3.5 Mechanics: Kinematics Depth: Test Pack

EDEXCEL 9MA0 · Calculator allowed · about 65 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 A particle moves in a straight line with initial speed 5 m/s and constant acceleration 3 m/s^2. Find its speed after 4 seconds.

(Total for Question 1 is 1 mark)

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2 A particle decelerates from 20 m/s to rest in a straight line, taking 8 seconds, with constant deceleration. State the magnitude of the deceleration.

(Total for Question 2 is 1 mark)

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3 Two cars, A and B, pass the same road sign at the same instant, travelling in the same direction along a straight road. Car A passes the sign with speed 15 m/s and travels at this constant speed. Car B passes the sign from rest with constant acceleration 3 m/s^2. Let t seconds be the time after the cars pass the sign. Find the value of t (other than t = 0) at which car B catches up with car A, and find the speed of car B at this instant.

(Total for Question 3 is 4 marks)

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4 A parcel trolley moves in a straight line across a warehouse floor. It passes point A with speed 3 m/s and constant acceleration 0.7 m/s^2. It passes point B, 9 m from A in the direction of motion, T seconds after passing A. Model the trolley as a particle.

(a) Show that $7T^2 + 60T - 180 = 0$. **(2)**

(b) Hence find the value of T, giving your answer to 3 significant figures. **(3)**

(Total for Question 4 is 5 marks)

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5 A stone is projected horizontally with speed 15 m/s from the top of a vertical cliff of height 45 m above the sea. The stone lands in the sea at point L. Model the stone as a particle moving freely under gravity, and use $g = 9.8$ m/s^2.

(a) Find the time taken for the stone to reach the sea, giving your answer to 3 significant figures. **(3)**

(b) Find the horizontal distance from the base of the cliff to L, giving your answer to 3 significant figures. **(2)**

(c) Find the speed of the stone as it hits the sea, giving your answer to 3 significant figures. **(4)**

(Total for Question 5 is 9 marks)

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6 A ball is projected from a point O on horizontal ground with speed U m/s at an angle θ above the horizontal, where $\tan(\theta) = 3/4$. The ball moves freely under gravity and lands on the ground at the same level as O. Take $U = 21$ and use $g = 9.8$ m/s^2.

(a) Show that the horizontal and vertical components of the initial velocity of the ball are 16.8 m/s and 12.6 m/s respectively. **(2)**

(b) Find the greatest height above the ground reached by the ball. **(2)**

(c) Show that the time of flight of the ball is 18/7 seconds. **(3)**

(d) Hence show that the horizontal range of the ball is 43.2 m. **(3)**

(Total for Question 6 is 10 marks)

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7 A lift moves along a straight horizontal track. It starts from rest and accelerates uniformly to a speed of V m/s in 5 s. It then moves at constant speed V for 34 s, and then decelerates uniformly to rest in 7 s. The total distance travelled is 440 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 $(1/2)V(80) = 440$, 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 7 is 10 marks)

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8 A particle P moves along the x-axis. At time t seconds, the velocity of P is v m/s, where $v = 6\sin(2t)$, for $0 \leq t \leq \pi$. When $t = 0$, P is at the origin O.

(a) Find an expression for the acceleration, a m/s^2, of P at time t seconds. **(2)**

(b) Find the values of t, for $0 \leq t \leq \pi$, at which P is instantaneously at rest. **(3)**

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

(d) Find the greatest distance of P from O in the interval $0 \leq t \leq \pi$, justifying that this value is a maximum. **(3)**

(Total for Question 8 is 11 marks)

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Mark scheme · 3.5 Mechanics: Kinematics Depth: Test Pack

Question 1

17 cao **B1**

Answer: 17 m/s

Question 2

2.5 cao **B1**

Answer: 2.5 m/s^2

Question 3

write distances travelled: A is 15t, B is 1.5t^2 (using s = 1/2 a t^2 with u=0, a=3) **M1**

set 1.5t^2 = 15t and solve, rejecting t=0 **M1**

t = 10 s cao **A1**

speed of B = 3 x 10 = 30 m/s cao **A1**

Answer: t = 10 s; speed of B = 30 m/s

Question 4

(a) substitutes into s = ut + 0.5at^2 with s = 9, u = 3, a = 0.7: 9 = 3T + 0.35T^2 **M1**

