MATHEMATICS · GRADES 10-12

Fundamental theorem of calculus

Difficulty level: Advanced

Mathematics: Grades 10-12

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Overview of the concept

This is how you work out a total that builds up over time, like the distance a car travels from its speed at each moment. If you know how fast something is changing at every instant, this is the idea that turns all those little changes into one total. It is how engineers work out the distance from a speed reading, how scientists total the flow of water over a day, and how a phone works out the distance you ran from your pace at each moment.



Rule

Fundamental theorem of calculus: the definite integral of f from a to b is F(b) - F(a), where F is any antiderivative of f.

Find the antiderivative, work it out at the top and bottom limits, and subtract.

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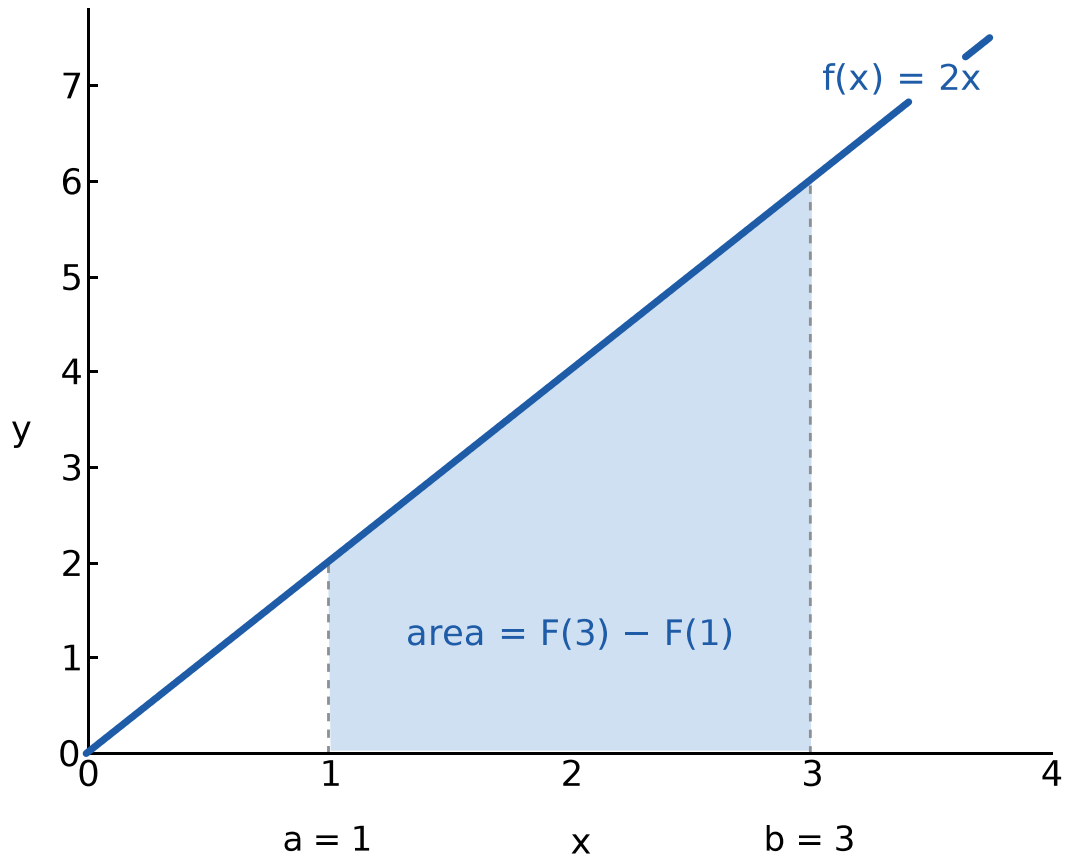
Worked examples

EXAMPLE 1

Q Use the fundamental theorem for the integral of 2x from 1 to 3.



SOLUTION

Antiderivative: $2x^2 \div 2 = x^2$

Evaluate: at 3, 9; at 1, 1.

Subtract: 9 - 1 = 8

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EXAMPLE 2

Q Use the fundamental theorem for the integral of $3x^2$ from 0 to 2.

SOLUTION

Antiderivative: $3x^3 \div 3 = x^3$

Evaluate: at 2, 8; at 0, 0.

