | An image from Desmos of a square, divided in half by a single vertical line and shaded on the left hand side. This square then has 3 horizontal dotted lines over the top cutting it into eighths with one shaded. |  |
| cup of water | An image from Desmos of a square, divided in quarters by 3 vertical lines. The first 3 sections are shaded. |  |
| cup of oyster sauce | An image from Desmos of a square, divided in quarters by 3 vertical lines and the first section is shaded. |  |
| 2 teaspoons of honey | An image from Desmos of 2 squares shaded entirely. |  |
| bunch of celery | An image from Desmos of a square, divided in thirds by 2 vertical lines. The first section is shaded. |  |
| grams of green beans | An image from Desmos of 4 squares shaded entirely and cut into hundreds in a 10 by 10 grid. |  |
| carrots | An image from Desmos of 3 squares shaded entirely. |  |
| cups of mushrooms | An image from Desmos of 2 squares shaded entirely. |  |
| cups of jasmine rice | An image from Desmos of 2 squares, each one divided in half by a single vertical line. One square is fully shaded. The first half of the second square is shaded. |  |

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## Appendix C

### One third of everything

Use representations to multiply each quantity of ingredient by .

Table 4 – one third of the chocolate cupcake ingredients

|  |  |  |
| --- | --- | --- |
| Original ingredient quantity | Representation | One third quantity |
| cups flour | An image from Desmos of 2 squares, each one divided in half by a single vertical line. One square is fully shaded. The first half of the second square is shaded. |  |
| cup of caster sugar | An image from Desmos of a square, divided in quarters by 3 vertical lines. The first 3 sections are shaded. |  |
| cup of butter | An image from Desmos of a square, divided in half by a single vertical line and shaded on the left hand side. |  |
| 2 eggs | An image from Desmos of 2 squares shaded entirely. |  |
| cup of milk | An image from Desmos of a square, divided in thirds by 2 vertical lines, the first section is shaded. |  |
| 2 teaspoons of vanilla extract | An image from Desmos of 2 squares shaded entirely. |  |
| cups of soft icing sugar | An image from Desmos of 2 squares, each one divided in quarters by 3 vertical lines. The first square is shaded entirely. Only the first section is shaded in the second square. |  |
| cup cocoa powder | An image from Desmos of a square, divided in quarters by 3 vertical lines. The first section is shaded. |  |

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## Appendix D

### Representing multiplication of fractions and decimals

Represent and evaluate each multiplication. Some representations are started for you.

