Equations of Motion

Mark Scheme 1

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Kinematics
Sub Topic	Equations of Motion
Paper Type	Theory
Booklet	Mark Scheme 1

Time Allowed: **84 minutes**

Score: **/70**

Percentage: **/100**

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 **(a) (i)** acceleration = $(v - u) / t$ or $(12 - 0.5) / 4$ C1

= $(12 - 0.5) / 4$ = 2.9 (2.875) (= approximately $3\,m\,s^{-2}$) M1 [2]

(ii) $x = (u + v)t / 2$

= $[(12 + 0.5) \times 4] / 2$ C1

= 25 m A [2]

(iii) line with increasing gradient M1
non-zero gradient at origin A1 [2]

(b) (i) weight down slope = $2 \times 9.81 \times \sin 25°$ = 8.29 / 8.3 M1 [1]

(ii) ($F = ma$) $8.3 - F_R = 2 \times 2.9$ C1

F_R = 2.5 (2.3 if 3 used for a) N A1 [2]

2 **(a) (i)** straight line from t = 0.60 s to t = 1.2 s and $|V_v|$ = 5.9 at t = 1.2 s M1
V_v = – 5.9 at t = 1.2 s i.e. line is for negative values of V_v A1 [2]

(ii) $s = 0 + ½ \times 9.81 \times (0.6)^2$ *or* area of graph = $(5.9 \times 0.6) / 2$ C1

= 1.8 (1.77) m = 1.8 (1.77) m A1 [2]

(iii) $V_h = V \cos 60°$ and $V_v = V \sin 60°$ *or* $V_h = 5.9 / \tan 60°$ *or* $V_h = 5.9 \tan 30°$ C1

$V_h = 3.4\,m\,s^{-1}$ A1 [2]

(iv) horizontal line at 3.4 from t = 0 to t = 1.2 s [to half a small square] B1 [1]

(b) (i) KE = $½mv^2$ C1

= $½ \times 0.65 \times (6.81)^2$ [allow if valid method to find v] C1

= 15 (15.1) J A1 [3]

(ii) PE = $0.65 \times 9.81 \times 1.77$ C1

= 11(11.3) J A1 [2]

3 **(a** scalar has magnitude only B1
vector has magnitude and direction B1 [2]

(b) (i) $v^2 = 0 + 2 \times 9.81 \times 25$ (or using $\frac{1}{2} m v^2 = mgh$) C

$v = 22(.1)\ \text{m s}^{-1}$ A1 [2]

(ii) $22.1 = 0 + 9.81 \times t$ (or $25 = \frac{1}{2} \times 9.81 \times t^2$) M

t (=22.1 / 9.81) = 2.26 s or t [=$(5.097)^{1/2}$] = 2.26 s A0 [1]

(iii) horizontal distance = 15 × t
= 15 × 2.257 = 33.86 (allow 15 × 2.3 = 34.5) C1

$(\text{displacement})^2 = (\text{horizontal distance})^2 + (\text{vertical distance})^2$ C1
$= (25)^2 + (33.86)^2$ C1

displacement = 42 (42.08) m (allow 43 (42.6) m, allow 2 or more s.f.) A1 [4]

(iv) distance is the actual (curved) path followed by ball B1
displacement is the straight line / minimum distance P to Q B1 [2]

4 **(a** units for D identified as kg m s^{-2} M1
all other units shown: units for A: m^2 units for v^2: m^2s^{-2} units for ρ: kg m^{-3}

$C = \dfrac{\text{kg m s}^{-2}}{\text{kg m}^{-3}\ \text{m}^2\ \text{m}^2\text{s}^{-2}}$ with cancelling / simplification to give C no units A1 [2]

(b) (i) straight line from (0,0) to (1,9.8) ± half a square B1 [1]

(ii) $\frac{1}{2}\, mv^2 = mgh$ or using $v^2 = 2as$ C1
$v = (2 \times 9.81 \times 1000)^{1/2} = 140\,\text{m s}^{-1}$ A1 [2]

(c) (i) weight = drag (D) (+ upthrust) B1 [1]
Allow mg or W for weight and D or expression for D for drag

(ii) 1. $mg = 1.4 \times 10^{-5} \times 9.81$ C1

$1.4 \times 10^{-5} \times 9.81 = 0.5 \times 0.6 \times 1.2 \times 7.1 \times 10^{-6} \times v^2$ M1

$v = 7.33\,\text{m s}^{-1}$ A0 [2]

2. line from (0,0) correct curvature to a horizontal line at velocity of $7\,\text{m s}^{-1}$ M1
line reaches $7\,\text{m s}^{-1}$ between 1.5 s and 3.5 s A [2]

5 **(a (i)** $v = u + at$ C1
$= 4.23 + 9.81 \times 1.51$ M1
$= 19.0(4)\ \text{m s}^{-1}$ (Allow 2 s.f.) A0 [2]
(*Use of –g max 1/2. Use of g = 10 max 1/2. Allow use of 9.8. Allow 19 m s*$^{-1}$)

(ii) either $s = ut + \frac{1}{2}\, at^2$ (or $v^2 = u^2 + 2as$ etc.)
$= 4.23 \times 1.51 + 0.5 \times 9.81 \times (1.51)^2$ C1
$= 17.6\,\text{m}$ (*or 17.5 m*) A1 [2]
(*Use of –g here wrong physics (0/2)*)

(b) (i) $F = \Delta P / \Delta t$ *need idea of <u>change</u> in momentum* C1
$= [0.0465 \times (18.6 + 19)] / 12.5 \times 10^{-3}$ C1
$= 140\,\text{N}$ A1
(*Use of – sign max 2/4. Ignore –ve sign in answer*)
Direction: upwards B1 [4]

(ii) $h = \frac{1}{2} \times (18.6)^2 / 9.81$ C1
$= 17.6$ m *(2 s.f. –1)* A1 [2]
(*Use of 19 m s*$^{-1}$*, 0/2 wrong physics*)

(c) *either* kinetic energy of the ball is not conserved on impact
or speed before impact is not equal to speed after hence inelastic B1 [1]

6 **(a) (i)** horizontal speed constant at 8.2 m s^{-1} C1
vertical component of speed = 8.2 tan 60° M1
= 14.2 m s^{-1} A0 [2]

(ii) $14.2^2 = 2 \times 9.8 \times h$ (using g = 10 then –1) C1
vertical distance = 10.3 m A1 [2]

(iii) time of descent = 14.2 / 9.8 = 1.45 s C1
x = 1.45 × 8.2
= 11.9 m A1 [2]

(b) (i) smooth path curved and above given path M1
hits ground at more acute angle A1 [2]

(ii) smooth path curved and below given path M1
hits ground at steeper angle A1 [2]

7 **(a) (i)** V_H = 12.4 cos 36° (= 10.0 m s^{-1}) C
distance = 10.0 × 0.17
= 1.7 m A1 [2]

(ii) V_V = 12.4 sin 36° (= 7.29 m s^{-1}) C
h = 7.29 × 0.17 – ½ × 9.81 × 0.17^2 C1
= 1.1 m A [3]

(b) smooth curve with ball hitting wall below original B1
smooth curve showing rebound to ground with correct reflection at wall B1 [2]