Subtract: 8 - 0 = 8

Practice questions

1 State the fundamental theorem, part 2.

- **A** The integral from a to b of f(x) equals F(b) – F(a), where F is an antiderivative of f
- **B** The integral from a to b of f(x) equals F(a) – F(b), where F is an antiderivative of f
- **C** The integral from a to b of f(x) equals f(b) – f(a)
- **D** The integral from a to b of f(x) equals F(b) + F(a), where F is an antiderivative of f

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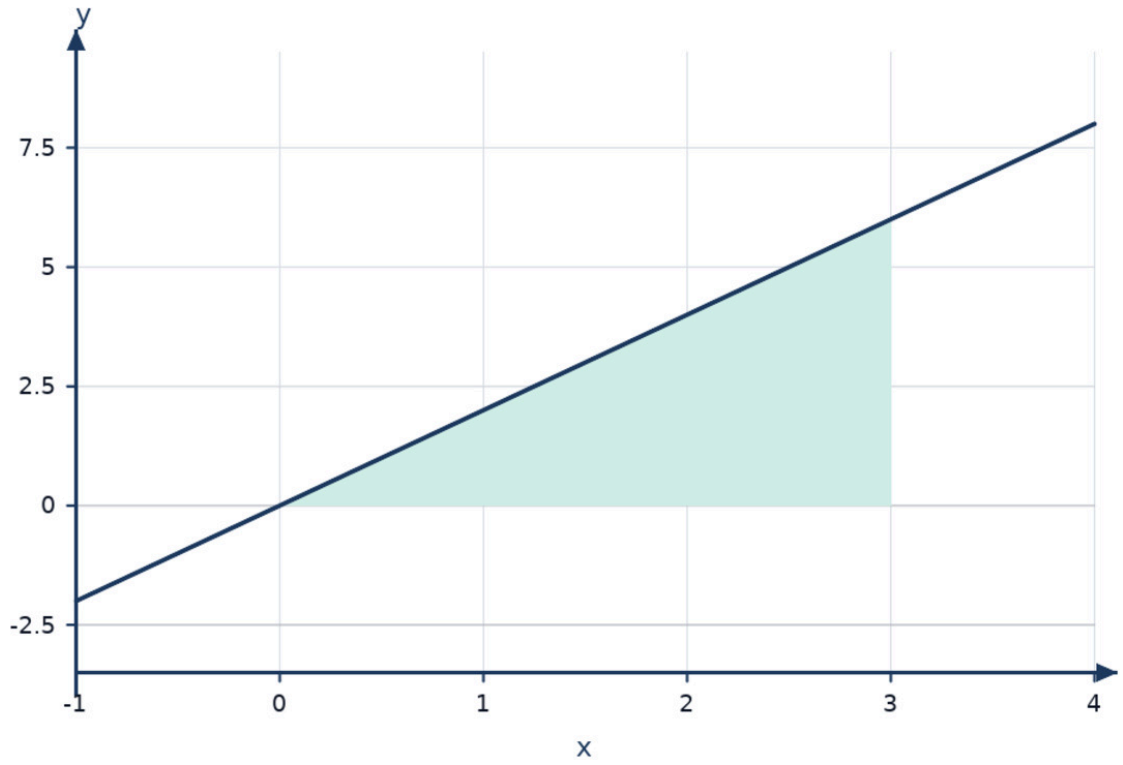
2 What is the integral of 2x from 0 to 3, using the theorem?



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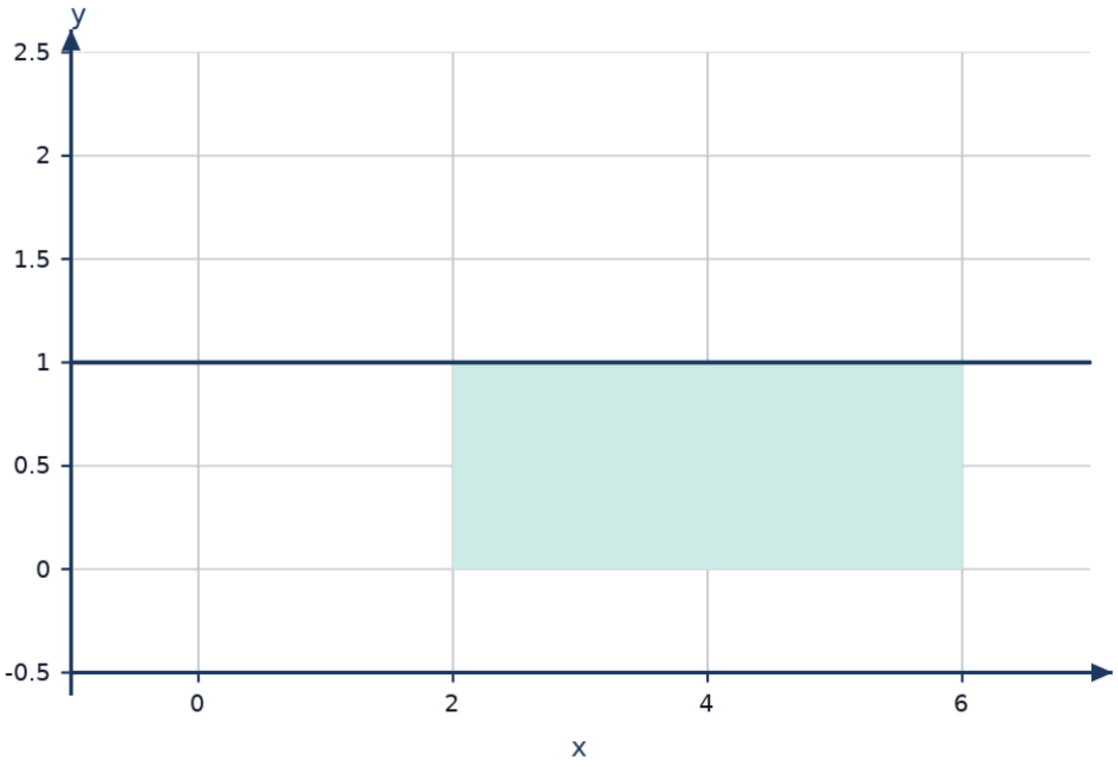
What is the integral of 1 from 2 to 6?



