# Marked example 3

Paper 2 style · Graphic display calculator

## 3 13 marks SL 5.9 ●●○ Typical to demanding

Two drones, $A$ and $B$, fly along the same straight horizontal line. Their displacements, in metres, from a fixed point $O$ on the line, $t$ seconds after a test begins, are

$$s_A(t) = 30 + 8t - 0.6t^2 \qquad \text{and} \qquad s_B(t) = 40\left(1 - \mathrm{e}^{-0.2t}\right), \qquad 0 \le t \le 10.$$

**(a)** Find expressions for the velocities $v_A(t)$ and $v_B(t)$. **[3]**

**(b)** Show that the two drones have the same velocity when $t = 0$. **[1]**

**(c)** Find the other value of $t$ at which the two drones have the same velocity. **[2]**

**(d)** Determine which drone has the greater speed when $t = 5$. **[2]**

**(e)** Find the time at which drone $A$ is momentarily at rest, and its displacement from $O$ at that time. **[2]**

Throughout the test, $s_A(t) > s_B(t)$.

**(f)** Find the maximum distance between the two drones, and explain why it occurs at the time found in part (c). **[3]**

**MARKSCHEME (a)**

$v_A(t) = 8 - 1.2t$ **A1**

$v_B(t) = 40 \times 0.2\,\mathrm{e}^{-0.2t} = 8\,\mathrm{e}^{-0.2t}$ **(M1)A1**

Total 3 marks

**MARKSCHEME (b)**

$v_A(0) = 8$ and $v_B(0) = 8\mathrm{e}^0 = 8$ **A1 AG**

Total 1 mark

**MARKSCHEME (c)**

$8 - 1.2t = 8\,\mathrm{e}^{-0.2t}$ **(M1)**

$t = 3.03 \;\; (3.02930\ldots)$ **A1**

Total 2 marks

**MARKSCHEME (d)**

$v_A(5) = 2,\; v_B(5) = 2.94 \;\; (8\mathrm{e}^{-1} = 2.94304\ldots)$ **A1**

drone $B$ **A1**

Total 2 marks

**Note** Do not award A0A1: the comparison must be supported by both values.

**MARKSCHEME (e)**

$v_A(t) = 0 \Rightarrow t = \dfrac{20}{3} = 6.67\ \mathrm{s}$ **A1**

$s_A\left(\dfrac{20}{3}\right) = 56.7\ \mathrm{m} \;\; (56.6666\ldots)$ **A1**

Total 2 marks

**MARKSCHEME (f)**

distance $d(t) = s_A(t) - s_B(t)$; maximum on the GDC, or $d'(t) = 0$ **(M1)**

maximum distance 30.6 m $(30.5525\ldots)$, at $t = 3.03$ **A1**

$d'(t) = v_A(t) - v_B(t)$ is zero when the velocities are equal, and changes from positive to negative at $t = 3.03$ (the other zero, $t = 0$, is a minimum of $d$; the endpoint values $d(0) = 30$ and $d(10) = 15.4$ are smaller) **R1**

**Total 3 marks**

**Note** "Because the velocities are equal" alone earns R0: equal velocities also occur at $t = 0$, where the distance is a minimum. A candidate who gives 30 (the initial distance) earns (M1)A0R0.

**ON THE CALCULATOR**

**NumWorks** Functions: $f(x) = 8 - 1.2x$, $g(x) = 8e^{-0.2x}$; Axes: $x$ from 1 to 10 (to skip $t = 0$); (c) Graph → Calculate → Find → Intersection → 3.029298. (f) $h(x) = 30 + 8x - 0.6x^2 - 40(1 - e^{-0.2x})$; Find → Maximum on $h$ → $x = 3.029298$, $h(x) = 30.55255$.

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