MATHEMATICS · GRADES 10-12

Stretches and compressions

Difficulty level: Advanced

Mathematics: Grades 10-12

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Overview of the concept

This is how you describe a graph that has been stretched taller or squashed wider, like a photo stretched on a phone screen, without moving it up, down, or sideways. A stretch pulls the graph taller or wider, while a compression squeezes it shorter or narrower, and the centre stays where it was. The shape changes, but it does not slide across the page, so you can describe the change with a single idea. That is how you read a graph that has been resized, or predict what a resize will do before you draw it.



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Rule

Stretches and compressions: a number outside the function stretches or compresses the graph vertically, and a number inside, next to x, stretches or compresses it horizontally.

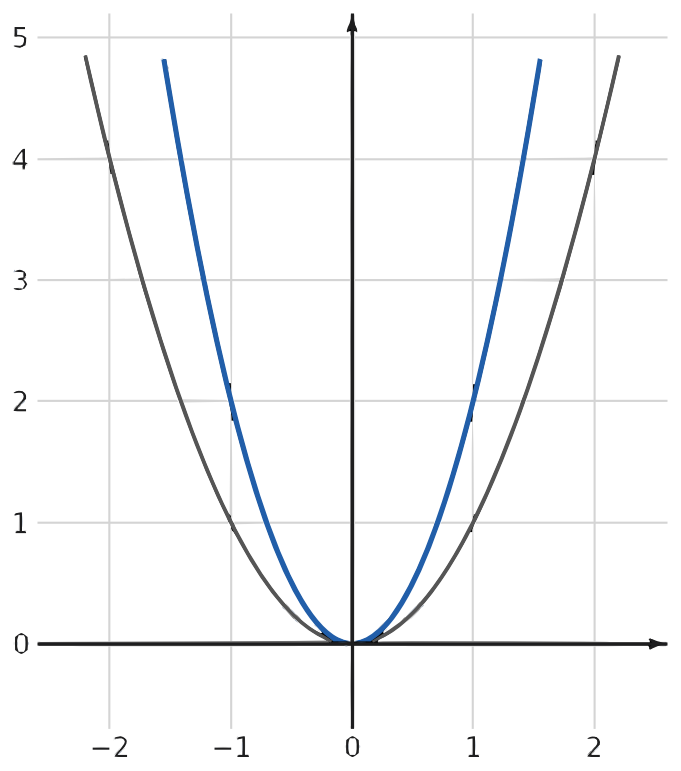
A factor bigger than 1 stretches, and a factor between 0 and 1 compresses.

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Worked examples

EXAMPLE 1

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



SOLUTION

The 2 is outside the square, multiplying the whole function.

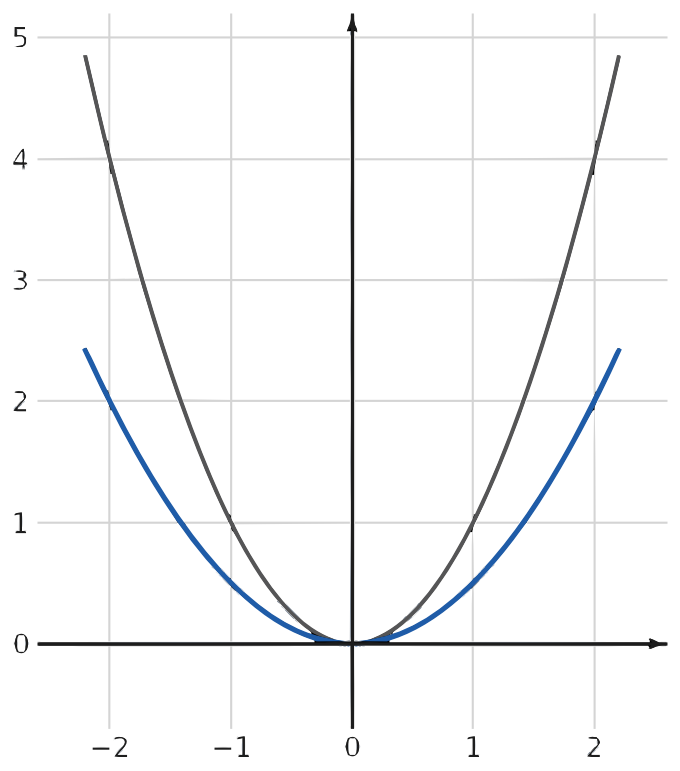
A factor greater than 1 outside stretches the graph vertically.

