MATHEMATICS · GRADES 10-12

Derivatives of exponential functions

Difficulty level: Advanced

Mathematics: Grades 10-12

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Overview of the concept

This is how fast something that grows in proportion to itself is changing. Money earning compound interest grows faster the more you have, and bacteria in a dish double faster as the colony gets bigger. The rate of change is tied to the size right now, so the growth speeds up as the amount grows. Knowing that rate tells you how quickly things will build up, or how quickly your savings will grow.



Rule

The derivative of e to the x is e to the x.

More generally, the derivative of $e^{k}x$ is k × $e^{k}x$. For a base other than e, such as 2^{x}, the derivative is the function times ln of the base — ln means the natural logarithm, the power you would raise e to in order to get that number. The number e is special because its rate of change equals its size.

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Worked examples

EXAMPLE 1

Q Differentiate $f(x) = e^{3x}$.

SOLUTION

This is an exponential with something other than x in the power, so the chain rule applies: the derivative of e to a power is e to that power, times the derivative of the power.

The power is 3x, and its derivative is 3.

So $f'(x) = 3e^{3x}$

EXAMPLE 2

Q Differentiate $f(x) = xe^{x}$.

SOLUTION

This is a product, x times e^{x}, so use the product rule: derivative of the first times the second, plus the first times the derivative of the second.

The derivative of x is 1, and the derivative of e^{x} is itself, e^{x}.

So $f'(x) = e^{x} + x \times e^{x} = (x + 1)e^{x}$

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Practice questions

1 Differentiate e^{5x}.

- **A** $5e^{5x}$
- **B** e^{5x}
- **C** $5xe^{5x}$
- **D** $25e^{5x}$

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2 Differentiate $4e^{x}$.

- **A** $4e^{x}$
- **B** e^{x}
- **C** $4xe^{x}$
- **D** e^{4x}

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3 Differentiate e^{x2}

A e^{x2}

B $2xe^{x2}$

C xe^{x2}

D $2e^{x2}$

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4 Differentiate 2^x.

A 2^x

B $2^x \ln 2$

C $x2^{x-1}$

D $2^x \ln x$

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5 Differentiate $e^x + e^{2x}$.

- A $e^x + e^{2x}$
- B $e^x + 2e^{2x}$
- C $2e^x + 2e^{2x}$
- D $e^x + 4e^{2x}$

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6 Differentiate e^(sin x).

- A cos x e^(sin x)
- B sin x e^(sin x)
- C e^(sin x)
- D cos x e^(cos x)

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7 Differentiate x^2e^x.

A $(x^2 + 2x)e^x$

B $2xe^x$

C x^2e^x

D $(2x + 2)e^x$

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8 Find $f'(0)$ for $f(x) = e^{2x} + 3$

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9 Find the second derivative of e^{4x}.

- **A** $4e^{4x}$
- **B** $16e^{4x}$
- **C** $8e^{4x}$
- **D** e^{4x}

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10 Find the equation of the tangent to $y = e^x$ at $x = 0$

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

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ANSWER KEY

1. $5e^{5x}$

2. $4e^{x}$

3. $2xe^{x^2}$

4. $2^{x} \ln 2$

5. $e^{x} + 2e^{2x}$

6. cos x e^(sin x)

7. $(x^2 + 2x)e^{x}$

8. 2

9. $16e^{4x}$

10. $y = x + 1$

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