MATHEMATICS · GRADES 10-12

Finite geometric series

Difficulty level: Advanced

Mathematics: Grades 10-12

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Overview of the concept

This is how you add up a set of payments that grow by the same factor each time. A loan with interest added each month grows the same way, and the total you pay back is the sum of all those growing payments. Adding them one by one would take forever, but the series formula gives you the total in one step. It is how banks work out what a loan really costs.



Rule

Finite geometric series: the sum of the first n terms is $S = a\frac{(1 - r^n)}{(1 - r)}$, where a is the first term and r is the common ratio.

For a short series you can also just add the terms up.

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Worked examples

EXAMPLE 1

Q Find the sum of 2 + 6 + 18 + 54.

SOLUTION

This is geometric with a = 2 and r = 3, with 4 terms.

Add directly: 2 + 6 = 8, 8 + 18 = 26, 26 + 54 = 80

The sum is 80

EXAMPLE 2

Q Use the formula for the sum of the first 5 terms of 1, 2, 4.

SOLUTION

Here a = 1, r = 2, n = 5

The Rule writes this formula the other way round, with $(1 - r^n)$ on top and $(1 - r)$ underneath. Flipping both the top and the bottom leaves the answer unchanged, so it can be written like this:

$$\text{Sum} = a\frac{(r^n - 1)}{(r - 1)}$$

Put the numbers in: $\text{Sum} = 1 \times \frac{(2^5 - 1)}{(2 - 1)}$

Work out $2^5 = 32$, so the top is 32 - 1 = 31 and the bottom is 2 - 1 = 1.

Sum = 31

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Practice questions

1. A bacteria colony triples each hour: 3, 9, 27. What is the total after three hours?

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2. A savings account doubles each week, starting with 1 dollar. What is the amount in the fourth week?

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3. A population doubles each year: 5, 10, 20, 40. What is the common ratio?

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4 A colony triples each day, starting with 1. What is the total after 6 days?

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5 A medicine halves each day: 10, 5, 2.5 mg. What fraction of the first day's amount is the third day's amount?

A $\frac{1}{4}$

B $\frac{1}{2}$

C $\frac{1}{8}$

D $\frac{2}{5}$

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6 A population triples each year. After 4 years the total is 120. What was the starting population?

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7 What is the formula for the sum of a finite geometric series?

A. $\text{Sum} = a\frac{(r^n - 1)}{(r + 1)}$, for r not equal to -1

B. $\text{Sum} = a\frac{(r^n - 1)}{(r - 1)}$, for r not equal to 1

C. $\text{Sum} = a\frac{(r^n + 1)}{(r - 1)}$, for r not equal to 1

D. $\text{Sum} = a\frac{(r - 1)}{(r^n - 1)}$, for r not equal to 1

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8 A bacteria colony triples each hour: 4, 12, 36. After how many hours does the total first pass 100?

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9 A savings account doubles each week, starting with 3 dollars. What is the ratio of the total after 5 weeks to the starting amount?

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10

Which series has the larger total: 100, 50, 25 or 10, 20, 40?

A 100, 50, 25

B 10, 20, 40

C They are equal

D Cannot tell

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ANSWER KEY

1. 39

2. 8

3. 2

4. 364

5. $\frac{1}{4}$

6. 3

7. Sum = $a \frac{(r^n - 1)}{(r - 1)}$

, for r not equal to 1

8. 4

9. 31

10. 100, 50, 25

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