Table 5 – representing multiplication of fractions and decimals

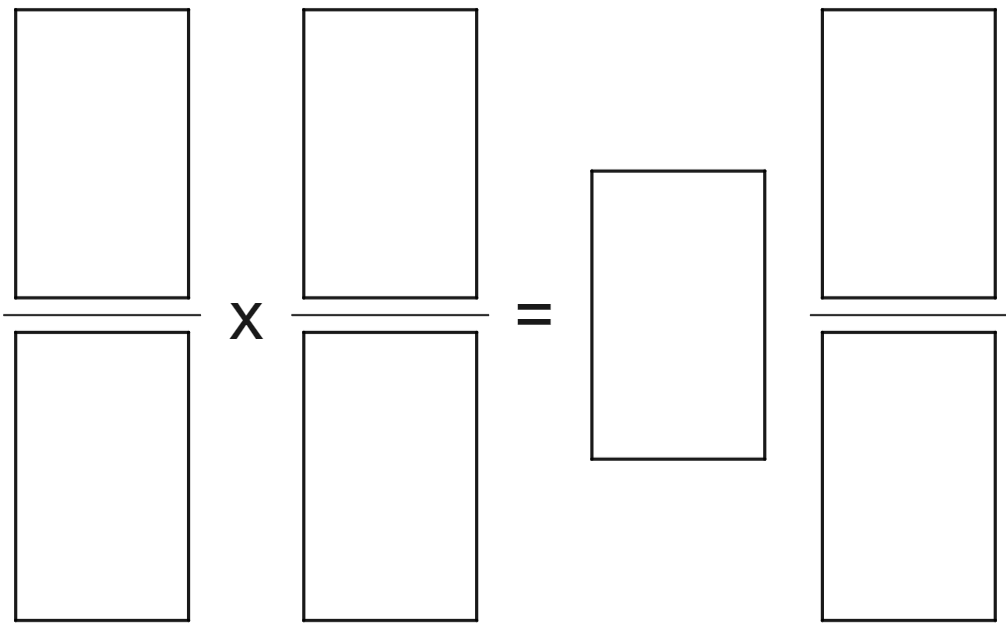
|  |  |  |
| --- | --- | --- |
| Calculation | Representation | Solution |
|  | An image of 3 squares arranged to form an equation. The first square is divided into 4 equal sections by 3 horizontal lines. The second square is divided into 5 equal sections by 4 vertical lines. The third square is divided into 20 equal parts by 3 equally spaced horizontal lines and 4 equally spaced vertical lines. The first 2 squares are separated by a multiplication symbol and the second and third squares are separated by an equal sign. |  |
|  | An image of 3 squares arranged to form an equation. The first square is divided into 4 equal sections by 3 horizontal lines. The second square is divided into 5 equal sections by 4 vertical lines. The third square is divided into 20 equal parts by 3 equally spaced horizontal lines and 4 equally spaced vertical lines. The first 2 squares are separated by a multiplication symbol and the second and third squares are separated by an equal sign. |  |
|  | An image of 3 squares arranged to form an equation. The first square is divided into 4 equal sections by 3 horizontal lines. The second square is divided into 5 equal sections by 4 vertical lines. The third square is divided into 20 equal parts by 3 equally spaced horizontal lines and 4 equally spaced vertical lines. The first 2 squares are separated by a multiplication symbol and the second and third squares are separated by an equal sign. |  |
|  | An image of 3 shapes arranged to form an equation. The first shape is 2 squares with each divided into 4 equal sections by 3 horizontal lines. The second shape is a square and is divided into 5 equal sections by 4 vertical lines. The third shape is 2 squares and each is divided into 20 equal parts by 3 equally spaced horizontal lines and 4 equally spaced vertical lines. The first 2 shapes are separated by a multiplication symbol and the second and third shapes are separated by an equal sign. |  |
|  | An image from desmos of 3 squares, with the first 2 separated by a multiplication symbol and the second and third separated by an equal sign to form an equation. |  |
|  |  |  |
|  |  |  |
|  | An image from Desmos of 3 shapes arranged to form an equation. The first shape is a square while the second shape is a rectangle made of 2 squares arranged horizontally. The first and second shape are separated by a multiplication symbol. The final shape is the same as the second shape. The second and third shapes are separated by an equal sign. The square in the first shape is divided into 10 equal parts each, by 9 horizontal lines. The squares in the second shape are also divided into 10 equal parts each, this time by 9 vertical lines. The squares in the final shape are divided into 100 equal parts by 9 vertical and 9 horizontal lines. |  |
|  | An image from Desmos of 3 shapes arranged to form an equation. The first shape is a rectangle made of 2 squares aligned vertically. The second shape is also a rectangle made of 2 squares, now arranged horizontally. The first and second shape are separated by a multiplication symbol. The final shape is a square, made up of 4 squares, equal in size with the previous squares. The second and third shape are separated by an equal sign. The squares in the first shape are divided into 10 equal parts each, by 9 horizontal lines. The squares in the second shape are also divided into 10 equal parts each, this time by 9 vertical lines. The squares in the final shape are divided into 100 equal parts by 9 vertical and 9 horizontal lines. |  |
|  | An image from Desmos of 3 shapes arranged to form an equation. The first shape is a rectangle made of 2 squares aligned vertically. The second shape is also a rectangle made of 2 squares, now arranged horizontally. The first and second shape are separated by a multiplication symbol. The final shape is a square, made up of 4 squares, equal in size with the previous squares. The second and third shape are separated by an equal sign. |  |
|  |  |  |
|  |  |  |
|  |  |  |

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## Appendix E

### Open middle problem

Use the integers from 1 to 9 at most once to make a product of fractions that makes this equation correct.



