MATHEMATICS · GRADES 10-12

Projectile-motion applications

Difficulty level: Advanced

Mathematics: Grades 10-12

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Overview of the concept

This is how you work out how high a basketball goes and when it comes back down, or how far a soccer ball travels before it lands. A basketball player judges a shot by its arc, and a goalkeeper judges where a kicked ball will land. A diver off a board, a fountain's arc of water, and a rocket's first seconds all follow the same curved path. Once you can read that path, you can predict where a thrown or kicked object will go before it gets there.



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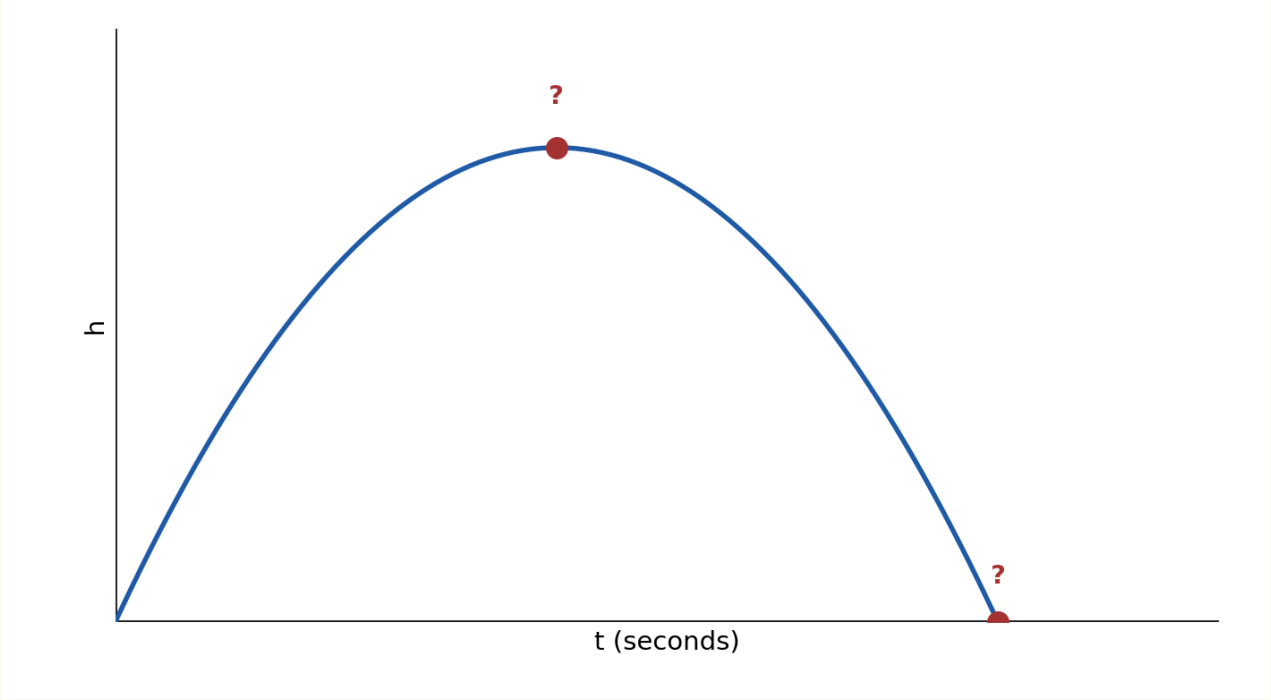
Worked examples

EXAMPLE 1

Q For $h = -5t^2 + 20t$, find the maximum height and the time it hits t he ground.



SOLUTION

Find the vertex time: $t = -\frac{20}{(2 \times -5)} = 2$

Find the height at t = 2: $-5 \times 4 + 40 = 20$

So the maximum height is 20, at 2 seconds, and it hits the ground when $-5t^2 + 20t = 0$. Factor out t: $t(-5t + 20) = 0$, so $t = 0$ or $t = 4$ seconds.

