MATHEMATICS · GRADES 10-12

Horizontal and vertical translations

Difficulty level: Advanced

Mathematics: Grades 10-12

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Overview of the concept

This is how you slide a whole graph to a new spot without changing its shape, like moving a design on a screen or shifting a schedule later in the day. The graph keeps its exact shape, it just starts somewhere else, and that is often all that changes between two situations. A designer uses this to reposition a picture, a scientist uses it to line a model up with new measurements, and anyone reading a timetable uses the same idea when a whole schedule shifts by an hour.



Rule

Translations: a change inside the brackets moves the graph sideways, and a change outside moves it up or down. $y = (x - h)^2 + k$ moves the graph right h and up k, and the sign inside works the opposite way to what you might expect.

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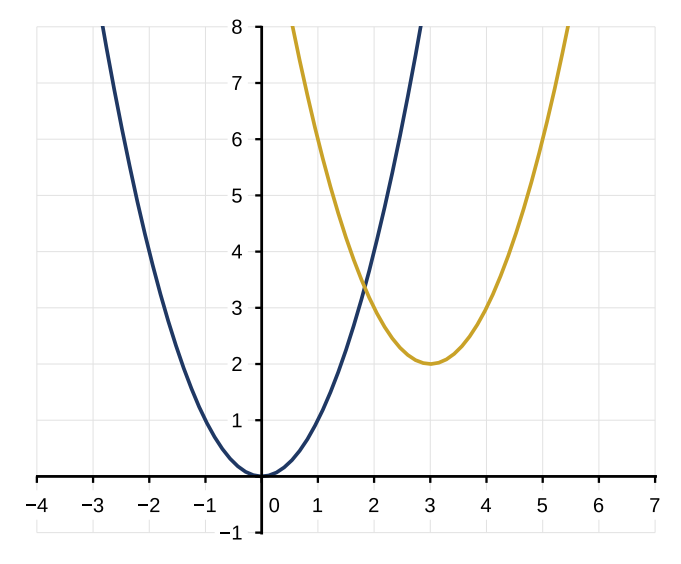
Worked examples

EXAMPLE 1

Q For $y = (x - 3)^2 + 2$, where does the vertex $(0, 0)$ of $y = x^2$ go?



$y = x^2$, the original parabola

$y = (x - 3)^2 + 2$, the moved parabola

SOLUTION

The inside change, $x - 3$, moves the graph right by 3.

The outside change, $+ 2$, moves the graph up by 2.

So $(0, 0)$ moves to $(3, 2)$

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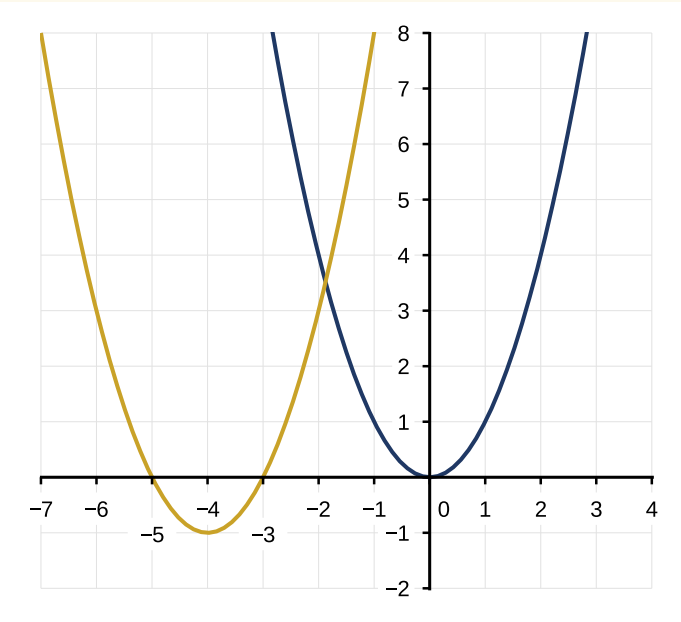
EXAMPLE 2

Q For $y = (x + 4)^2 - 1$, where does the vertex (0, 0) go?



$y = x^2$, the original parabola

$y = (x + 4)^2 - 1$, the moved parabola

SOLUTION

The inside change, $x + 4$, moves the graph left by 4.

The outside change, -1, moves the graph down by 1.

So (0, 0) moves to (-4, -1)

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Practice questions

1 A parabola $y = x^2$ is slid 5 units to the right. Where does its vertex (0, 0) go?

- **A** (5, 0)
- **B** (-5, 0)
- **C** (0, 5)
- **D** (5, 5)

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2 $y = x^2$ is raised 6 units. Where does its vertex (0, 0) go?

- **A** (0, -6)
- **B** (0, 6)
- **C** (6, 0)
- **D** (6, 6)

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3 Where is the vertex of $y = (x + 2)^2 + 3$?

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

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4 How far does the vertex of $y = (x - 1)^2 - 7$ move from (0, 0)?

- A 1 unit right and 7 units down
- B 1 unit left and 7 units up
- C 7 units right and 1 unit down
- D 1 unit right and 7 units up

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5 A parabola $y = x^2$ is pushed 8 units to the left. Where does its vertex (0, 0) go?

- **A** (8, 0)
- **B** (-8, 0)
- **C** (0, -8)
- **D** (-8, -8)

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6 A parabola with vertex (0, 0) is shifted 4 units right and 2 units up. Where does the vertex go?

- **A** (4, 2)
- **B** (-4, 2)
- **C** (4, -2)
- **D** (2, 4)

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7 For $y = (x - a)^2 + b$ with lowest point $(3, -1)$. What are a and b?

A a = -3 and b = -1

B a = 3 and b = 1

C a = 3 and b = -1

D a = -1 and b = 3

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8

A student expects $y = (x + 3)^2$ to shift right because of the plus sign. Explain why it shifts left.

A. The vertex is where x + 3 is 0, which is x = -3, so the shift is 3 units left

B. The plus sign means the graph moves right, so it shifts 3 units right

C. The vertex moves to x = 3, so the shift is 3 units right

D. The plus sign means the graph moves up 3 units

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9 **Which of these slides comes from $y = x^2 + 5$?**

- **A** Slide A, vertex (0, –5)
- **B** Slide B, vertex (0, 5)
- **C** Slide C, vertex (5, 0)
- **D** None of the three slides

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10 **Which one moves the vertex along the x-axis only?**

- **A** $y = (x - 2)^2$
- **B** $y = x^2 + 2$
- **C** $y = (x + 1)^2 - 3$
- **D** $y = x^2 - 4$

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ANSWER KEY

1. (5, 0)

2. (0, 6)

3. (-2, 3)

4. 1 unit right and 7 units down

5. (-8, 0)

6. (4, 2)

7. a = 3 and b = -1

8. The vertex is where x + 3 is 0, which is x = -3, so the shift is 3 units left

9. Slide B, vertex (0, 5)

10. $y = (x - 2)^2$

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