3.4 Mechanics: Projectiles and Further Kinematics: 1-hour Pack

Total Marks

EDEXCEL 9MA0 · Calculator allowed · about 60 minutes

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 A particle is projected from horizontal ground and moves freely under gravity, following a projectile path. State the direction of the particle's velocity at the instant it reaches its greatest height.

(Total for Question 1 is 1 mark)

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2 A ball is thrown horizontally from a height and takes 2 seconds to hit the ground. Using $g = 9.8$ m/s^2, find the vertical component of its velocity at the instant it hits the ground.

(Total for Question 2 is 1 mark)

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3 A particle is projected horizontally with speed 15 m/s from the top of a cliff. It takes 3 seconds to reach the sea. Find the horizontal distance travelled by the particle.

(Total for Question 3 is 2 marks)

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4 A hang glider is launched from a hillside. The horizontal component of the hang glider's initial velocity is 12.4 m/s, at an angle of 37 degrees above the horizontal.

(a) Find the initial speed of the hang glider, giving your answer to 3 significant figures. **(1)**

(b) Find the initial vertical component of the hang glider's velocity, giving your answer to 3 significant figures. **(1)**

(Total for Question 4 is 2 marks)

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5 A conker falls from rest from a window ledge 4.9 m above the ground. Using $g = 9.8$ m/s^2 and modelling the conker as a particle, find the speed at which it hits the ground.

(Total for Question 5 is 2 marks)

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6 A paraglider launches horizontally from a hillside and lands 37.4 m (measured horizontally) from the launch point after 3.4 seconds of flight. Find the horizontal component of the paraglider's velocity.

(Total for Question 6 is 2 marks)

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7 A particle moves with velocity $v = 4ti - 3j$ m/s. Find the acceleration vector of the particle.

(Total for Question 7 is 1 mark)

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8 A particle moves in a straight line with velocity $v = 6t^2 - 2$ m/s at time t seconds. Find the acceleration of the particle when $t = 3$ seconds.

(Total for Question 8 is 2 marks)

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9 A particle moves in a straight line with acceleration $a = 4t - 1$ m/s^2 at time t seconds. Given that the particle is at rest when $t = 0$, find an expression for the velocity v m/s at time t.

(Total for Question 9 is 2 marks)

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10 A particle P has velocity $(2i - j)$ m/s at time $t = 0$ and moves with constant acceleration $(1i + 2j)$ m/s^2. Find the velocity of P at time $t = 4$ seconds.

(Total for Question 10 is 2 marks)

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11 A particle P has position vector $(1i - 4j)$ m at time $t = 0$, velocity $(3i + 0j)$ m/s at $t = 0$, and moves with constant acceleration $(0i + 4j)$ m/s^2. Find the position vector of P at time $t = 2$ seconds.

(Total for Question 11 is 2 marks)

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12 A particle is projected from a point O on horizontal ground with speed 21 m/s at an angle of 40 degrees above the horizontal. Using $g = 9.8$ m/s^2, find the greatest height reached by the particle above O, giving your answer to 3 significant figures.

(Total for Question 12 is 3 marks)

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13 A particle is projected from a point O with speed 40 m/s at an angle of 50 degrees above the horizontal. The point O lies on a straight slope which is inclined at 20 degrees to the horizontal and rises in the same vertical plane as the motion of the particle. The particle lands at the point A on the slope. Horizontal and vertical distances from O are denoted x and y respectively (both measured in metres). Use $g = 9.8$ m/s^2.

(a) Write down the equation of the slope in terms of x and y, and the equation of the trajectory of the particle in terms of x and y. **(3)**

(b) Hence find the horizontal distance travelled by the particle before it lands at A, giving your answer to 3 significant figures. **(5)**

(c) Find the distance OA. **(3)**

(d) Find the time of flight from O to A, giving your answer to 3 significant figures. **(3)**

(Total for Question 13 is 14 marks)

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14 A particle is projected from a point O on horizontal ground with speed 28 m/s at an angle of 30 degrees above the horizontal. The particle moves freely under gravity until it returns to the horizontal ground. Use $g = 9.8$ m/s^2.

