MATHEMATICS · GRADES 10-12

Transformations of quadratic functions

Difficulty level: Advanced

Mathematics: Grades 10-12

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Overview of the concept

This is how you describe a parabola that has moved, flipped, or stretched, like the path of a basketball shot from different spots on the court, without plotting lots of points. A parabola can shift up or sideways, flip upside down, or stretch taller or wider, and each change can be read straight from the equation. Knowing how to read those changes means you can sketch the new path without working out point after point. That is how you predict where a ball will go from a new spot, or how a curve changes when its rule changes.



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Rule

Transformations of quadratic functions: a number inside the brackets shifts the graph sideways, a number outside shifts it up or down, a negative sign flips it over, and a number multiplying the whole function stretches or compresses it.

Inside the brackets, the shift goes the opposite way from the sign.

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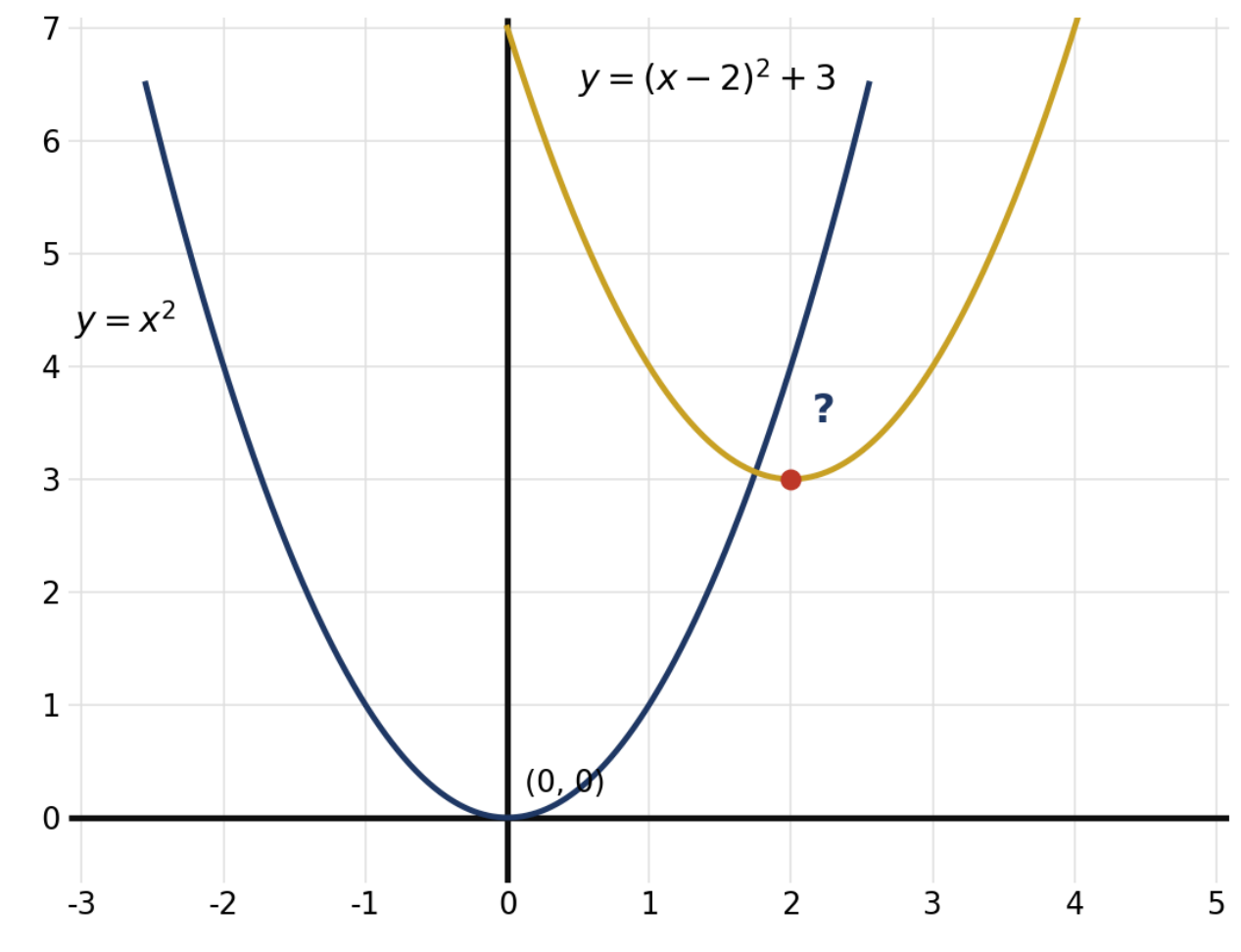
Worked examples

