IB MATHS AA HL · UNIT 5

Kinematics: exam practice

10 questions · 44 marks · worked solutions and markschemes

Name _____ Date _____ Score / 44

- Answer every question before you look at the solutions. They start after the last question, with the marks for each line: M for method, A for accuracy, R for reasoning.
- Online, with more practice: ibmathrevision.com/hlaa/kinematics-exam-practice

1. **3 marks · Paper 1 style · no calculator**

A particle moves with velocity $v(t) = 4\cos 2t$, starting at the origin.

Find the displacement $s(t)$ and the maximum displacement. **[3]**

2. **4 marks · Paper 1 style · no calculator**

A stone is thrown upwards with height $h(t) = 20t - 5t^2$ m.

Find the maximum height and the speed with which it returns to its starting height. **[4]**

3. **4 marks · Paper 2 style · calculator**

A particle has velocity $v(t) = t^2 - 5t + 4$ m s^{-1} for $0 \le t \le 5$.

Find the total distance travelled. **[4]**

4. **4 marks · Paper 1 style · no calculator**

The displacement of a particle is $s(t) = te^{-t}$ for $t \geq 0$.

Find the time when the velocity is zero and the acceleration at that time. **[4]**

5. **4 marks · Paper 2 style · calculator**

A cyclist's velocity is $v(t) = 8\sin\left(\frac{\pi t}{10}\right)$ m s^{-1} for $0 \leq t \leq 10$.

Find the distance travelled and the maximum acceleration. **[4]**

6. **4 marks · Paper 1 style · no calculator**

A particle starts from rest and its acceleration is $a = \frac{6}{(t+1)^2}$ m s^{-2}.

Find $v(t)$ and the limiting velocity as $t \to \infty$. **[4]**

7. 4 marks · Paper 2 style · calculator

A car accelerates from rest with $a(t) = 6 - 0.6t$ m s^{-2} for $0 \leq t \leq 10$.

(a) Find the velocity at $t = 10$. **[2]**

(b) Find the distance travelled in the 10 seconds. **[2]**

8. 5 marks · Paper 1 style · no calculator

A particle moves in a straight line with displacement $s(t) = t^3 - 9t^2 + 24t$ m, for $t \geq 0$ seconds.

(a) Find the times when the particle is at rest. **[3]**

(b) Find the acceleration when $t = 5$. **[2]**

9. 5 marks · Paper 2 style · calculator

A particle has velocity $v(t) = e^{0.5t} - 3$ m s^{-1} for $0 \leq t \leq 4$.

(a) Find the time when the particle changes direction. **[2]**

(b) Find the total distance travelled. **[3]**

10. **7 marks · Paper 2 style · calculator**

A particle has acceleration $a = 2t - 4$ m s^{-2}. When $t = 0$, $v = 3$ m s^{-1} and $s = 0$.

(a) Find $v(t)$ and $s(t)$. **[4]**

(b) Find the distance travelled in the first 3 seconds. **[3]**

Answers and worked solutions

Question 1

3 marks

Answer: $s(t) = 2\sin 2t$; maximum 2

$s = 2\sin 2t + c$ A1

$c = 0$ A1

maximum 2 A1

Question 2

4 marks

Answer: $20\,m$; $20\,\mathrm{m\,s^{-1}}$

$v = 20 - 10t = 0$, $t = 2$ M1

$h = 20\,m$ A1

returns at $t = 4$ A1

speed $20\,\mathrm{m\,s^{-1}}$ A1

Question 3

4 marks

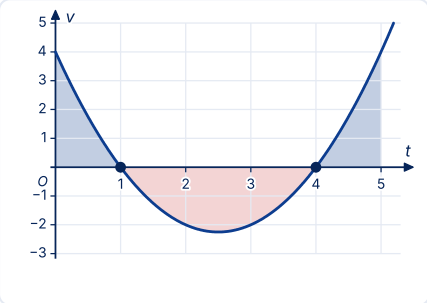
Answer: $\frac{49}{6}\,m$

$v = 0$ at $t = 1, 4$ A1

$\int_0^5 |v|\,dt$ M1

$\frac{11}{6} + \frac{9}{2} + \frac{11}{6}$ A1

$\frac{49}{6}\,m$ A1



Distance = sum of the areas, all counted positive

Question 4

4 marks

Answer: $t = 1$; $a = -e^{-1}$

$v = (1-t)e^{-t}$ A1

$t = 1$ A1

$a = (t-2)e^{-t}$ A1

$a(1) = -e^{-1}$ A1

Question 5

4 marks

Answer: $\frac{160}{\pi}\,m$; $\frac{4\pi}{5}\,\mathrm{m\,s^{-2}}$

$\int_0^{10} 8\sin\frac{\pi t}{10}\,dt = \frac{160}{\pi}$ M1A1

$a = \frac{4\pi}{5}\cos\frac{\pi t}{10}$ A1

maximum $\frac{4\pi}{5}$ A1

Question 6

4 marks

Answer: $v = 6 - \frac{6}{t+1}$; $6\,\mathrm{m\,s^{-1}}$

$v = -\frac{6}{t+1} + c$ A1

$c = 6$ A1

$v = 6 - \frac{6}{t+1}$ A1

limit $6\,\mathrm{m\,s^{-1}}$ A1

Question 7

4 marks

Answer: (a) $30\,\mathrm{m\,s^{-1}}$; (b) $200\,m$

(a)

$v = 6t - 0.3t^2$ A1

$30\,\mathrm{m\,s^{-1}}$ A1

(b)

$\int_0^{10} (6t - 0.3t^2)\,dt$ M1

$200\,m$ A1

Question 8

5 marks

Answer: (a) $t = 2\,s$ and $t = 4\,s$; (b) $12\,\mathrm{m\,s^{-2}}$

(a)

$v = 3t^2 - 18t + 24$ A1

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

$t = 2$, $t = 4$ A1

(b)

$a = 6t - 18$ A1

$12\,\mathrm{m\,s^{-2}}$ A1

Question 9

5 marks

Answer: (a) $t = 2.20\,s$; (b) $5.96\,m$

(a)

$e^{0.5t} = 3$ M1

$t = 2\ln 3 = 2.20\,s$ A1

(b)

$\int_0^4 |v|\,dt$ M1

GDC (M1)

$5.96\,m$ A1

Question 10

7 marks

Answer: (a) $v = t^2 - 4t + 3$, $s = \frac{t^3}{3} - 2t^2 + 3t$; (b) $\frac{8}{3}\,m$

(a)

$v = t^2 - 4t + 3$ A1A1

$s = \frac{t^3}{3} - 2t^2 + 3t$ A1A1

(b)

$v = 0$ at $t = 1, 3$ A1

$s(1) = \frac{4}{3}$, $s(3) = 0$ A1

$\frac{4}{3} + \frac{4}{3} = \frac{8}{3}\,m$ A1

Every solution is also on ibmathrevision.com/hlaa/kinematics-exam-practice

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