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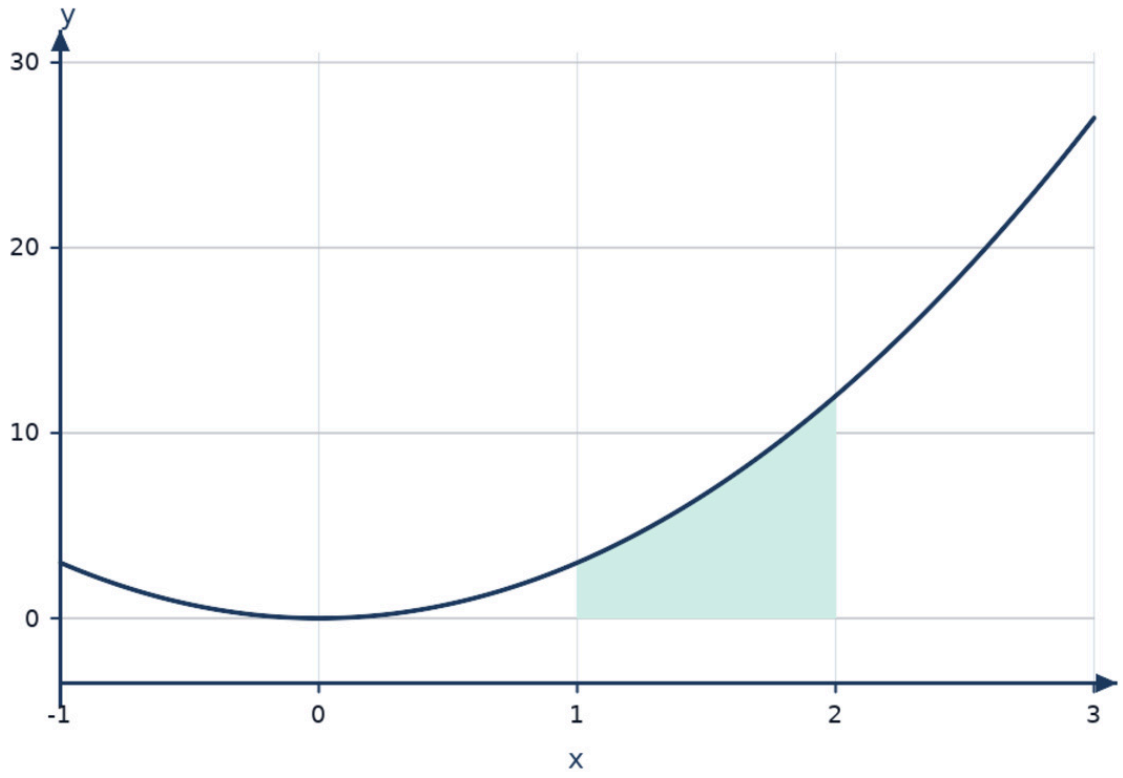
What is the integral of $3x^2$ from 1 to 2?



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What does the fundamental theorem connect?