EXAMPLE 1

Q Describe $y = (x - 2)^2 + 3$ compared to $y = x^2$



SOLUTION

Look inside the bracket: x - 2 shifts the graph right by 2.

Look outside the bracket: + 3 shifts the graph up by 3.

So the vertex moves from (0, 0) to (2, 3), with no flip or stretch.

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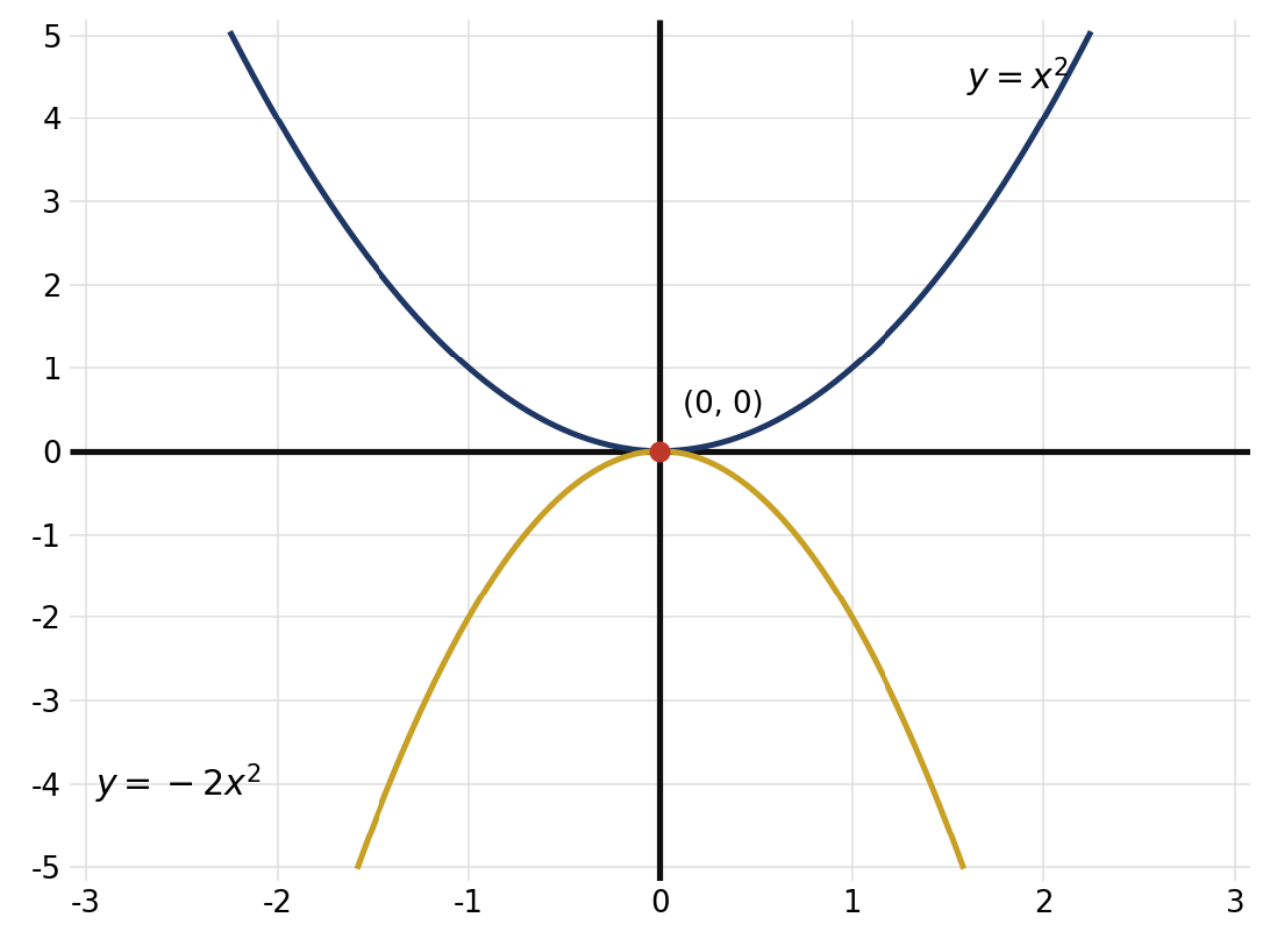
EXAMPLE 2