## Sample solutions

### Appendix A – dinner and dessert recipes

#### Vegetarian stir-fry

Table 6 – solution for Table 1

|  |  |
| --- | --- |
| Ingredients | Modified quantities |
| red capsicum | red capsicum |
| cup of water | cup of water |
| cup of oyster sauce | cup of oyster sauce |
| 2 teaspoons of honey | teaspoons of honey |
| bunch of celery | bunch of celery |
| grams of green beans | grams of green beans |
| carrots | carrots |
| cups of mushrooms | cups of mushrooms |
| cups of jasmine rice | cups of jasmine rice |

#### Chocolate cupcakes

Table 7 – solution for Table 2

|  |  |
| --- | --- |
| Ingredients | Modified quantities |
| cups flour | cups flour |
| cup of caster sugar | cup of caster sugar |
| cup of butter | cup of butter |
| 2 eggs | eggs |
| cup of milk | cup of milk |
| 2 teaspoons of vanilla extract | teaspoons of vanilla extract |
| cups of soft icing sugar | cups of soft icing sugar |
| cup cocoa powder | cup cocoa powder |

### Appendix B – one quarter of everything

Table 8 – solution for Table 3

|  |  |  |
| --- | --- | --- |
| Original ingredient quantity | Representation | One quarter quantity |
| red capsicum | An image from Desmos of a square, divided in half by a single vertical line and shaded on the left hand side. This square then has 3 horizontal dotted lines over the top cutting it into eighths with one shaded. |  |
| cup of water | An image from Desmos of a square, divided in quarters by 3 vertical lines and shaded on the first 3 sections. This square then has 3 horizontal dotted lines over the top cutting it into sixteenths with 3 shaded. |  |
| cup of oyster sauce | An image from Desmos of a square, divided in quarters by 3 vertical lines and one section shaded on the left. This square then has 3 horizontal dotted lines over the top cutting it into sixteenths with one shaded. |  |
| 2 teaspoons of honey | An image from Desmos of 2 squares shaded entirely. These squares then have 3 horizontal dotted lines over the top cutting them into quarters with 2 shaded (one in each square). |  |
| bunch of celery | An image from Desmos of a square, divided in thirds by 2 vertical lines and shaded on the left most section. This square then has 3 horizontal dotted lines over the top cutting it into twelfths with one shaded. |  |
| grams of green beans | An image from Desmos of 4 squares shaded entirely and cut into hundreds in a 10 by 10 grid. Three are then crossed out, leaving one only. | grams |
| carrots | An image from Desmos of 3 squares shaded entirely. These squares then have 3 horizontal dotted lines over the top cutting them into quarters with 3 sections shaded. |  |
| cups of mushrooms | An image from Desmos of 2 squares shaded entirely. These squares then have 3 horizontal dotted lines over the top cutting them into quarters with 2 sections shaded. |  |
| cups of jasmine rice | An image from Desmos of 2 squares, divided in half by a single vertical line with one fully shaded and one shaded only on the left hand side. These squares then have 3 horizontal dotted lines over the top cutting them into eighths with 3 sections shaded. |  |

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### Appendix C – one third of everything

