Position: measure of how far a particle is from a fixed point (usually the origin) and its direction relative to the fixed point.

Distance: measure of how far a particle is away from a fixed point (usually the origin) and does not indicate direction. Distance is the magnitude of position and is always positive.

Displacement: the change in position. The displacement of an object may be positive, negative or zero depending on its motion.

- The velocity of a particle \( v = \frac{ds}{dt} \), is the measure of how fast an object is moving and its direction of motion relative to a fixed point.

- The speed of a particle is measure of how fast an object is moving and does not indicate direction.

- The acceleration, \( a = \frac{dv}{dt} = \frac{d^2s}{dt^2} \), of a particle is a measure of how fast its velocity is changing.

**Example:** The position of a particle is given by the function \( s(t) = -t^2 + 6t \). Where \( s \) is cm and \( t \) is seconds.

a) find the particle's position at times: \( t = 0, 1, 3 \) and 6

**Solution**

When \( t = 0 \), \( s(0) = -(0)^2 + 6(0) = 0 \)

When \( t = 1 \), \( s(1) = -(1)^2 + 6(1) = -1 + 6 = 5 \)

When \( t = 3 \), \( s(3) = -(3)^2 + 6(3) = -9 + 18 = 9 \)

When \( t = 6 \), \( s(6) = -(6)^2 + 6(6) = -36 + 36 = 0 \)
Graph 
\[ s(t) = -t^2 + 6t \]
\[ s(t) = t(-t + 6) \]
\[ x\text{-intercepts} \Rightarrow y = 0 \]
\[ 0 = t(-t + 6) \]
\[ t = 0 \quad \text{or} \quad t = 6 \]

\[ S \]

\[ k \]

Determine the particle's displacement for the following intervals: \( 0 \leq t \leq 1 \), \( 1 \leq t \leq 3 \)
\( 3 \leq t \leq 6 \) and \( 0 \leq t \leq 6 \)

Solution

displacement \( 0 \leq t \leq 1 \): \( S(1) - S(0) \)
\[ 5 - 0 = 5 \text{ cm} \]

\( 1 \leq t \leq 3 \): \( S(3) - S(1) \)
\[ 9 - 5 = 4 \text{ cm} \]

\( 3 \leq t \leq 6 \): \( S(6) - S(3) \)
\[ 0 - 9 = -9 \text{ cm} \]
\[ 0 \leq t \leq 6 : \quad s(6) - s(0) \]
\[ 0 - 0 = 0 \text{ cm} \]

Determine total distance travelled

- distance is an absolute value

\[ 0 \leq t \leq 1 : \quad |s(1) - s(0)| = |5| = 5 \]
\[ 1 \leq t \leq 3 : \quad |s(3) - s(1)| = |4| = 4 \]
\[ 3 \leq t \leq 6 : \quad |s(6) - s(3)| = |-9| = 9 \]

Total distance is 18 cm

Key point: We need to know when our derivative equals zero, because that indicates a change of direction.

* Total distance travelled from \( t_1 \) to \( t_2 \):

\[ \text{distance} = \int_{t_1}^{t_2} |v(t)| \, dt \]

Position function \( \rightarrow \) Velocity function \( \rightarrow \) Acceleration function

Use the distance formula to determine the total distance travelled of our particle.
in the example above.