9.1 Solving Systems of Linear Equations by Substitution

- Solve problems that involve systems of linear equations in two variables graphically and algebraically

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9.1 Solving Systems of Linear Equations by Substitution

Activity: In the following balance diagrams, each block is identical in mass. Each cone is identical in mass.

Diagram 1

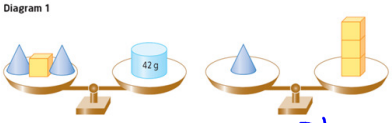
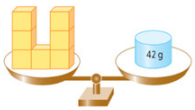


Diagram 2



$2c + 1b = 42$
$2(18) + 1(6) = 42$
$36 + 6 = 42$ ✓

$c = 3b$
$c = 3(6)$
$c = 18$

$\frac{7b}{7} = \frac{42}{7}$
$b = 6$

1. Describe how Diagram 2 relates to Diagram 1.

2. Describe how you could determine the mass of one block from Diagram 2. What is the mass of one block?

3. What is the mass of one cone? How did you determine your answer?

4. Write an equation for each balance scale in Diagram 1. Remember to state what your variables represent.

5. Write an equation for Diagram 2.

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6. **Reflect and Respond** Use diagrams to explain how to determine the mass of a single pyramid and the mass of a single cylinder for the following scenario.
   - Five pyramids and three cylinders have a mass of 44 g.
   - Two pyramids have the same mass as one cylinder.

$5p+3y=44$ $5p+3(2p)=44$ y

$2p=y$ $5p+6p=44$ $p=4$

$11p=44$

11

7. Use algebra to determine the mass of one pyramid, p, and the mass of one cylinder, c.

$2(4)=y$

$8=y$

8. Describe a situation where using a diagram is less effective than using algebra.

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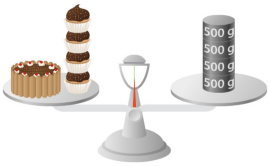
Chapter 9

Substitution

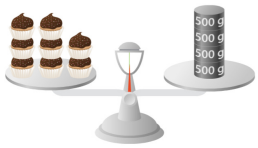
Use Balances 1, 2, and 3 to help answer the questions below. Then, use the pull tab to check your answers.

Balance 1

Balance 2



Balance 3



1. The mass of one cupcake is 250g.
2. The mass of one birthday cake is 1000g.

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Answer

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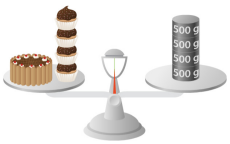
Chapter 9

Substitution

Consider the relationships represented by Balance 1 and Balance 2.

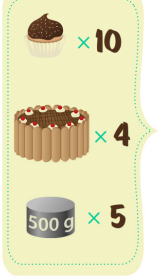
Balance 1

Balance 2

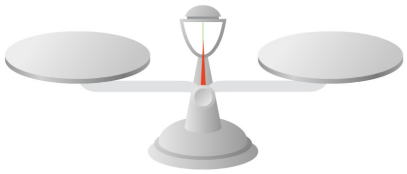


Use Balance 3 to represent the relationship between the cupcakes and the 2000 g weight.

Number of items



Balance 3



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Chapter 9

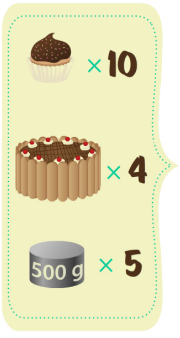
Substitution

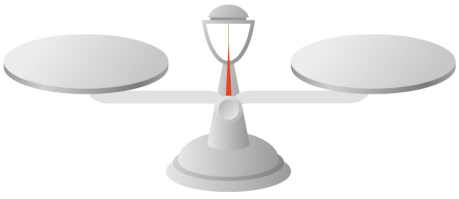
Consider the desserts Greg has made at his job. The total mass of one birthday cake and four cupcakes is 2000 g.

Represent this scenario by dragging the cupcakes and the birthday cake onto the balance.

Balance 2

Number of items





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To represent the scenario using an equation.
Let *b* represent the mass of a birthday cake.
Let *c* represent the mass of a cupcake.

The equation is _____ .

Answer

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Chapter 9

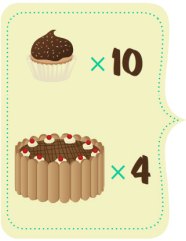
Substitution

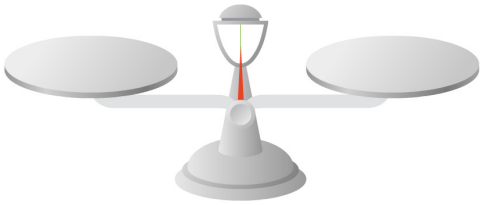
Greg works at a bakery. He makes birthday cakes and cupcakes. The mass of the birthday cake is four times the mass of a cupcake.

Represent this scenario by dragging the cupcakes and the birthday cake onto the balance.

Balance 1

Number of items





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Represent the scenario using an equation.
Let ___ represent the mass of a birthday cake.
Let ___ represent the mass of a cupcake.

The equation is _____ .

Answer

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The skill of substituting algebraic expressions is used regularly in math and science. The **substitution method** can provide a quick solution to a linear system.

Example 1

Solve the following linear system.

$4x + 5y = 26$

$3x = y - 9$

Solution

First, solve for y in $3x = y - 9$.

$+9 \quad +9$

$3x + 9 = y$

Substitute $3x + 9$ for y in $4x + 5y = 26$.