Q Describe $y = -2x^2$ compared to $y = x^2$



SOLUTION

The negative sign reflects the graph across the x-axis, so it opens downward.

The 2 stretches the graph vertically by a factor of 2.

So the vertex stays at (0, 0), but the parabola is narrower and opens downward.

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Practice questions

1 Describe $y = -x^2 + 2$ compared to $y = x^2$

- **A** Reflect across the x-axis, shift up 2; vertex at (0, 2), opens downward
- **B** Reflect across the x-axis, shift down 2; vertex at (0, -2), opens downward
- **C** Shift up 2 only; vertex at (0, 2), opens upward

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2 Describe $y = -3x^2$ compared to $y = x^2$

A. Stretch vertically by a factor of 3; vertex stays at (0, 0), narrower and opens upward

B. Reflect across the x-axis and stretch vertically by a factor of 3; vertex stays at (0, 0), narrower and opens downward

C. Reflect across the x-axis and compress vertically by a factor of 3; vertex stays at (0, 0), wider and opens downward

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3 Describe $y = (\frac{1}{2})x^2$ compared to $y = x^2$

A. Vertical stretch by a factor of 2; narrower, opens upward

B. Reflect across the x-axis; narrower, opens downward

C. Vertical compression by a factor of $\frac{1}{2}$; wider, opens upward

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4 Describe $y = -x^2$ compared to $y = x^2$

A. Reflect across the x-axis

B. Reflect across the y-axis

C. Shift up 1

D. Shift down 1

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5 Describe $y = (x + 3)^2$ compared to $y = x^2$

A Shift right 3

B Shift left 3

C Shift up 3

D Shift down 3

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6 Describe $y = x^2 - 5$ compared to $y = x^2$

A Shift up 5

B Shift left 5

C Shift right 5

D Shift down 5

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7 Describe $y = (x - 1)^2 + 4$ compared to $y = x^2$

A Shift left 1 and up 4; vertex at (-1, 4)

B Shift right 1 and up 4; vertex at (1, 4)

C Shift right 1 and down 4; vertex at (1, -4)

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8 Describe $y = 2x^2$ compared to $y = x^2$

A Vertical compression by a factor of $\frac{1}{2}$; wider, opens upward

B Reflect across the x-axis; narrower, opens downward

C Vertical stretch by a factor of 2; narrower, opens upward

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9 **A parabola is shifted right 3 and down 1 compared to $y = x^2$. What is its equation?**

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

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10 **Describe $y = -(x - 2)^2 + 3$ compared to $y = x^2$**

- **A** Shift right 2 and up 3; vertex at (2, 3), opens upward
- **B** Reflect across the x-axis, shift right 2 and up 3; vertex at (2, 3)
- **C** Reflect across the x-axis, shift left 2 and up 3; vertex at (-2, 3)

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ANSWER KEY

1. Reflect across the x-axis, shift up 2; vertex at (0, 2), opens downward

2. Reflect across the x-axis and stretch vertically by a factor of 3; vertex stays at (0, 0), narrower and opens downward

3. Vertical compression by a factor of $\frac{1}{2}$; wider, opens upward

4. Reflect across the x-axis

5. Shift left 3

6. Shift down 5

7. Shift right 1 and up 4; vertex at (1, 4)

8. Vertical stretch by a factor of 2; narrower, opens upward

9. $y = (x - 3)^2 - 1$

10. Reflect across the x-axis, shift right 2 and up 3; vertex at (2, 3)

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