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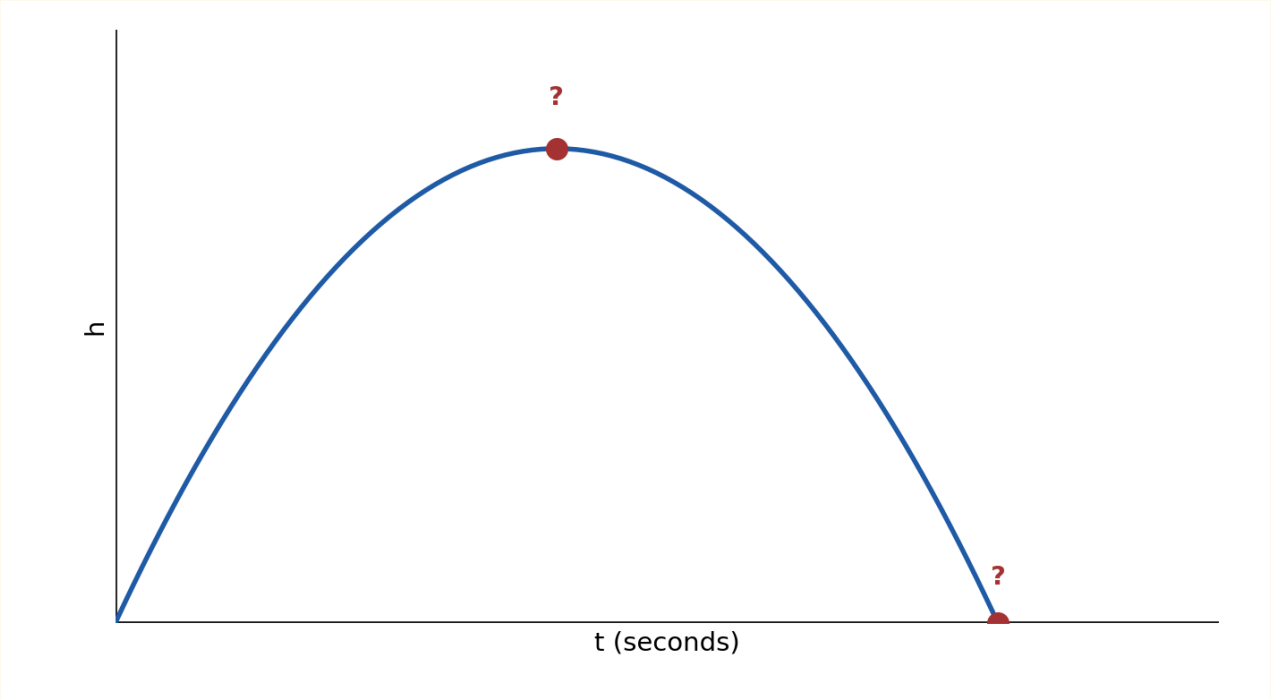
EXAMPLE 2

Q For $h = -5t^2 + 30t$, find the maximum height and the time it hits t he ground.



SOLUTION

Find the vertex time: $t = -\frac{30}{(2 \times -5)} = 3$

Find the height at t = 3: $-5 \times 9 + 90 = 45$

So the maximum height is 45, at 3 seconds, and it hits the ground when $-5t^2 + 30t = 0$. Factor out t: $t(-5t + 30) = 0$, so $t = 0$ or $t = 6$ seconds.

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Practice questions

1 For $h = -5t^2 + 10t$. Find the maximum height and the time it hits the ground.

- **A** Maximum height 5 at 1 second; hits the ground at 2 seconds
- **B** Maximum height 5 at 2 seconds; hits the ground at 1 second
- **C** Maximum height 10 at 1 second; hits the ground at 2 seconds
- **D** Maximum height 2.5 at 1 second; hits the ground at 4 seconds

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2 For $h = -5t^2 + 40t$. What is the height after 2 seconds?

- **A** 60
- **B** 80
- **C** 40
- **D** 120

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3 For $h = -5t^2 + 15t$. After how many seconds is the height 10 metres?

- **A** 1 second
- **B** 2 seconds
- **C** 1 or 2 seconds
- **D** 3 seconds

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4 **A basketball is shot upward. Its height is $h = -5t^2 + 50t$ metres. What is the maximum height, and when does it hit the ground?**

- **A** Maximum height 125 at 5 seconds; hits the ground at 10 seconds
- **B** Maximum height 250 at 5 seconds; hits the ground at 10 seconds
- **C** Maximum height 125 at 10 seconds; hits the ground at 5 seconds
- **D** Maximum height 62.5 at 5 seconds; hits the ground at 20 seconds

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5 For $h = -2t^2 + 16t$. After how many seconds does it reach its maximum height?

- **A** 4 seconds
- **B** 8 seconds
- **C** 2 seconds
- **D** 16 seconds

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6 For $h = -4t^2 + 24t$. How long until it hits the ground?

- **A** 6 seconds
- **B** 3 seconds
- **C** 12 seconds
- **D** 24 seconds

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7 The table shows the height of a stone over time. When does it reach its highest point, and how high is that?

Time (s)	0	1	2	2.5	3	4	5
Height (m)	0	20	30	31.25	30	20	0

A 2.5 seconds, 31.25 m

B 2 seconds, 30 m

C 3 seconds, 30 m

D 5 seconds, 0 m

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8 Two balls are thrown upward. Ball A has height $h = -5t^2 + 60t$. Ball B has height $h = -5t^2 + 40t$. Which ball goes higher?

A Ball A

B Ball B

C They go the same height

D Cannot tell

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9 For $h = -5t^2 + 20t + 5$. What is the height at $t = 0$?

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10 For $h = -5t^2 + 35t$. What is the maximum height?

A 61.25

B 30.625

C 122.5

D 3.5

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ANSWER KEY

1. Maximum height 5 at 1 second; hits the ground at 2 seconds

2. 60

3. 1 or 2 seconds

4. Maximum height 125 at 5 seconds; hits the ground at 10 seconds

5. 4 seconds

6. 6 seconds

7. 2.5 seconds, 31.25 m

8. Ball A

9. 5

10. 61.25

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