MATHEMATICS · GRADES 10-12

Sum of cubes

Difficulty level: Advanced

Mathematics: Grades 10-12

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Overview of the concept

This is how you factor two cubes added together, like breaking a large volume into a short piece and a longer piece, using a pattern that always rebuilds the original. A sum of cubes looks like a single hard expression, but it always splits into the same two factors, a short one and a longer one. Once you know the pattern, the split is quick, and multiplying the two factors back together gives you exactly what you started with. That is how you turn a bulky volume or a cubic expression into two simpler pieces you can work with.



Rule

Sum of cubes: $a^3 + b^3 = (a + b)(a^2 - ab + b^2)$.

The first bracket is the sum of the cube roots, and the second bracket squares the first, takes away their product, and adds the square of the second.

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Worked examples

EXAMPLE 1

Q Factor $x^3 + 8$

SOLUTION

Write each term as a cube: x^3 is $(x)^3$ and 8 is $(2)^3$.

Use $a^3 + b^3 = (a + b)(a^2 - ab + b^2)$ with $a = x$ and $b = 2$.

Write the result: $(x + 2)(x^2 - 2x + 4)$

EXAMPLE 2

Q Factor $27x^3 + 1$

SOLUTION

Write each term as a cube: $27x^3$ is $(3x)^3$ and 1 is $(1)^3$.

Use the pattern with $a = 3x$ and $b = 1$:
$(3x + 1)((3x)^2 - (3x)(1) + (1)^2)$

Write the result: $(3x + 1)(9x^2 - 3x + 1)$

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Practice questions

1 Factor $x^3 + 27$

A $(x + 3)(x^2 - 3x + 9)$

B $(x + 3)(x^2 + 3x + 9)$

C $(x - 3)(x^2 + 3x + 9)$

D $(x + 3)(x^2 - 3x - 9)$

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2 Factor $x^3 + 1$

A $(x + 1)(x^2 + x + 1)$

B $(x + 1)(x^2 - x + 1)$

C $(x - 1)(x^2 + x + 1)$

D $(x + 1)(x^2 - x - 1)$

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3 Factor $8x^3 + 27$

A $(2x + 3)(4x^2 - 6x + 9)$

B $(2x + 3)(4x^2 + 6x + 9)$

C $(2x - 3)(4x^2 + 6x + 9)$

D $(2x + 3)(4x^2 - 6x - 9)$

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4 Factor $x^3 - 27$

A $(x - 3)(x^2 + 3x + 9)$

B $(x + 3)(x^2 - 3x + 9)$

C $(x - 3)(x^2 - 3x + 9)$

D $(x - 3)(x^2 + 3x - 9)$

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5 Factor $27x^3 + 8$

A $(3x + 2)(9x^2 - 6x + 4)$

B $(3x + 2)(9x^2 + 6x + 4)$

C $(3x - 2)(9x^2 + 6x + 4)$

D $(3x + 2)(9x^2 - 6x - 4)$

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6 What is the second factor when $x^3 + 216$ is factored?

A $(x^2 - 6x + 36)$

B $(x^2 + 6x + 36)$

C $(x^2 - 6x - 36)$

D $(x - 6)$

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7 **The factored form is $(x + 4)(x^2 - 4x + 16)$. What was the original expression?**

A $x^3 + 64$

B $x^3 - 64$

C $x^3 + 16$

D $(x + 4)(x^2 - 4x + 16)$

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8 Why does the second bracket in the sum of cubes have a minus sign in the middle?

- **A** Expanding $(x + a)(x^2 - ax + a^2)$ cancels the middle terms and leaves $x^3 + a^3$
- **B** The minus sign makes the first factor negative
- **C** Without the minus sign, the product would be $x^3 - a^3$
- **D** The minus sign means a is subtracted from x in the final answer

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9 Which sum of cubes has the factor $(x + 5)$?

- **A** $x^3 + 8$
- **B** $x^3 + 27$
- **C** $x^3 + 64$
- **D** $x^3 + 125$

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10 Which one is not a sum of cubes?

- **A** $x^3 + 27$
- **B** $x^3 + 64$
- **C** $x^3 + 125$
- **D** $x^3 + 100$

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ANSWER KEY

1. $(x + 3)(x^2 - 3x + 9)$

2. $(x + 1)(x^2 - x + 1)$

3. $(2x + 3)(4x^2 - 6x + 9)$

4. $(x - 3)(x^2 + 3x + 9)$

5. $(3x + 2)(9x^2 - 6x + 4)$

6. $(x^2 - 6x + 36)$

7. $x^3 + 64$

8. Expanding $(x + a)(x^2 - ax + a^2)$ cancels the middle terms and leaves $x^3 + a^3$

9. $x^3 + 125$

10. $x^3 + 100$

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