MATHEMATICS · GRADES 10-12

Graph transformations

Difficulty level: Advanced

Mathematics: Grades 10-12

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Overview of the concept

This is how you shift, flip or stretch a graph to fit a new situation, like moving a flight path on a map or resizing a photo without redrawing it. The shape stays the same, it just moves to a new place or grows to a new size, and that is often all you need to describe a new situation. A designer uses this to move a logo or resize a picture, a scientist uses it to shift a model to match new data, and a mapmaker uses it to fit a route onto a page.



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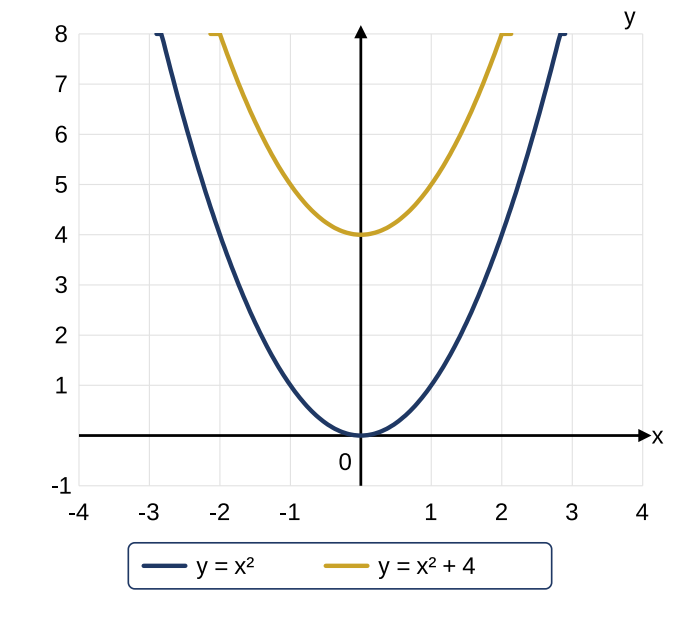
Worked examples

EXAMPLE 1

Q Describe how $y = x^2 + 4$ is obtained from $y = x^2$



SOLUTION

Compare the two rules: the only change is + 4 outside the square.

A number added outside moves the graph up.

So the graph shifts up by 4.

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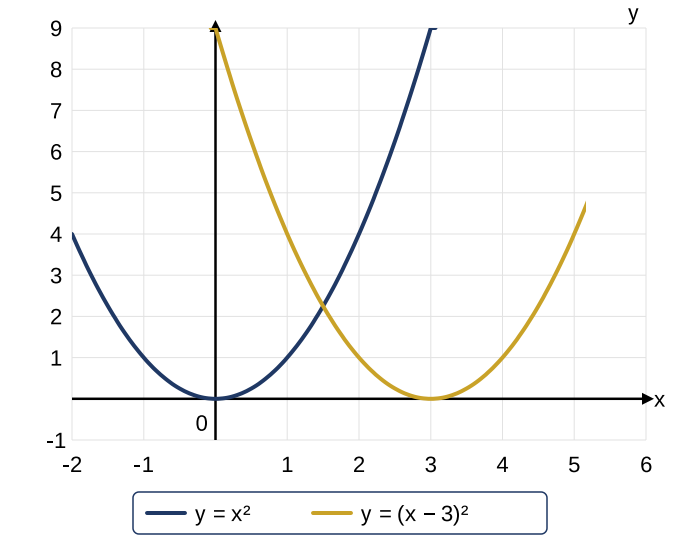
EXAMPLE 2

Q Describe how $y = (x - 3)^2$ is obtained from $y = x^2$



SOLUTION

Compare the two rules: the change is inside the bracket, x - 3.

A change inside moves the graph sideways, in the opposite direction to the sign.

So the graph shifts right by 3.

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Practice questions

1 Describe how $y = x^2 - 2$ is obtained from $y = x^2$.

- **A** Shift down 2
- **B** Shift up 2
- **C** Shift left 2
- **D** Shift right 2

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2 $y = x^2$ is lifted 9 units straight up. Write the new equation.

- **A** $y = x^2 + 9$
- **B** $y = x^2 - 9$
- **C** $y = x^2 + 11$
- **D** $y = x^2 + 8$

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3 Describe how $y = (x + 5)^2$ is obtained from $y = x^2$.

- **A** Shift right 5
- **B** Shift left 5
- **C** Shift up 5
- **D** Shift down 5

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4 $y = x^2$ is flipped upside down. Write the new equation.

- **A** $y = x^2$
- **B** $y = -x^2$
- **C** $y = -2x^2$
- **D** $y = -x^2 + 1$

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5 A stretch turns $y = x^2$ into $y = 2x^2$. Describe the stretch.

- **A** Vertical stretch by a factor of 2
- **B** Vertical compression by a factor of 2
- **C** Horizontal stretch by a factor of 2
- **D** Reflection across the x-axis

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6 $y = x^2$ is made one third as steep. Write the new equation.

- **A** $y = (-\frac{1}{3})x^2$
- **B** $y = (\frac{1}{3})x^2$
- **C** $y = (\frac{4}{3})x^2$
- **D** $y = (-\frac{2}{3})x^2$

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7 **Which change turns $y = x^2$ into $y = (x - 6)^2 + 1$?**

- **A** Shift left 6 and up 1
- **B** Shift right 6 and down 1
- **C** Shift right 6 and up 1
- **D** Shift left 6 and down 1

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8 **A parabola $y = x^2$ is shifted left 1 and down 4. Write the new equation.**

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

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9 **Two moves turn $y = x^2$ into $y = -(x - 2)^2$. Describe both moves.**

- **A** Shift right 2 and reflect across the x-axis
- **B** Shift left 2 and reflect across the x-axis
- **C** Shift right 2 and reflect across the y-axis
- **D** Shift up 2 and reflect across the x-axis

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10 **A graph of $y = x^2$ is reflected across the x-axis and then moved up 3. Write the new equation.**

- **A** $y = -x^2 + 3$
- **B** $y = x^2 + 3$
- **C** $y = -2x^2 + 3$
- **D** $y = -x^2 - 3$

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ANSWER KEY

1. Shift down 2

2. $y = x^2 + 9$

3. Shift left 5

4. $y = -x^2$

5. Vertical stretch by a factor of 2

6. $y = (\frac{1}{3})x^2$

7. Shift right 6 and up 1

8. $y = (x + 1)^2 - 4$

9. Shift right 2 and reflect across the x-axis

10. $y = -x^2 + 3$

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