# 16 Kinematics

**1** In each of the following cases:

**(i)** find expressions for the velocity and acceleration at time $t$

**(ii)** find the initial position, velocity and acceleration

**(iii)** find the time and position when the velocity is zero.

**a)** $s = 3t^2 - t - 4$

**(i)**

**(ii)**

**(iii)**

**b)** $s = 4t - t^3$

**(i)**

**(ii)**

**(iii)**

**c)** $s = 5t^4 - 2t^2 + 3$

**(i)**

**(ii)**

**(iii)**

**2** A particle is projected in a straight line from a point O. After $t$ seconds its displacement, $s$ metres, from O is given by $s = 3t - t^3$.

**a)** Find expressions for the velocity and acceleration at time $t$.

**b)** Find the time when the particle is instantaneously at rest.

**c)** Find the velocity when $t = 2$ and interpret your result.

**d)** Find the initial acceleration.

**3** A ball is thrown vertically upwards and its height, $h$ metres, above the ground after $t$ seconds is given by $h = 2 + 10t - 5t^2$.

**a)** From what height is the ball projected?

**b)** When is the ball instantaneously at rest?

**c)** What is the greatest height reached by the ball?

**d)** After what length of time does the ball reach the ground?

**e)** At what speed is the ball travelling when it reaches the ground?

**4** A hot air balloon is rising at a rate of $0.6\,\text{m}\,\text{s}^{-1}$ and is at a height of 28 m when it starts to experience a downward acceleration of $0.2\,\text{m}\,\text{s}^{-1}$.

**a)** Find the height reached by the balloon before it starts to descend.

**b)** How long does the balloon take to return to the ground?

**c)** At what speed is the balloon travelling when it reaches the ground?

**5** The height of a ball thrown up in the air is given by $h = 10t - 5t^2 + 2$, where $h$ is the height above ground level.

**a)** Find an expression for the velocity of the ball.

**b)** Find the maximum height reached by the ball and the time when this occurs.

**c)** Find the acceleration of the ball.

**d)** Find the time taken for the ball to reach the ground.

**6** Find expressions for the velocity, $v$, and displacement, $s$, at time $t$ in each of the following:

**a)** $a = 2 + 4t$; when $t = 0$, $v = 3$ and $s = 0$.

**b)** $a = 6t^2 - 2t$; when $t = 0$, $v = 6$ and $s = 2$.

**c)** $a = 4$; when $t = 0$, $v = 2$ and $s = 3$.

**7** The acceleration of a particle $a\,\text{m}\,\text{s}^{-2}$, at time $t$ seconds is given by $a = 5 - 4t$. When $t = 0$ the particle is moving at $3\,\text{m}\,\text{s}^{-1}$ in the positive direction, and is 2 m from the point O.

**a)** Find expressions for the velocity and displacement in terms of $t$.

**b)** Find when the particle is instantaneously at rest and its displacement from O at that time.