MATHEMATICS · GRADES 10-12

# Maximum and minimum values

### Difficulty level: Advanced

### Mathematics: Grades 10-12

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## *Overview of the concept*

This is how you find the best possible result, like the biggest area a fence can enclose or the lowest cost to build something. Almost every practical problem is about getting the most of something good or the least of something bad, and this is how you find that best value instead of guessing. A farmer uses it to get the biggest field from a fixed length of fence, a builder uses it to keep costs down, and a business uses it to find the price that earns the most profit.



## *Rule*

**The vertex of a parabola (see Vertex form) is its maximum when the parabola opens downward and its minimum when it opens upward.**

Find the vertex, and its y value is the maximum or minimum value.

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## Worked examples

EXAMPLE 1

### Q Find the minimum value of $y = x^2 - 4x + 3$

**SOLUTION**

The coefficient of $x^2$ is positive, so the parabola opens upward and the vertex is a minimum.

Find the vertex: $x = -(-4) \div (2 \times 1) = 2$, $y = 2^2 - 4 \times 2 + 3 = -1$

So the minimum value is -1, at $x = 2$.

EXAMPLE 2

### Q Find the maximum value of $y = -2x^2 + 8x - 3$

**SOLUTION**

The coefficient of $x^2$ is negative, so the parabola opens downward and the vertex is a maximum.

Find the vertex: $x = -8 \div (2 \times -2) = 2$, $y = -2 \times 2^2 + 8 \times 2 - 3 = 5$

So the maximum value is 5, at $x = 2$.

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## Practice questions

1. A ball's height is $y = x^2 + 2x - 3$. What is its lowest value?

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2. A shop's profit is $y = -x^2 + 4x + 1$. What is the greatest profit?

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3. For $y = x^2 - 6x + 5$, at what value of x does the minimum occur?

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4 A jump reaches height $y = -x^2 - 2x + 8$. What is the value of y when $x = 0$?

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5 A parabola has vertex (2, -5) and opens upward. What is its minimum value?

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6 A fountain jet follows $y = -2x^2 + 4x + 6$. Its greatest height is 8. How much greater is that than its height at $x = 0$?

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**7** **Which has the smaller minimum value: $y = x^2 + 4x - 12$ or $y = x^2 - 2x - 3$?**

A $y = x^2 + 4x - 12$

B $y = x^2 - 2x - 3$

C They are equal

D Neither has a minimum

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**8** **An arch is modelled by $y = -x^2 + 6x - 5$. Its highest point is at $x = 3$. What is the highest point of the arch?**

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**9** Two roofs are modelled by $y = -3x^2 + 12x - 7$ and $y = -2x^2 + 4x + 6$. Which one has a maximum value of 5?

- **A** $y = -3x^2 + 12x - 7$
- **B** $y = -2x^2 + 4x + 6$
- **C** $y = -3x^2 - 12x - 7$
- **D** $y = 2x^2 + 4x + 6$

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**10** The minimum value of $y = 3x^2 - 6x + 1$ is -2. What is the minimum value of $y = 3x^2 - 6x + 5$?

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## ANSWER KEY

**1.** -4

**2.** 5

**3.** 3

**4.** 8

**5.** -5

**6.** 2

**7.** $y = x^2 + 4x - 12$

**8.** 4

**9.** $y = -3x^2 + 12x - 7$

**10.** 2

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