(a) Find the time taken for the particle to return to the ground. **(3)**

(b) Find the greatest height reached by the particle above the ground. **(3)**

(c) Find the horizontal distance travelled by the particle before it first returns to the ground (the range). **(3)**

(d) Show that, for a particle projected with speed u at angle θ above horizontal ground and landing at the same level, the range is given by $R = u^2 \sin(2\text{theta})/g$. **(4)**

(Total for Question 14 is 13 marks)

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Mark scheme · 3.4 Mechanics: Projectiles and Further Kinematics: 1-hour Pack

Question 1

horizontal (parallel to the ground) oe **B1**

Answer: Horizontal (parallel to the ground)

Question 2

19.6 cao **B1**

Answer: 19.6 m/s

Question 3

horizontal distance = horizontal speed x time **M1**

45 m cao **A1**

Answer: 45 m

Question 4

(a) awrt 15.5 m/s **B1**

(a) Answer: 15.5 m/s (3 s.f.)

(b) awrt 9.34 m/s **B1**

(b) Answer: 9.34 m/s (3 s.f.)

Question 5

use $v^2 = u^2 + 2as$ (or $v^2 = 2gh$) with u=0, s=4.9 **M1**

9.8 m/s cao **A1**

Answer: 9.8 m/s

Question 6

horizontal speed = horizontal distance / time **M1**

11 m/s cao **A1**

Answer: 11 m/s

Question 7

4i cao **B1**

Answer: 4i m/s^2 (i.e. 4i + 0j)

Question 8

differentiate: a = 12t, substitute t=3 **M1**

36 m/s^2 cao **A1**

Answer: 36 m/s^2

Question 9

integrate a with respect to t: $v = 2t^2 - t + C$, use v(0)=0 to find C=0 **M1**

$v = 2t^2 - t$ cao **A1**

Answer: $v = 2t^2 - t$

Question 10

v = u + at applied with t=4 **M1**

(6i + 7j) m/s cao **A1**

Answer: (6i + 7j) m/s

Question 11

$r = r0 + ut + 1/2\ a\ t^2$ applied with t=2 **M1**

(7i + 4j) m cao **A1**

Answer: (7i + 4j) m

Question 12

find initial vertical component: $u_y = 21 \sin 40$ **M1**

use $v^2 = u_y^2 - 2\ g\ h$ with v=0, rearranged for h **M1**

awrt 9.30 m **A1**

Answer: 9.30 m (3 s.f.)

Question 13

(a) slope equation y = x tan(20) (oe) **B1**

(a) trajectory equation with θ=50, u=40 substituted: $y = x \tan(50) - (9.8x^2(1+\tan^2(50)))/(2x40^2)$ (oe) **B1**

(a) correctly simplified coefficient (accept unsimplified equivalent form) **B1**

(a) Answer: $y = x \tan(20)$; $y = x \tan(50) - (9.8\ x^2 \sec^2(50)) / 3200$

(b) equate the two equations for y **M1**

(b) factor out x (x not equal to 0) to obtain a linear equation in x **M1**

(b) substitute numerical values of tan(20), tan(50) and $\sec^2(50)$ **M1**

(b) correct simplified linear equation, e.g. 0.0074121x = 0.827784 (oe) **A1**

(b) x = awrt 112 m **A1**

(b) Answer: x = awrt 112 m

(c) OA = x / cos(20) (oe, or use Pythagoras with y = x tan(20)) **M1**

(c) correct method with ft value of x from (b) **A1**

(c) OA = awrt 119 m **A1**

(c) Answer: awrt 119 m

(d) use x = u cos(50) x t **M1**

(d) rearrange for t, ft value of x from (b) **M1**

(d) t = awrt 4.34 s **A1**

(d) Answer: awrt 4.34 s

Question 14

(a) initial vertical speed = 28 sin(30) = 14 (oe) **M1**

(a) T = 2 x 14 / 9.8 (oe) **M1**

(a) T = 20/7 s = awrt 2.86 s **A1**

(a) Answer: T = 20/7 s = awrt 2.86 s

(b) use $v^2 = u^2 - 2gs$ with v = 0, u = 14 **M1**

(b) rearrange for s **M1**

(b) H = 10 m (cao) **A1**

(b) Answer: 10 m

(c) horizontal speed = 28 cos(30) (oe) **M1**

(c) R = horizontal speed x T **M1**

(c) $R = 40\sqrt{3}$ m, awrt 69.3 m **A1**

(c) Answer: $40\sqrt{3}$ m = awrt 69.3 m

(d) time of flight $T = 2u \sin(\theta)/g$ stated or derived **M1**

(d) R = (u cos(θ)) x T **M1**

(d) substitute and use $\sin(2\text{theta}) = 2 \sin(\theta) \cos(\theta)$ **M1**

(d) $R = u^2 \sin(2\text{theta})/g$ (cso, no errors seen) **A1**

(d) Answer: $R = u^2 \sin(2\text{theta})/g$ (shown)

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