Marked example 1

Paper 1 style · No calculator

1 15 marks SL 5.9

●●○ Typical to demanding

A particle moves along a straight line. Its displacement from a fixed point O, s metres, at time t seconds is given by

$$s(t) = t^3 - 9t^2 + 24t, \qquad t \geq 0.$$

(a) Find an expression for the velocity v of the particle at time t. **[2]**

(b) Find the values of t for which the particle is at rest. **[2]**

(c) Find the interval of time during which the particle is moving in the negative direction. **[2]**

(d) Find an expression for the acceleration a of the particle, and the value of t for which $a = 0$. **[2]**

(e) Find the intervals of time during which the particle is speeding up. **[4]**

(f) Find the maximum speed of the particle for $0 \leq t \leq 5$. **[3]**

MARKSCHEME (a)

$v = \dfrac{\mathrm{d}s}{\mathrm{d}t} = 3t^2 - 18t + 24$ **(M1)A1**

Total 2 marks

MARKSCHEME (b)

$3(t-2)(t-4) = 0$ **(M1)**

$t = 2,\ t = 4$ **A1**

Total 2 marks

MARKSCHEME (c)

$v < 0$ **(M1)**

$2 < t < 4$ **A1**

Total 2 marks

Note Accept $2 \leq t \leq 4$.

MARKSCHEME (d)

$a = 6t - 18$ **A1**

$t = 3$ **A1**

Total 2 marks

MARKSCHEME (e)

speeding up when v and a have the same sign **R1**

$v < 0$ and $a < 0$: $2 < t < 3$ **A1**

$v > 0$ and $a > 0$: $t > 4$ **A1**

both intervals given, and no others **A1**

Total 4 marks

Note Accept non-strict inequalities at 2, 3 and 4. A candidate who answers "$a > 0$, so $t > 3$" has confused speeding up with positive acceleration: award R0A0A1A0 at most.

MARKSCHEME (f)

considering speed $|v|$ at the endpoints and at the turning point of v: $v(0) = 24$, $v(3) = -3$, $v(5) = 9$ **M1A1**

maximum speed $= 24\ \text{m s}^{-1}$ (at $t = 0$) **A1**

Total 3 marks

Note An answer of $3\ \text{m s}^{-1}$ (from $v(3) = -3$ only) or of $9\ \text{m s}^{-1}$ earns M1A0A0 at most.

Written and verified by a practising IB mathematics teacher, produced with AI assistance; solved twice and recomputed by software.
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