(a) multiplies through by 20 and rearranges to 7T^2 + 60T - 180 = 0 cso **A1**

(a) Answer: 7T^2 + 60T - 180 = 0 (shown)

(b) uses the quadratic formula on 7T^2 + 60T - 180 = 0 **M1**

(b) T = awrt 2.35 (s) **A1**

(b) rejects the negative root since T must be positive (time) **B1**

(b) Answer: T = 2.35 s (3sf)

Question 5

(a) uses s = ut + 0.5at^2 vertically with u = 0, a = 9.8, s = 45 **M1**

(a) t^2 = 45/4.9 = awrt 9.18 **A1**

(a) t = awrt 3.03 (s) cao **A1**

(a) Answer: t = 3.03 s (3sf)

(b) horizontal distance = 15 * their t **M1**

(b) awrt 45.5 (m) cao **A1**

(b) Answer: 45.5 m (3sf)

(c) finds the vertical component of velocity at impact: $v_y = gt$ **M1**

(c) v_y = awrt 29.7 (m/s) **A1**

(c) combines horizontal and vertical components using Pythagoras: speed = $\sqrt{15^2 + v_y^2}$ **M1**

(c) speed = awrt 33.3 (m/s) cao **A1**

(c) Answer: 33.3 m/s (3sf)

Question 6

(a) uses tan(θ) = 3/4 to identify sin(θ) = 3/5 and cos(θ) = 4/5 (3-4-5 triangle), and finds horizontal component 21 * 4/5 = 16.8 cso **B1**

(a) finds vertical component 21 * 3/5 = 12.6 cso **B1**

(a) Answer: 16.8 m/s and 12.6 m/s (shown)

(b) uses v^2 = u^2 - 2gh vertically with v = 0, u = 12.6 **M1**

(b) h = 8.1 (m) cao **A1**

(b) Answer: 8.1 m

(c) sets vertical displacement to zero: 0 = 12.6t - 4.9t^2, factorises to t(12.6 - 4.9t) = 0 **M1**

(c) rejects t = 0 and solves 4.9t = 12.6 **A1**

(c) t = 18/7 (s) (oe, awrt 2.57 s) cso **A1**

(c) Answer: T = 18/7 s (= 2.57 s to 3sf)

(d) uses range = horizontal component of velocity * time of flight **M1**

(d) R = 16.8 * 18/7 **A1**

(d) R = 43.2 (m) cso **A1**

(d) Answer: 43.2 m (shown)

Question 7

(a) a trapezium: straight line rising from the origin to (5, V), horizontal until t = 39, then straight line falling to zero **B1**

(a) total time = 5 + 34 + 7 = 46 s **B1**

(a) Answer: 46 s

(b) area of trapezium = (1/2)(parallel sides)(height) = (1/2)(46 + 34)V **M1**

(b) (1/2)(80)V = 440 **A1**

(b) V = 11 **A1**

(b) Answer: V = 11

(c) a = (v - u)/t for each stage **M1**

(c) acceleration = 11/5 m/s^2 **A1**

(c) deceleration = 11/7 m/s^2 **A1**

(c) Answer: 11/5 m/s^2 and 11/7 m/s^2

(d) total distance / total time **M1**

(d) 9.57 m/s **A1**

(d) Answer: 9.57 m/s

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Question 8

(a) differentiates v with respect to t, using the chain rule **M1**

(a) a = 12cos(2t) cao **A1**

(a) Answer: a = 12cos(2t)

(b) sets v = 0: 6sin(2t) = 0, so sin(2t) = 0 **M1**

(b) 2t = 0, π, 2pi within the range $0 \leq 2t \leq 2pi$ **A1**

(b) t = 0, π/2, π (all three values, oe exact form) cao **A1**

(b) Answer: t = 0, π/2, π seconds

(c) integrates v with respect to t: x = -3cos(2t) + c **M1**

(c) uses x = 0 at t = 0 to find c = 3 **A1**

(c) x = 3 - 3cos(2t) (oe, e.g. 3(1 - cos(2t))) cao **A1**

(c) Answer: x = 3 - 3cos(2t)

(d) recognises x is greatest when cos(2t) is least, i.e. cos(2t) = -1 **M1**

(d) this occurs at t = π/2 (matches a value found in part (b) where v = 0, confirming a turning point) **A1**

(d) greatest distance = 6 (m) cao **A1**

(d) Answer: 6 m, at t = π/2 s

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