$4x + 5(3x + 9) = 26$

$4x + 5y = 26$

$4x + 5(3x + 9) = 26$

$4x + 15x + 45 = 26$

$19x + 45 = 26$

$-45 \quad -45$

$\frac{19x}{19} = \frac{-19}{19}$ $x = -1$

Substitute -1 for x in $3x = y - 9$.

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The skill of substituting algebraic expressions is used regularly in math and science. The **substitution method** can provide a quick solution to a linear system.

Solve the following linear system.

$4x + 5y = 26$

$3x = y - 9$

$4(1) + 5(6) = 26$

$-4 + 30 = 26$

$26 = 26$

First, solve for y in $3x = y - 9$.

$3x + 9 = y - 9 + 9$

$3x + 9 = y$

Substitute $3x + 9$ for y in $4x + 5y = 26$.

$4x + 5(3x + 9) = 26$

$4x + 15x + 45 = 26$

$19x + 45 = 26$

$19x + 45 - 45 = 26 - 45$

$19x = -19$

$x = -1$

Substitute -1 for x in $3x = y - 9$.

$3(-1) = y - 9$

$-3 = y - 9$

$-3 + 9 = y - 9 + 9$

$6 = y$

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Chapter 9

Substitution

In each of the linear systems, circle the variable you would isolate first. Use the magnifying glass to see the suggested answers. Why did you choose the variable you chose?

$\begin{cases} 3x + 2y = 12 \\ -2x + y = -1 \end{cases}$ *y*

$\begin{cases} s + 2t = 12 \\ 2s + 2t = 14 \end{cases}$ *s*

$\begin{cases} 2a + 3b = 13 \\ a + 2b = 10 \end{cases}$ *a*

$\begin{cases} 4p - q = 3 \\ 3p - 5q = -19 \end{cases}$ *q*

$\begin{cases} 5C + 2A = 14 \\ -C + 2A = 2 \end{cases}$ *C*

$\begin{cases} 7x - 3y = 5 \\ 4x - 2y = 2 \end{cases}$ *y*

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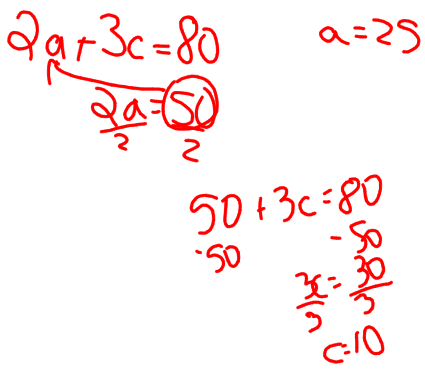
Steps for the Substitution Method

Step 1: Solve one equation for one variable
Step 2: Substitute into the other equation and solve for the one variable.
Step 3: Substitute into an original equation and solve for the second variable.

Example 2 Solve a System of Linear Equations by Substitution

Admission to the 2009 Abbotsford International Airshow cost $80 for a car with two adults and three children. Admission for a car with two adults cost $50. Use algebra to determine the cost for one child and the cost for one adult. There was no charge for the vehicle or parking. Determine the admission prices.

Solution



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Example 1 Solve a System of Linear Equations by Substitution

Admission to the 2009 Abbotsford International Airshow cost $80 for a car with two adults and three children. Admission for a car with two adults cost $50. Use algebra to determine the cost for one child and the cost for one adult. There was no charge for the vehicle or parking.

Solution

Let C represent the cost for one child, in dollars.
Let A represent the cost for one adult, in dollars.
For the first car, $2A + 3C = 80$.
For the second car, $2A = 50$.

The second equation has only one variable. So, determine the cost for one adult first.
$2A = 50$
$A = 25$
Solve for C by replacing A with 25.
$2A + 3C = 80$
$2(25) + 3C = 80$
$50 + 3C = 80$
$3C = 30$
$C = 10$

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Example 3 Isolate a Variable Before Solving by Substitution

At a dance recital, there were 220 people. Tickets cost $9 for an adult and $6 for a child. The dance school collected $1614 in ticket sales. How many adults and how many children attended the recital?

adult: a
child: c

Solution

$a + c = 220$

$1614 = 9a + 6c$

$a + c = 220$
$-c \quad -c$
$a = 220 - c$

$1614 = 9(220 - c) + 6c$
$1614 = 1980 - 9c + 6c$
$1614 = 1980 - 3c$
$-1980 \quad -1980$
$-366 = -3c$
$\frac{-366}{-3} = \frac{-3c}{-3}$
$122 = c$

$a = 220 - c$
$a = 220 - 122$
$a = 98$

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Example 3 Isolate a Variable Before Solving by Substitution

At a dance recital, there were 220 people. Tickets cost $9 for an adult and $6 for a child. The dance school collected $1614 in ticket sales. How many adults and how many children attended the recital?

Solution

Let a be the number of adults at the recital.
Let c be the number of children at the recital.
Write an equation that represents the total number of adults and children.
$a + c = 220$
Write an equation that represents the amount collected by the dance school.
$9a + 6c = 1614$

Isolate the Variable c in the first equation

$a + c = 220$
$c = 220 - a$

Substitute for c in w.
$9a + 6(220 - a) = 1614$
$9a + 1320 - 6a = 1614$
$3a + 1320 = 1614$
$3a = 294$
$a = 98$

Substitute the number of adults into q to finish solving the system.
$98 + c = 220$
$c = 122$

Dec 15-10:00 AM

Your Turn

Solve the following linear systems algebraically using substitution. Check your solution.

a) $3x + 5y = 27$
$4x = 16$

b) $2x + y = 13$
$x - 0.4y = -16$

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