MATHEMATICS · GRADES 10-12

Solving systems by substitution

Difficulty level: Advanced

Mathematics: Grades 10-12

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Overview of the concept

This is how you work out two unknowns at once, like the cost of a ticket and the cost of a snack from two receipts, by swapping one value into the other equation. One receipt tells you how the two costs relate, so you can write one cost in terms of the other. Putting that into the second receipt leaves a single unknown you can solve directly. It is the natural way to untangle two linked prices, or any two unknowns where one fact ties them together.



Rule

Solving systems by substitution: solve one equation for one unknown, put that expression into the other equation, and solve for the remaining unknown, then work back to find the first.

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Worked examples

EXAMPLE 1

Q **Solve $y = 2x$ and $x + y = 9$ by substitution.**

SOLUTION

Replace y in the second equation with 2x: $x + 2x = 9$.

So $3x = 9$, giving $x = 3$.

Then $y = 2 \times 3 = 6$.

Answer: (3, 6)

EXAMPLE 2

Q **Solve $x = y + 1$ and $2x + y = 8$ by substitution.**

SOLUTION

Replace x in the second equation with y + 1: $2(y + 1) + y = 8$.

So $2y + 2 + y = 8$, giving $3y = 6$, so $y = 2$.

Then $x = 2 + 1 = 3$. Answer: (3, 2)

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Practice questions

1 Solve $y = 3x$ and $x + y = 12$ by substitution.

- **A** (9, 3)
- **B** (3, 9)
- **C** (3, 6)
- **D** (4, 9)

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2 Solve $y = x + 2$ and $2x + y = 11$ by substitution.

- **A** (3, 5)
- **B** (5, 3)
- **C** (3, 8)
- **D** (2, 5)

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3 A notebook costs twice as much as a pen. Together they cost $9. Let x be the notebook price and y be the pen price. Solve by substitution.

- **A** (3, 6)
- **B** (6, 6)
- **C** (6, 3)
- **D** (3, 3)

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4 Mia has 4 times as many stickers as her brother. Together they have 15 stickers. Let x be the brother's stickers and y be Mia's stickers. Solve by substitution.

- **A** (3, 12)
- **B** (12, 3)
- **C** (3, 4)
- **D** (4, 12)

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5 What do you do first when you solve by substitution?

- **A** Add the two equations together
- **B** Solve one equation for one variable
- **C** Graph both lines and read the crossing point
- **D** Multiply both equations by the same number

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6 A large box holds 1 more pen than a small box. Together they hold 7 pens. Let x be the large box pens and y be the small box pens. Solve by substitution.

- **A** (3, 4)
- **B** (4, 4)
- **C** (3, 3)
- **D** (4, 3)

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7 A jacket costs 3 times as much as a scarf. Two jackets and a scarf cost $14. Let x be the jacket price and y be the scarf price. Solve by substitution.

- A (6, 3)
- B (6, 2)
- C (2, 6)
- D (4, 2)

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8 A taxi fare is $1 more than twice the bus fare. Three bus fares and a taxi fare cost $11. Let x be the bus fare and y be the taxi fare. Solve by substitution.

- A (5, 2)
- B (2, 4)
- C (2, 5)
- D (3, 5)

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9 A child ticket costs $5. Two adult tickets and a child ticket cost $13. Let x be the adult ticket price and y be the child ticket price. Solve by substitution.

- **A** (4, 5)
- **B** (5, 4)
- **C** (4, 4)
- **D** (3, 5)

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10 Why check the answer in both equations, not just one?

- **A** Because the answer is always a whole number
- **B** To check that the lines are parallel
- **C** To make sure the pair satisfies both equations, not just one
- **D** Because one equation is enough once x is known

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ANSWER KEY

1. (3, 9)

2. (3, 5)

3. (6, 3)

4. (3, 12)

5. Solve one equation for one variable

6. (4, 3)

7. (6, 2)

8. (2, 5)

9. (4, 5)

10. To make sure the pair satisfies both equations, not just one

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