3.5 Mechanics: Kinematics Depth: 1-hour Pack

EDEXCEL 9MA0 · Calculator allowed · about 60 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 A particle moves in a straight line with initial speed 4 m/s and constant acceleration 1.5 m/s^2. Find the distance it travels in the first 6 seconds.

(Total for Question 1 is 2 marks)

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2 A ball is thrown vertically upwards from ground level with speed 24.5 m/s. Using g = 9.8 m/s^2, find the greatest height reached, giving your answer to 3 significant figures.

(Total for Question 2 is 2 marks)

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3 A particle P moves along the x-axis with acceleration a = 6t - 4 m/s^2 at time t seconds. Given that P has velocity 3 m/s when t = 0, find an expression for the velocity of P at time t.

(Total for Question 3 is 2 marks)

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4 A particle P moves along the x-axis. At time t seconds, the velocity of P is v = t^2 - 4t m/s. Find the acceleration of P when t = 5 seconds.

(Total for Question 4 is 2 marks)

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5 A stone is thrown vertically upwards from a point 5 m above the ground with speed 16 m/s. Using g = 9.8 m/s^2, find the time taken for the stone to hit the ground, giving your answer to 3 significant figures.

(Total for Question 5 is 3 marks)

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6 A train travels along a straight section of track between station P and station Q. It starts from rest at P and accelerates uniformly to a speed of 30 m/s in 40 seconds. It then travels at this constant speed for 90 seconds, before decelerating uniformly to rest at Q, coming to rest 25 seconds after the deceleration begins. Model the train as a particle.

(a) Find the total distance from P to Q. **(4)**

(b) Find the average speed for the whole journey from P to Q, giving your answer to 3 significant figures. **(2)**

(Total for Question 6 is 6 marks)

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7 A particle Q moves in a straight line. At time t seconds, the acceleration of Q is a m/s^2, where a = 4 - 6t. When t = 0, the velocity of Q is 3 m/s and the displacement of Q from a fixed point O is 0.

(a) Show that the velocity of Q at time t seconds is given by $v = 3 + 4t - 3t^2$. **(3)**

(b) Find the displacement of Q from O when t = 2 seconds. **(3)**

(c) Find the value of t, other than t = 0, at which Q returns to O. **(2)**

(Total for Question 7 is 8 marks)

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8 A particle P moves along the x-axis. At time t seconds ($t \geq 0$), the acceleration of P is a m/s^2, where a = 6t - 18. When t = 0, P is at the origin O and moving with velocity 15 m/s in the positive x-direction.

(a) Show that the velocity of P at time t seconds is given by $v = 3t^2 - 18t + 15$. **(3)**

(b) Find the values of t at which P is instantaneously at rest. **(2)**

(c) Find an expression for the displacement, x metres, of P from O at time t seconds. **(3)**

(d) Find the total distance travelled by P in the interval $0 \leq t \leq 5$. **(5)**

(Total for Question 8 is 13 marks)

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9 A cyclist moves along a straight horizontal track. It starts from rest and accelerates uniformly to a speed of V m/s in 7 s. It then moves at constant speed V for 18 s, and then decelerates uniformly to rest in 8 s. The total distance travelled is 229.5 m.

(a) Sketch the speed-time graph and find the total time for the journey. **(2)**

(b) Use the area of the graph to show that V satisfies the equation (1/2)V(51) = 229.5, and hence find V. **(3)**

(c) Find the acceleration in the first stage and the deceleration in the final stage. **(3)**

(d) Find the average speed for the whole journey, to 3 significant figures. **(2)**

(Total for Question 9 is 10 marks)

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Mark scheme · 3.5 Mechanics: Kinematics Depth: 1-hour Pack

Question 1

$s = ut + 1/2\ a\ t^2$ with u=4, a=1.5, t=6	**M1**
51 m cao	**A1**

Answer: 51 m

Question 2

use $v^2 = u^2 - 2gs$ with v=0, u=24.5	**M1**
awrt 30.6 m	**A1**

Answer: 30.6 m (3 s.f.)

