MATHEMATICS · GRADES 10-12

Local and absolute extrema

Difficulty level: Advanced

Mathematics: Grades 10-12

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Overview of the concept

This is how you find the highest and lowest points of a curve, like the peak of a roller coaster or the cheapest price a stock hit all year. A local peak is the highest point nearby, while the absolute peak is the highest point of all, and knowing which is which keeps you from mistaking a small hill for the top of the mountain. You use it to find the best price to sell at, the lowest cost to build something, or the highest point a ball reaches before it falls.

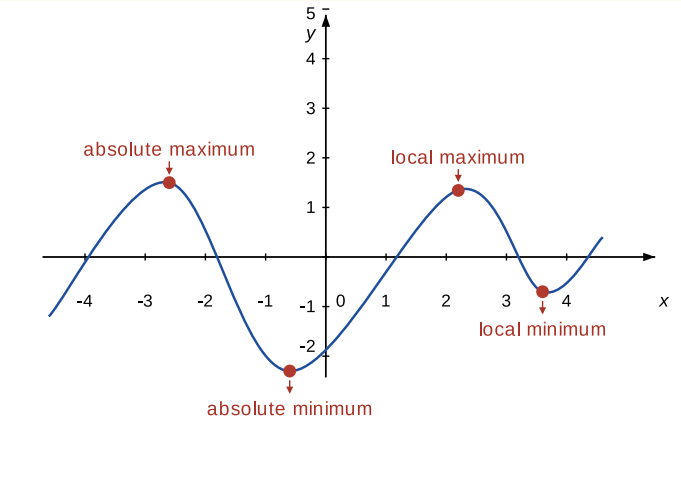


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Rule

At a point where the derivative is zero, the function has a local maximum when the derivative changes from positive to negative, and a local minimum when it changes from negative to positive.

A local extreme is the highest or lowest point nearby, while the absolute extreme is the highest or lowest point of all.



Worked examples

EXAMPLE 1

Q **Find the local minimum of $f(x) = x^2$.**

SOLUTION

Derivative $2x$ is 0 at $x = 0$.

The derivative changes from negative to positive at 0.

So $(0, 0)$ is a local minimum, and also the absolute minimum.

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EXAMPLE 2

Q Find the local maximum of $f(x) = -x^2 + 4$.

SOLUTION

Derivative $-2x$ is 0 at $x = 0$.

The derivative changes from positive to negative at 0.

So $(0, 4)$ is a local maximum, and also the absolute maximum.

Practice questions

1 What is the local minimum of $f(x) = x^2 + 1$?

- **A** $(0, 0)$
- **B** $(0, 1)$
- **C** $(1, 1)$
- **D** $(0, -1)$

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2 What is the local maximum of $f(x) = -x^2$?

A (0, 1)

B (0, -1)

C (0, 0)

D (1, 0)

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3 What is the difference between a local extreme and an absolute extreme?

A Local is the highest point; absolute is the lowest point

B Local is best nearby; absolute is best over the whole domain

C They mean the same thing

D Local is best over the whole domain; absolute is best nearby

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4 What is the absolute minimum of $f(x) = x^2$ on all real numbers?

- **A** 1, at $x = 1$
- **B** 0, at $x = 1$
- **C** 0, at $x = 0$
- **D** There is no absolute minimum

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5 Does $f(x) = x^3$ have a local maximum?

- **A** Yes
- **B** No

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6 What is the local maximum of $f(x) = -(x - 2)^2 + 3$?

- **A** (2, -3)
- **B** (-2, 3)
- **C** (2, 3)
- **D** (3, 2)

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7 What is the absolute maximum of $f(x) = -x^2$?

- **A** 0, at $x = 0$
- **B** -1, at $x = 0$
- **C** 0, at $x = 1$
- **D** There is no absolute maximum

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8 How do you test a critical point?

A. Check whether the function value is zero

B. Check whether the second derivative is zero

C. Check whether the graph is straight there

D. Check whether the derivative changes sign there

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9 What is the local minimum of $f(x) = (x - 1)^2$?

A. (0, 1)

B. (1, 1)

C. (-1, 0)

D. (1, 0)

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10 **What is the absolute maximum of $f(x) = x^2$ on $[-1, 2]$?**

A 1, at x = -1

B 4, at x = 2

C 0, at x = 0

D There is no absolute maximum

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ANSWER KEY

1. (0, 1)

2. (0, 0)

3. Local is best nearby; absolute is best over the whole domain

4. 0, at x = 0

5. No

6. (2, 3)

7. 0, at x = 0

8. Check whether the derivative changes sign there

9. (1, 0)

10. 4, at x = 2

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