Table 9 – solution for Table 4

|  |  |  |
| --- | --- | --- |
| Original ingredient quantity | Representation | One quarter quantity |
| cups flour | An image from Desmos of 2 squares, divided in half by a single vertical line with one fully shaded and one shaded only on the left hand side. These squares then have 2 horizontal dotted lines over the top cutting them into sixths with 3 shaded. |  |
| cup of caster sugar | An image from Desmos of a square, divided in quarters by 3 vertical lines and shaded on the 3 left most sections. This square then has 2 horizontal dotted lines over the top cutting it into twelfths with 3 shaded. |  |
| cup of butter | An image from Desmos of a square, divided in half by a single vertical line and shaded on the left hand side. This square then has 2 horizontal dotted lines over the top cutting it into sixths with one shaded. |  |
| 2 eggs | An image from Desmos of 2 squares shaded entirely. These squares then have 2 horizontal dotted lines over the top cutting them into thirds with 2 shaded. |  |
| cup of milk | An image from Desmos of a square, divided in thirds by 2 vertical lines and shaded on the left most section. This square then has 2 horizontal dotted lines over the top cutting it into ninths with one shaded. |  |
| 2 teaspoons of vanilla extract | An image from Desmos of 2 squares shaded entirely. These squares then have 2 horizontal dotted lines over the top cutting them into thirds with 2 shaded. |  |
| cups of soft icing sugar | An image from Desmos of 2 squares, each divided in quarters by 3 vertical lines, the first shaded entirely and the second shaded on the left most section. These squares then have 2 horizontal dotted lines over the top cutting them into twelfths with 5 shaded. |  |
| cup cocoa powder | An image from Desmos of a square, divided in quarters by 3 vertical lines and shaded on the left most section. This square then has 2 horizontal dotted lines over the top cutting it into twelfths with one shaded. |  |

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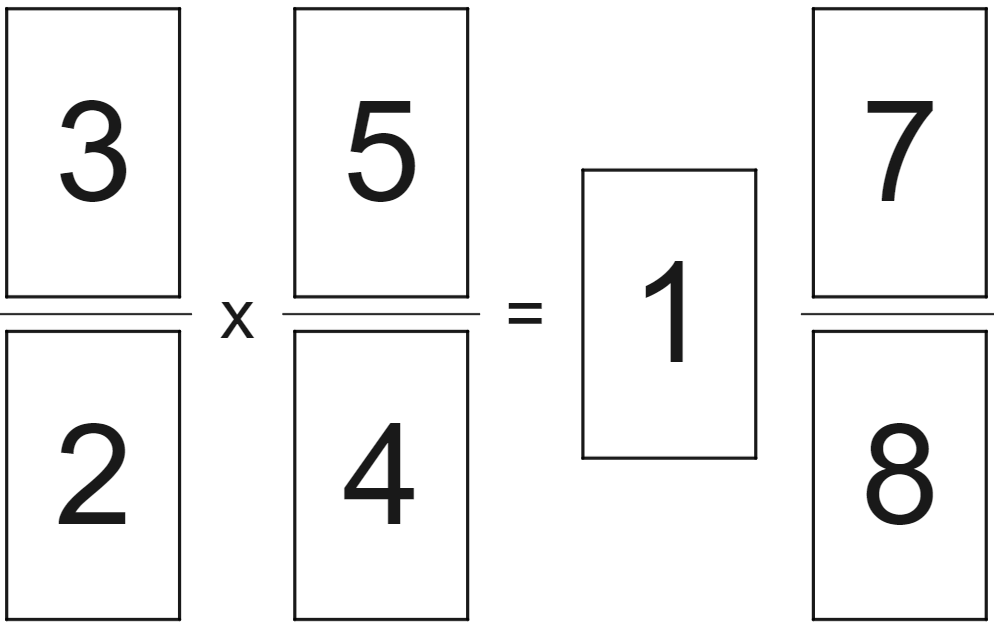
### Appendix D – representing multiplication of fractions and decimals