A Differentiation and algebra

B Differentiation and integration

C Integration and geometry

D Addition and subtraction

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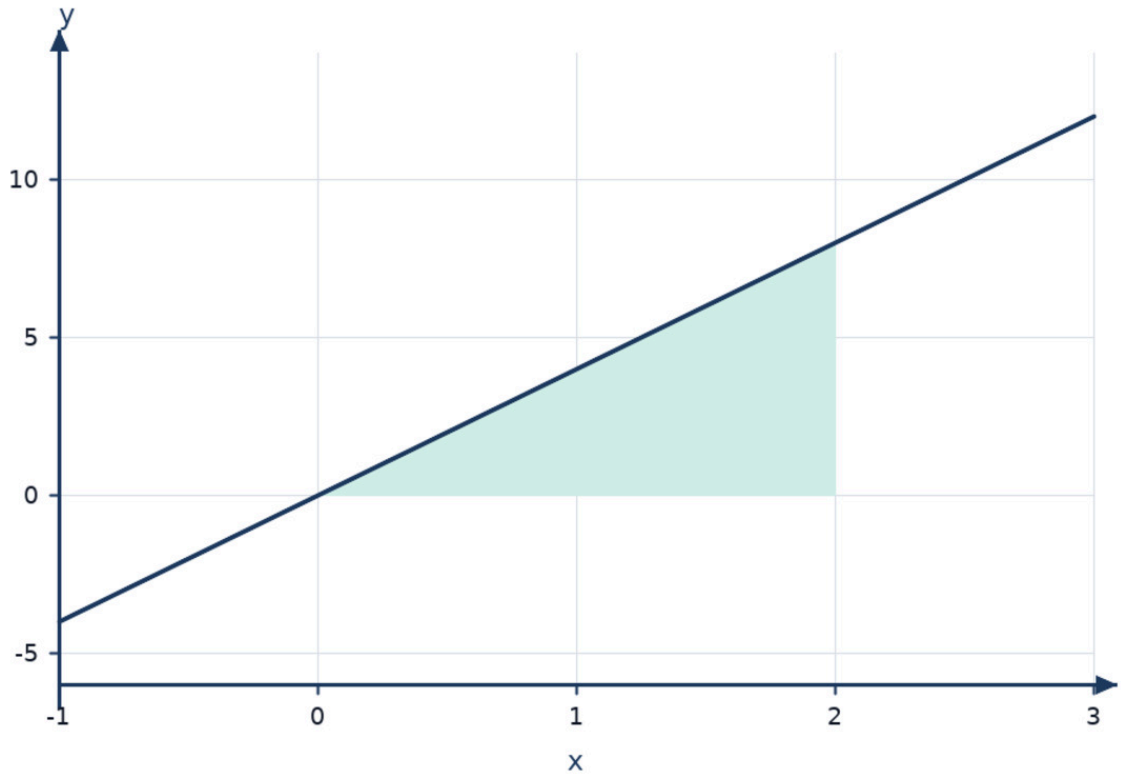
6 **The graph shows the area under y = 4x from 0 to 2. What does the fundamental theorem say this area equals?**



- **A** F(2) – F(0)
- **B** F(0) – F(2)
- **C** F(2) + F(0)
- **D** f(2) – f(0)

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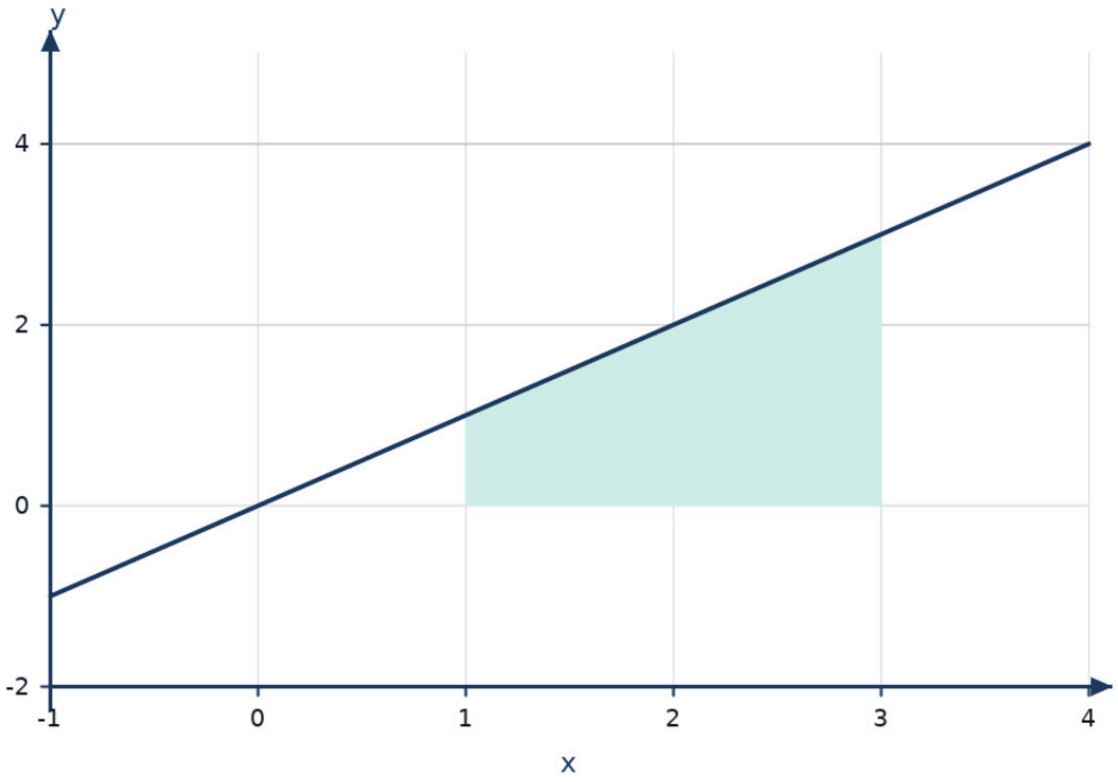
What is the integral of x from 3 to 1?