So the graph is stretched vertically by a factor of 2: it looks narrower.

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EXAMPLE 2

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



— $y = (\frac{1}{2})x^2$ — $y = x^2$

SOLUTION

The $\frac{1}{2}$ is outside the square.

A factor between 0 and 1 outside compresses the graph vertically.

So the graph is compressed vertically by a factor of $\frac{1}{2}$: it looks wider.

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Practice questions

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

- **A** Vertical stretch by a factor of 3
- **B** Vertical compression by a factor of 3
- **C** Horizontal stretch by a factor of 3
- **D** Vertical stretch by a factor of $\frac{1}{3}$

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2 **Describe $y = (\frac{1}{4})x^2$ compared to $y = x^2$**

- **A** Vertical stretch by a factor of $\frac{1}{4}$
- **B** Vertical compression by a factor of $\frac{1}{4}$
- **C** Horizontal compression by a factor of $\frac{1}{4}$
- **D** Vertical compression by a factor of 4

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3 **Is $y = (2x)^2$ wider or narrower than $y = x^2$, and by what factor?**

- **A** Narrower, by a factor of 0.5
- **B** Wider, by a factor of 0.5
- **C** Narrower, by a factor of 2
- **D** Wider, by a factor of 2

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4 How does $y = (x \div 2)^2$ compare with $y = x^2$?

A Horizontal stretch by a factor of 2

B Horizontal compression by a factor of 2

C Vertical stretch by a factor of 2

D Horizontal stretch by a factor of $\frac{1}{2}$

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5 How does $y = 5f(x)$ compare with $y = f(x)$?

A Vertical compression by a factor of 5

B Vertical stretch by a factor of 5

C Horizontal stretch by a factor of 5

D Vertical stretch by a factor of $\frac{1}{5}$

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6

How does $y = 0.2f(x)$ compare with $y = f(x)$?

A Vertical compression by a factor of 0.2

B Vertical stretch by a factor of 0.2

C Horizontal compression by a factor of 0.2

D Vertical compression by a factor of 5

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7 How does $y = f(3x)$ compare with $y = f(x)$?

A. Horizontal compression by a factor of $\frac{1}{3}$

B. Horizontal stretch by a factor of $\frac{1}{3}$

C. Vertical compression by a factor of $\frac{1}{3}$

D. Horizontal compression by a factor of 3

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8 How does $y = f(x \div 3)$ compare with $y = f(x)$?

A. Horizontal compression by a factor of 3

B. Vertical stretch by a factor of 3

C. Horizontal stretch by a factor of 3

D. Horizontal stretch by a factor of $\frac{1}{3}$

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9 How does $y = 4x^2$ compare with $y = x^2$?

A. Vertical stretch by a factor of 4

B. Vertical compression by a factor of 4

C. Horizontal stretch by a factor of 4

D. Vertical stretch by a factor of $\frac{1}{4}$

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10

How does $y = 0.5f(x)$ compare with $y = f(x)$?

A Vertical stretch by a factor of 0.5

B Vertical compression by a factor of 0.5

C Horizontal compression by a factor of 0.5

D Vertical compression by a factor of 2

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ANSWER KEY

1. Vertical stretch by a factor of 3

2. Vertical compression by a factor of $\frac{1}{4}$

3. Narrower, by a factor of 0.5

4. Horizontal stretch by a factor of 2

5. Vertical stretch by a factor of 5

6. Vertical compression by a factor of 0.2

7. Horizontal compression by a factor of $\frac{1}{3}$

8. Horizontal stretch by a factor of 3

9. Vertical stretch by a factor of 4

10. Vertical compression by a factor of 0.5

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