Table 10 – solution for Table 5

|  |  |  |
| --- | --- | --- |
| Calculation | Representation | Solution |
|  | An image of 3 squares arranged to form an equation. The first square is divided into 4 equal sections by 3 horizontal lines with the top section shaded. The second square is divided into 5 equal sections by 4 vertical lines with the left 2 sections shaded. The third square is divided into 20 equal parts by 3 equally spaced horizontal lines and four equally spaced vertical lines. The top row of 5 parts is shaded, as are the left most columns of 8 parts. The overlapping 2 parts are shaded darker. The first 2 squares are separated by a multiplication symbol and the second and third squares are separated by an equal sign. |  |
|  | An image of 3 squares arranged to form an equation. The first square is divided into 4 equal sections by 3 horizontal lines with the top 3 sections shaded. The second square is divided into 5 equal sections by 4 vertical lines with the left 2 sections shaded. The third square is divided into 20 equal parts by 3 equally spaced horizontal lines and 4 equally spaced vertical lines. The top 3 rows of 15 parts total are shaded, as are the 2 left most columns of 8 parts. The overlapping 6 parts are shaded darker. The first 2 squares are separated by a multiplication symbol and the second and third squares are separated by an equal sign. |  |
|  | An image of 3 squares arranged to form an equation. The first square is divided into 4 equal sections by 3 horizontal lines with the top 3 sections shaded. The second square is divided into 5 equal sections by 4 vertical lines with the left 4 sections shaded. The third square is divided into 20 equal parts by 3 equally spaced horizontal lines and 4 equally spaced vertical lines. The top 3 rows of 15 parts are shaded, as are the 4 left most columns of 16 parts. The overlapping 12 parts are shaded darker. The first 2 squares are separated by a multiplication symbol and the second and third squares are separated by an equal sign. |  |
|  | An image of 3 shapes arranged to form an equation. The first shape is made of 2 squares, each is divided into 4 equal sections by 3 horizontal lines with the top 5 out of 8 sections shaded. The second shape is a single square and is divided into 5 equal sections by 4 vertical lines with the left 4 sections shaded. The third shape is like the first, with 2 squares but now divided into 20 equal parts each by 3 equally spaced horizontal lines and 4 equally spaced vertical lines. The top 5 rows of 25 parts is shaded, as are the 4 left most columns of 32 parts. The overlapping 20 parts are shaded darker. The first 2 shapes are separated by a multiplication symbol and the second and third shapes are separated by an equal sign. |  |
|  | An image of 3 squares arranged to form an equation. The first square is divided into 10 equal sections by 9 horizontal lines with the top 5 sections shaded. The second square is divided into 5 equal sections by 4 vertical lines with the left 4 sections shaded. The third square is divided into 50 equal parts by 9 equally spaced horizontal lines and 4 equally spaced vertical lines. The top 5 rows of 25 parts is shaded, as are the 4 left most columns of 40 parts. The overlapping 20 parts are shaded darker. The first 2 squares are separated by a multiplication symbol and the second and third squares are separated by an equal sign. |  |
|  | An image of 3 squares arranged to form an equation. The first square is divided into 10 equal sections by 9 horizontal lines with the top 5 sections shaded. The second square is divided into 5 equal sections by 4 vertical lines with the left 4 sections shaded. The third square is divided into 50 equal parts by 9 equally spaced horizontal lines and 4 equally spaced vertical lines. The top 5 rows of 25 parts is shaded, as are the 4 left most columns of 40 parts. The overlapping 20 parts are shaded darker. The first 2 squares are separated by a multiplication symbol and the second and third squares are separated by an equal sign. |  |
|  | An image of 3 squares arranged to form an equation. The first square is divided into 10 equal sections by 9 horizontal lines with the top 5 sections shaded. The second square is divided into 10 equal sections by 9 vertical lines with the left 8 sections shaded. The third square is divided into 100 equal parts by 9 equally spaced horizontal lines and 9 equally spaced vertical lines. The top 5 rows of 50 parts is shaded, as are the left most columns of 80 parts. The overlapping 40 parts are shaded darker. The first 2 squares are separated by a multiplication symbol and the second and third squares are separated by an equal sign. |  |
