MATHEMATICS · GRADES 10-12

Exponential functions

Difficulty level: Advanced

Mathematics: Grades 10-12

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Overview of the concept

This is how you describe something that multiplies by the same amount each step. Money growing with interest multiplies by the same factor every year, and a rumour spreading through a school multiplies by the same factor every day. The pattern is the same even though the situations look different. Once you recognise it, you can predict how big things will get and how fast.



Rule

Exponential function: $f(x) = a^x$, where each step multiplies the output by the same factor a.

If a is more than 1 the function grows, and if a is between 0 and 1 it shrinks.

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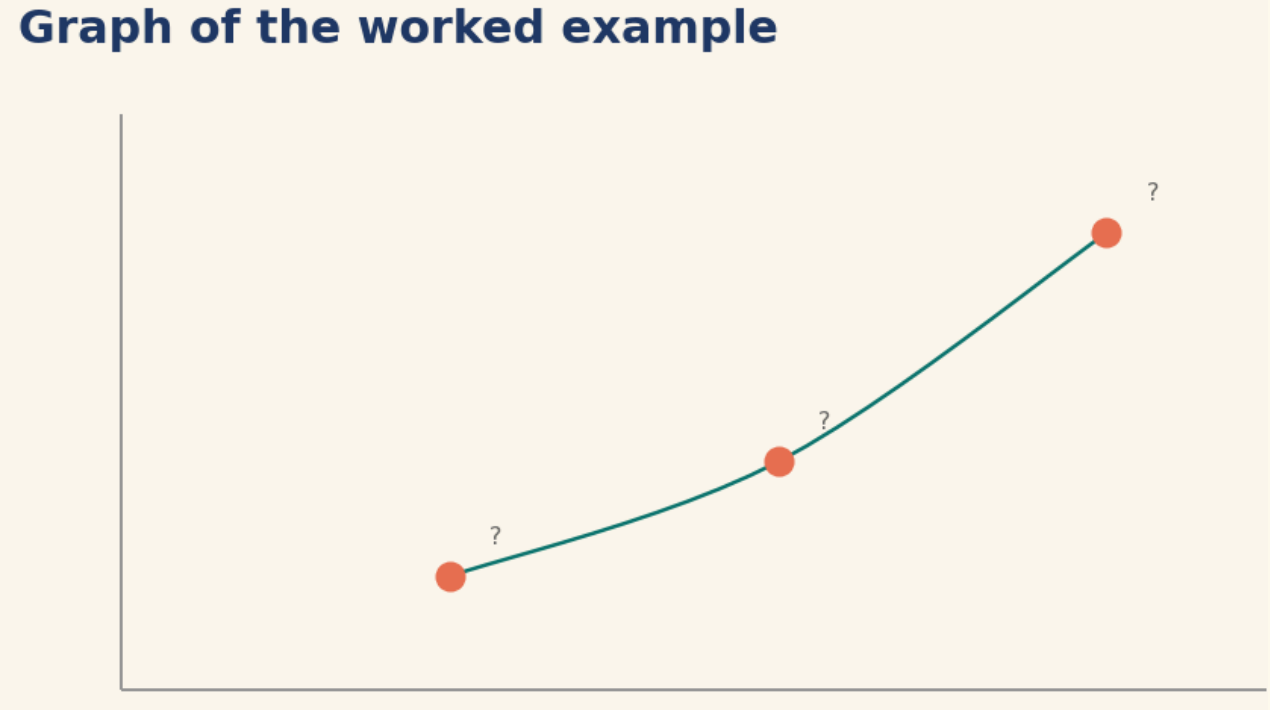
Worked examples

EXAMPLE 1

Q Make a table for $f(x) = 2^x$



SOLUTION

Choose x values: 0, 1, 2

Work each one out: $2^0 = 1$, $2^1 = 2$, $2^2 = 4$

Write the pairs: (0, 1), (1, 2), (2, 4). Each step multiplies the output by 2.

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EXAMPLE 2

Q Make a table for $f(x) = 3^x$

SOLUTION

Choose x values: 0, 1, 2

Work each one out: $3^0 = 1$, $3^1 = 3$, $3^2 = 9$

Write the pairs: (0, 1), (1, 3), (2, 9)

Practice questions

1 **Bacteria double every hour. Which set of ordered pairs gives f(x) for x = 0, 1, 2, 3?**

- **A** (0, 1), (1, 2), (2, 4), (3, 6)
- **B** (0, 1), (1, 2), (2, 4), (3, 8)
- **C** (0, 2), (1, 4), (2, 8), (3, 16)
- **D** (0, 1), (1, 3), (2, 5), (3, 7)

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2 A plant triples its leaves each week, starting with 1 leaf. Which function gives the number of leaves after x weeks?

- **A** $f(x) = 3^x$
- **B** $f(x) = x^3$
- **C** $f(x) = 3x$
- **D** $f(x) = x + 3$

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3 A colony grows by a factor of 5 each day. The table shows f(0) = 1, f(1) = 5, and f(2) = 25. What is f(3)?

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4 A quantity halves going backwards in time and doubles going forwards. Which set of ordered pairs gives f(x) for x = -1, 0, 1, 2?

A $(-1, \frac{1}{2}), (0, 1), (1, 2), (2, 4)$

B $(-1, 2), (0, 1), (1, \frac{1}{2}), (2, \frac{1}{4})$

C $(0, 1), (1, 2), (2, 4), (3, 8)$

D $(-1, \frac{1}{2}), (0, 1), (1, 2), (2, 8)$

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5 For $f(x) = 2^x$, find $f(3)$.

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6 For $f(x) = 2^x$, find the value of x when $f(x) = 32$.

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7 For $f(x) = 3^x$, find $f(-1)$.

A $\frac{1}{3}$

B 3

C -3

D 1

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8 A population doubles every hour, starting at 1. The population after x hours is $f(x) = 2^x$. What is the population after 6 hours?

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9 A savings account grows by a factor of 4 each year. In $f(x) = a^x$, what is a?

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10 A population triples each year, so $f(x) = 3^x$. Which ordered pair is NOT on the graph of f?

A $(2, 9)$

B $(-1, \frac{1}{3})$

C $(1, 3)$

D $(2, 6)$

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ANSWER KEY

1. (0, 1), (1, 2), (2, 4), (3, 8)

2. $f(x) = 3^x$

3. 125

4. $(-1, \frac{1}{2})$, (0, 1), (1, 2), (2, 4)

5. 8

6. 5

7. $\frac{1}{3}$

8. 64

9. 4

10. (2, 6)

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