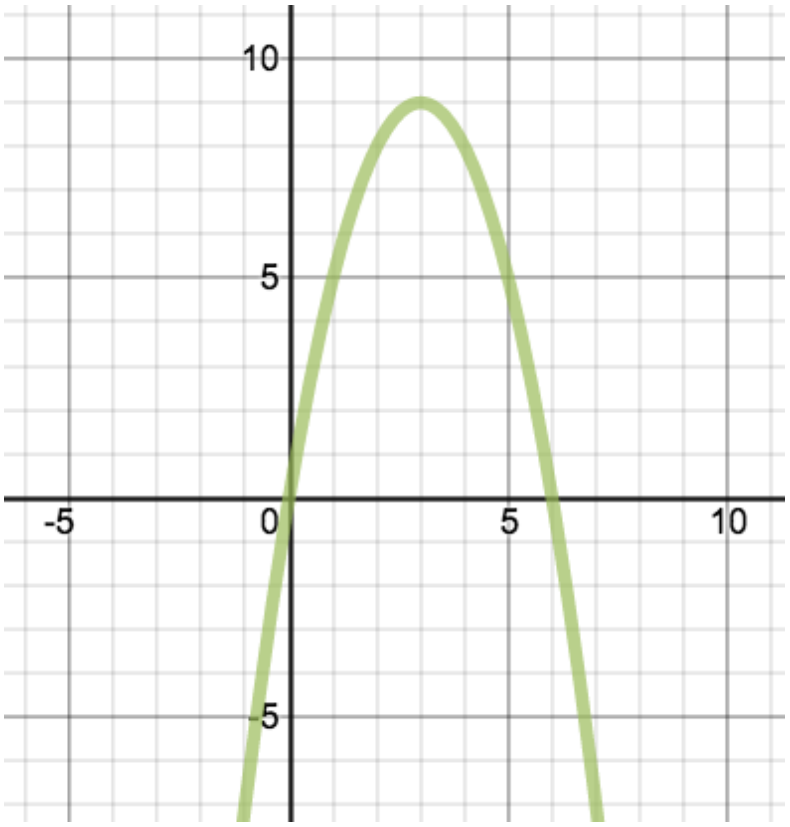
# Kinematics – The Physics (and Calculus!) of Motion

You throw a ball. It's height (or position) dependent on time is graphed below and can be represented by the position function:

$$s(t) = -t^2 + 6t$$




1. At what time is the ball at its highest?

2. How high is the highest point?

3. When does the ball have the highest **velocity** (speed) ?

4. What is happening to velocity as the ball goes up to its highest point?

5. When does the ball have no velocity?

6. What is happening to velocity when the ball is falling from its highest point?

7. Considering 1-6 above, do you see a connection between velocity and some aspect of the graph?

8. Draw a **motion diagram** for t = 0 - 5.

9. Find the **displacement**.

10. Find the **total distance** traveled.

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**velocity: v(t) = ____**

Find the velocity function:

Fill the table:

| t | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| v(t) | | | | | | | |

* Add the velocity graph to the co-ordinate plane above.

**acceleration: a(t) = ____**

Find the acceleration function:

Note how the acceleration affects the velocity.

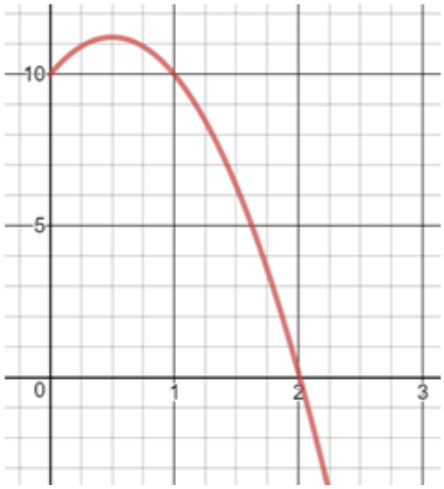
* Add the acceleration graph to the co-ordinate plane above.

A diver jumps from a platform at time $t = 0$ seconds. The distance of the diver above water level at time $t$ is given by $s(t) = -4.9t^2 + 4.9t + 10$, where $s$ is in metres.

**a** Find the **average velocity** of the diver over the given time intervals.

**i** $[1,2]$

**b** Find the **instantaneous velocity** of the diver at $t = 1$ second.




**c** Find the acceleration at t = 2.

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A particle moves in a horizontal line so that its position from a fixed point after $t$ seconds, where $t \geq 0$, is $s$ metres, where $s(t) = 5t^2 - t^4$.

**a** Find the position, velocity and acceleration of the particle after 1 second.

**b** Determine whether the particle is speeding up or slowing down at $t = 1$.

**c** Find the values of $t$ when the particle is at rest.

**d** Find the time intervals on which the particle is speeding up, and the intervals on which it is slowing down.

**e** Find the total distance the particle travels in the first 3 seconds.

A particle moves in a straight line with a displacement of $s$ metres $t$ seconds after leaving a fixed point. The displacement function is given by $s(t) = 2t^3 - 21t^2 + 60t + 3$, for $t \geq 0$.

**a** Find the velocity of the particle at any time $t$.

**b** Find the initial position and initial velocity of the particle.

**c** Find when the particle is at rest.

**d** Find when the particle is moving left and when the particle is moving right.

**e** Draw a motion diagram for the particle.

For the displacement function $s(t) = 2t^3 - 21t^2 + 60t + 3$, with $s$ in metres and $t \geq 0$ seconds, we found that $v(t) = 6t^2 - 42t + 60$.

**a** Find the **average acceleration** of the particle from $t = 1$ seconds to $t = 4$ seconds.

**b** Find the **instantaneous acceleration** of the particle at $t = 3$ seconds. Explain the meaning of your answer.

**c** Find the speed of the particle at $t = 3$ seconds and determine whether the particle is speeding up or slowing down when $t = 3$ seconds.