MATHEMATICS · GRADES 10-12

Instantaneous rate of change

Difficulty level: Advanced

Mathematics: Grades 10-12

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Overview of the concept

This is how you read the speed at one exact moment, like the number on a car speedometer, rather than the average speed over a whole trip. An average can hide a lot, because a car that averaged 60 kilometres an hour might have been doing 100 on the highway and 20 in town. The speedometer reading is the instantaneous rate, and the same idea tells you how fast a population is growing right now, or how quickly a temperature is dropping at this exact minute.



Rule

The instantaneous rate of change at a point is the derivative at that point.

Find the derivative, then put in the x value. That number is the rate at that exact moment, like the reading on a speedometer.

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Worked examples

EXAMPLE 1

Q For $f(x) = x^2$, find the instantaneous rate of change at $x = 2$.

SOLUTION

The instantaneous rate is the derivative: $f'(x) = 2x$.

At $x = 2$, $f' = 4$

So the rate is 4 at that moment.

EXAMPLE 2

Q For $f(x) = 3x$, find the instantaneous rate of change at $x = 10$.

SOLUTION

The derivative of $3x$ is 3, a constant.

So at $x = 10$ the rate is 3.

A straight line has the same instantaneous rate everywhere.

Practice questions

1 For $f(x) = x^2$, what is the instantaneous rate of change at $x = 3$?

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2 For $f(x) = x^2$, at which x is the instantaneous rate of change equal to 0?

- **A** x = 0
- **B** x = 1
- **C** x = 2
- **D** It is never 0

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3 For $f(x) = 5x$, what is the instantaneous rate of change at any x?

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4 What is another name for the instantaneous rate of change?

A The derivative

B The integral

C The average rate of change

D The second derivative

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5 What does it mean if the instantaneous rate of change is negative?

A The function is decreasing there

B The function is increasing there

C The function is constant there

D The rate is zero there

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6 **On a graph, the instantaneous rate of change at a point is the slope of which line?**

A The slope of the tangent line

B The slope of the secant line

C The area under the curve

D The height of the graph

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7 **For f(x) = 7, what is the instantaneous rate of change at any x?**

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8 For $f(x) = x^2$, how does the instantaneous rate of change at $x = 3$ compare with the rate at $x = 1$?

A Greater

B Less

C Equal

D It is zero at both

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9

Average rates of $f(x) = x^2$ near $x = 2$ over shorter and shorter intervals. How is the instantaneous rate of change found from average rates?

A By shrinking the interval to zero

B By making the interval as large as possible

C By adding the average rates together

D By finding the average of the two ends

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10

Use the average rate of change over $[2, 2.1]$ to estimate the instantaneous rate of change of $f(x) = x^2$ at $x = 2$.

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ANSWER KEY

1. 6

2. $x = 0$

3. 5

4. The derivative

5. The function is decreasing there

6. The slope of the tangent line

7. 0

8. Greater

9. By shrinking the interval to zero

10. 4.1

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