Section 1: Using calculus

Section test

1. The displacement s m of a particle after t seconds is given by $s = t^3 - 3t^2 + 6$. Find the velocity after 5 seconds.

2. The displacement s m of a particle after t seconds is given by $s = t^4 - 4t$. At what time is the particle is stationary?

3. The displacement s m of a particle after t seconds is given by $s = 3t^3 - 5t^2 + 7$. Find the acceleration of the particle after 1 second.

4. The velocity v ms^{-1} of a particle after t seconds is given by $v = (3t - 2)(t - 4)$. Find the acceleration when $t = 3$.

5. The acceleration a ms^{-2} after t seconds of a particle, initially at rest, is given by $a = t^3 - 2t$. What is its velocity after 2 seconds?

6. The velocity v ms^{-1} of a particle is given by $v = t - 3t^2$. The initial displacement of the particle from the origin is 3 m. Find its displacement from the origin after 5 seconds.

7. The acceleration a ms^{-2} of a particle after t seconds is given by $a = t$. The particle is initially at the origin at rest. After how long is its displacement 4.5 m?

8. The velocity v ms^{-1} of a particle after t seconds is given by $v = 2t - t^3$. The particle starts from rest. What is its maximum displacement?

9. The acceleration a ms^{-2} of a particle after t seconds is given by $a = 4t^3 - 8$. If it starts from rest, after how long is it next stationary?

10. During braking the speed of a car is modelled by $v = 75 - 3t^2$ until it stops moving. From when braking begins, what is the distance that the car travels before it stops?

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Solutions to section test

1. $s = t^3 - 3t^2 + 6$

$v = \frac{ds}{dt} = 3t^2 - 6t$

When $t = 5$, $v = 3 \times (5)^2 - 6 \times 5 = 45$

The velocity after 5 seconds is 45 ms^{-1}.

2. $s = t^4 - 4t$

$v = \frac{ds}{dt} = 4t^3 - 4$

When $v = 0$, $4t^3 - 4 = 0$

$t^3 = 1$

$t = 1$

The particle is stationary after 1 second.

3. $s = 3t^3 - 5t^2 + 7$

$v = \frac{ds}{dt} = 9t^2 - 10t$

$a = \frac{dv}{dt} = 18t - 10$

When $t = 1$, $a = 18 \times 1 - 10 = 8$

The acceleration after 1 second is 8 ms^{-2}.

4. $v = (3t - 2)(t - 4)$

$= 3t^2 - 14t + 8$

$a = \frac{dv}{dt} = 6t - 14$

When $t = 3$, $a = 6 \times 3 - 14 = 4$

The acceleration when $t = 3$ is 4 ms^{-2}.

5. $a = t^3 - 2t$

$v = \int a\,dt = \frac{1}{4}t^4 - t^2 + c$

When $t = 0$, $v = 0 \Rightarrow c = 0$

$v = \frac{1}{4}t^4 - t^2$

When $t = 2$, $v = \frac{1}{4} \times 2^4 - 2^2 = 0$

After 2 seconds the velocity is 0 ms^{-1}.

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6. $v = t - 3t^2$

$s = \int v\,dt = \frac{1}{2}t^2 - t^3 + c$

When $t = 0$, $s = 3 \Rightarrow c = 3$

$s = \frac{1}{2}t^2 - t^3 + 3$

When $t = 5$, $s = \frac{1}{2} \times 5^2 - 5^3 + 3 = -109.5$

Its displacement from the origin after 5 seconds is -109.5 m.

7. $a = t$

$v = \int a\,dt = \frac{1}{2}t^2 + c$

When $t = 0$, $v = 0 \Rightarrow c = 0$

$v = \frac{1}{2}t^2$

$s = \int v\,dt = \frac{1}{6}t^3 + k$

When $t = 0$, $s = 0 \Rightarrow k = 0$

$s = \frac{1}{6}t^3$

When $s = 4.5$, $4.5 = \frac{1}{6}t^3$

$27 = t^3$

$t = 3$

Its displacement is 4.5 m after 3 seconds.

8. $v = 2t - t^3$

The maximum displacement occurs when $v = 0$: $t\left(2 - t^2\right) = 0$

$t = 0$ or $t = \sqrt{2}$

$s = \int v\,dt = t^2 - \frac{1}{4}t^4 + c$

When $t = 0$, $s = 0 \Rightarrow c = 0$

$s = t^2 - \frac{1}{4}t^4$

When $t = \sqrt{2}$, $s = 2 - \frac{1}{4} \times 2^2 = 1$

The maximum displacement is 1 m.

9. $a = 4t^3 - 8$

$v = \int a\,dt = t^4 - 8t + c$

When $t = 0$, $v = 0 \Rightarrow c = 0$

$v = t^4 - 8t$

When it is stationary, $t^4 - 8t = 0$

$t\left(t^3 - 8\right)$

$t = 0$ or $t = 2$

It is next stationary after 2 seconds.

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10. $v = 75 - 3t^2$

When the car stops, $75 - 3t^2 = 0$

$$t^2 = 25$$

$$t = 5$$

$s = \int v\,dt = 75t - t^3 + c$

When $t = 0$, $s = 0 \Rightarrow c = 0$

$s = 75t - t^3$

When $t = 5$, $s = 75 \times 5 - 5^3 = 250$

It travels 250 m before stopping.