Question 3

integrate a with respect to t, then use v(0)=3 to find the constant	**M1**
$v = 3t^2 - 4t + 3$ cao	**A1**

Answer: $v = 3t^2 - 4t + 3$

Question 4

differentiate: a = 2t - 4, substitute t=5	**M1**
6 m/s^2 cao	**A1**

Answer: 6 m/s^2

Question 5

use $s = ut - 1/2\ g\ t^2$ with s=-5 (taking upward as positive, ground 5 m below the start): $-5 = 16t - 4.9t^2$	**M1**
form $4.9t^2 - 16t - 5 = 0$ and apply the quadratic formula, rejecting the negative root	**M1**
awrt 3.55 s	**A1**

Answer: 3.55 s (3 s.f.)

Question 6

(a) finds the distance in the acceleration phase: 0.5(0+30)(40) = 600 (m)	**M1**
(a) finds the distance in the constant-speed phase: 30 * 90 = 2700 (m)	**B1**
(a) finds the distance in the deceleration phase: 0.5(30+0)(25) = 375 (m)	**M1**
(a) total distance = 3675 (m) cao	**A1**

(a) Answer: 3675 m

(b) uses total time = 40 + 90 + 25 = 155 (s), with their total distance	**M1**
(b) average speed = awrt 23.7 (m/s) cao	**A1**

(b) Answer: 23.7 m/s (3sf)

Question 7

(a) integrates a with respect to t: $v = 4t - 3t^2 + c$	**M1**
(a) uses t = 0, v = 3 to find c = 3	**B1**
(a) $v = 3 + 4t - 3t^2$ cso	**A1**

(a) Answer: $v = 3 + 4t - 3t^2$ (shown)

(b) integrates their v with respect to t: $s = 3t + 2t^2 - t^3 + c$, using s = 0 at t = 0 to give c = 0	**M1**
(b) substitutes t = 2 into their expression for s	**M1**
(b) s = 6 (m) cao	**A1**

(b) Answer: 6 m

(c) sets s = 0 and factorises out t: $t(3 + 2t - t^2) = 0$, then solves the quadratic factor	**M1**
(c) t = 3 (s), rejecting t = -1 since $t \geq 0$	**A1**

(c) Answer: t = 3 s

Question 8

(a) integrates a with respect to t: $v = 3t^2 - 18t + c$	**M1**
(a) uses t = 0, v = 15 to find c = 15	**B1**
(a) $v = 3t^2 - 18t + 15$ cso	**A1**

(a) Answer: $v = 3t^2 - 18t + 15$ (shown)

(b) factorises $v = 3(t-1)(t-5)$	**M1**
(b) t = 1 and t = 5 cao	**A1**

(b) Answer: t = 1 s and t = 5 s

(c) integrates v with respect to t: $x = t^3 - 9t^2 + 15t + c$	**M1**
(c) uses x = 0 at t = 0 to find c = 0	**A1**
(c) $x = t^3 - 9t^2 + 15t$ cao	**A1**

(c) Answer: $x = t^3 - 9t^2 + 15t$

(d) evaluates x at t = 0, t = 1 and t = 5, using their expression for x	**M1**
(d) x(1) = 7 (m)	**A1**
(d) x(5) = -25 (m)	**A1**
(d) recognises P changes direction at t = 1 (dependent on rest values from part (b)) and combines $\|x(1)-x(0)\| + \|x(5)-x(1)\|$	**dM1**
(d) total distance = 39 (m) cao	**A1**

(d) Answer: 39 m

Question 9

(a) a trapezium: straight line rising from the origin to (7, V), horizontal until t = 25, then straight line falling to zero	**B1**
(a) total time = 7 + 18 + 8 = 33 s	**B1**

(a) Answer: 33 s

(b) area of trapezium = (1/2)(parallel sides)(height) = (1/2)(33 + 18)V	**M1**
(b) (1/2)(51)V = 229.5	**A1**
(b) V = 9	**A1**

(b) Answer: V = 9

(c) a = (v - u)/t for each stage	**M1**
(c) acceleration = 9/7 m/s^2	**A1**
(c) deceleration = 9/8 m/s^2	**A1**

(c) Answer: 9/7 m/s^2 and 9/8 m/s^2

(d) total distance / total time	**M1**
(d) 6.95 m/s	**A1**

(d) Answer: 6.95 m/s

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