|  | An image of 3 shapes arranged to make an equation. The first shape is a single square, with the second and third each made of 2 squares horizontally aligned. The first 2 shapes are separated by a multiplication sign and the final 2 shapes are separated by an equals sign. The first square is divided into 10 equal parts by 9 horizontal lines, the top 5 sections are shaded. Each of the squares in the second shape are also divided into 10 equal parts, this time by 9 vertical lines, 18 sections are shaded. The squares in the final shape are divided into 100 equally spaced parts each, by 9 vertical and 9 horizontal lines. The top 5 rows are shaded, as are the 18 left most columns. The overlapping 90 parts are shaded darker. |  |
|  | An image of 3 shapes arranged to make an equation. The first shape is made of 2 squares aligned vertically, with the second made of 2 squares horizontally aligned. The final shape is made of 4 squares arranged to make a larger square. The first 2 shapes are separated by a multiplication sign and the final 2 shapes are separated by an equals sign. The squares in the first shape are divided into 10 equal parts by 9 horizontal lines each. The squares in the second shape are also divided into 10 equal parts each, this time by 9 vertical lines. The squares in the final shape are divided into 100 equally spaced parts each, by 9 vertical and 9 horizontal lines. 15 parts are shaded in the first shape, with 18 in the second shape and an overlapping 270 in the final shape. |  |
|  | An image of 3 shapes arranged to make an equation. The first shape is made of 2 squares aligned vertically, with the second made of 2 squares horizontally aligned. The final shape is made of 4 squares arranged to make a larger square. The first 2 shapes are separated by a multiplication sign and the final 2 shapes are separated by an equals sign. The squares in the first shape are divided into 10 equal parts by 9 horizontal lines. The squares in the second shape are also divided into 10 equal parts each, this time by 9 vertical lines. The squares in the final shape are divided into 100 equally spaced parts each, by 9 vertical and 9 horizontal lines. 15 parts are shaded in the first shape, with 18 in the second shape and an overlapping 270 in the final shape. |  |
|  | An image of 3 shapes arranged to make an equation. The first shape is made of 2 squares aligned vertically, with the second made of 2 squares horizontally aligned. The final shape is made of 4 squares arranged to make a larger square. The first 2 shapes are separated by a multiplication sign and the final 2 shapes are separated by an equals sign. The squares in the first shape are divided into 10 equal parts by 9 horizontal lines. The squares in the second shape are also divided into 10 equal parts each, this time by 9 vertical lines. The squares in the final shape are divided into 100 equally spaced parts each, by 9 vertical and 9 horizontal lines. 15 parts are shaded in the first shape, with 18 in the second shape and an overlapping 270 in the final shape. |  |
|  | An image of 3 shapes arranged to make an equation. The first shape is made of 2 squares aligned vertically, and the second shape is made of 2 squares horizontally aligned. The final shape is made of 4 squares arranged to make a larger square. The first 2 shapes are separated by a multiplication sign and the final 2 shapes are separated by an equals sign. The squares in the first shape are divided into 2 equal parts by one horizontal line each. The squares in the second shape are divided into 5 equal parts each, this time by 4 vertical lines each. The squares in the final shape are divided into 10 equally spaced parts each, by 4 vertical and one horizontal lines. Three parts are shaded in the first shape, with 9 in the second shape and an overlapping 27 in the final shape. |  |
|  | An image of 3 shapes arranged to make an equation. The first and third shapes are both made of 2 squares aligned vertically, with the second made of a single square. The first 2 shapes are separated by a multiplication sign and the final 2 shapes are separated by an equals sign. The squares in the first shape are divided into 2 equal parts by one horizontal line. The squares in the second shape are divided into 5 equal parts each, this time by 4 vertical lines. The squares in the final shape are divided into 10 equally spaced parts each, by 4 vertical and one horizontal line. Three parts are shaded in the first shape, with 2 in the second shape and an overlapping 6 in the final shape. |  |

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### Appendix E – open middle problem



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