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8 Why do you subtract the lower evaluation?

A. To count only the accumulation between the two limits

B. To cancel out the antiderivative

C. To make the answer positive

D. To remove the constant of integration

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9 What is the integral of 2 from 0 to 0?

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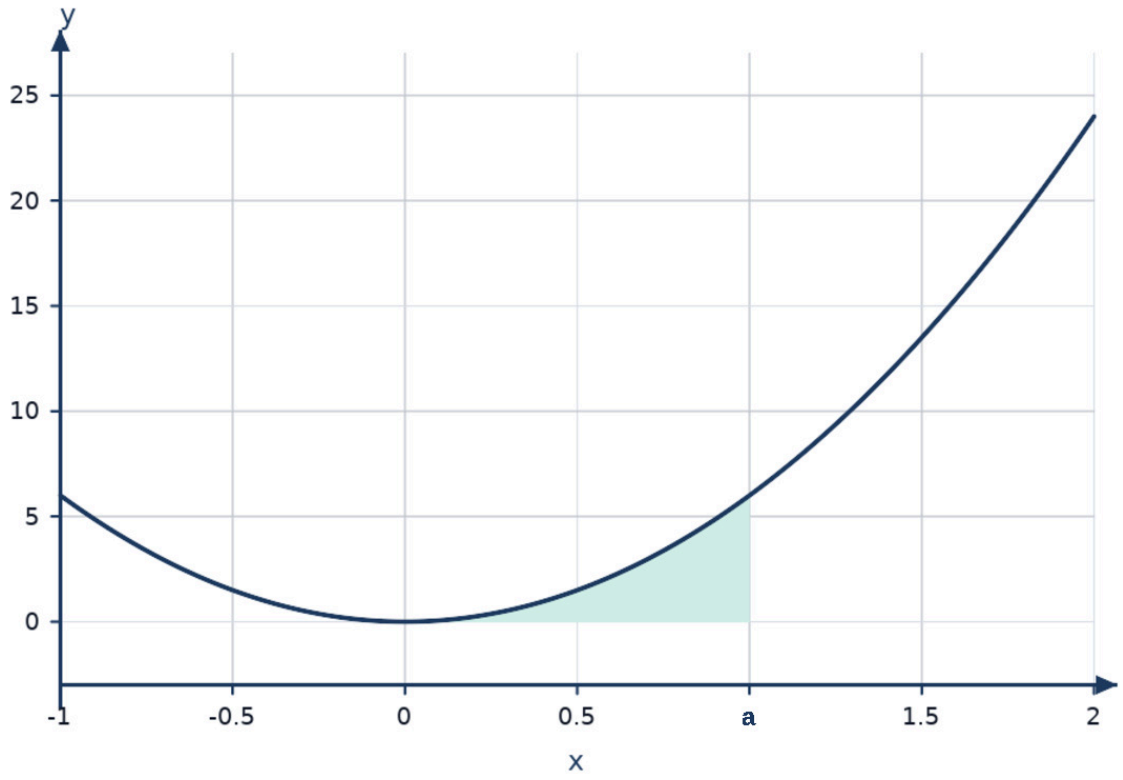
Find the number a so that the integral of $6x^2$ from 0 to a equals 2.



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ANSWER KEY

1. The integral from a to b of f(x) equals F(b) – F(a), where F is an antiderivative of f

2. 9

3. 4

4. 7

5. Differentiation and integration

6. F(2) – F(0)

7. -4

8. To count only the accumulation between the two limits

9. 0

10. 1

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