Motion Graphs

Mark Scheme 2

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Kinematics
Sub Topic	Motion Graphs
Paper Type	Theory
Booklet	Mark Scheme 2

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**	force = rate of change of momentum	A1	[1]
	(b)	**(** horizontal line on graph from t = 0 to t about 2.0 s ± ½ square, a > 0	M1	
		horizontal line at 3.5 on graph from 0 to 2 s	A	
		vertical line at t = 2.0 s to a = 0 or sharp step without a line	B1	
		horizontal line from t = 2 s to t = 4 s with a = 0	B1	[4]
	(ii)	straight line and positive gradient	M1	
		starting at (0,0)	A1	
		finishing at (2,16.8)	A1	
		horizontal line from 16.8	M1	
		from 2.0 to 4.0	A1	[5]
2	**(a (i)**	**1.** distance of path / along line AB	B1	[1]
		2. shortest distance between AB / distance in straight line between AB or displacement from A to B	B1	[1]
	(ii)	acceleration = rate of change of velocity	A1	[1]
	(b) (i)	distance = area under line or $(v/2)t$ or $s = (8.8)^2 / (2 \times 9.81)$	C1	
		= 8.8 / 2 × 0.90 = 3.96 m or s = 3.95 m = 4(.0) m	A	[2]
	(ii)	acceleration = (– 4.4 – 8.8) / 0.50	C1	
		= (–) 26(.4) m s^{-2}	A1	[2]
	(c) (i)	the accelerations are constant as straight lines	B1	
		the accelerations are the same as same gradient or no air resistance as acceleration is constant or change of speed in opposite directions (one speeds up one slows down)	B1	[2]
	(ii)	area under the lines represents height or KE at trampoline equals PE at maximum height	B1	
		second area is smaller / velocity after rebound smaller hence KE less	B1	
		hence less height means loss in potential energy	A0	[2]

3	**(a**	**(i)**	$v^2 = u^2 + 2as$	
			$= (8.4)^2 + 2 \times 9.81 \times 5$	C1
			$= 12.99\ \text{m s}^{-1}$ *(allow 13 to 2 s.f. but not 12.9)*	A1 [2]
		(ii)	$t = (v - u) / a$ or $s = ut + ½at^2$	
			$= (12.99 - 8.4) / 9.81$ or $5 = 8.4t + ½ \times 9.81t^2$	M1
			$t = 0.468$ s	A0 [1]
	(b)		reasonable shape	M1
			suitable scale	A1
			correctly plotted 1st and last points at (0,8.4) and (0.88 – 0.96,0) with non-vertical line at 0.47 s	A1 [3]
	(c)	**(i)**	**1.** kinetic energy at end is zero so $\Delta KE = ½ mv^2$ or $\Delta KE = ½ mu^2 - ½ mv^2$	C1
			$= ½ \times 0.05 \times (8.4)^2$	
			$= (-)\ 1.8$ J	A1 [2]
			2. final maximum height $= (4.2)^2 / (2 \times 9.8) = (0.9\ (\text{m}))$	
			change in PE $= mgh_2 - mgh_1$	C1
			$= 0.05 \times 9.8 \times (0.9 - 5)$	C1
			$= (-)\ 2.0$ J	A1 [3]
		(ii)	change is – 3.8 (J)	B1
			energy lost to ground (on impact) / energy of deformation of the ball / thermal energy in ball	B1 [2]
4	**(a**		average velocity $= 540 / 30$	C1
			$= 18\ \text{m s}^{-1}$	A1 [2]
	(b)		velocity zero at time $t = 0$	B1
			positive value and horizontal line for time $t = 5$ s to 35 s	B
			line / curve through $v = 0$ at $t = 45$ s to negative velocity	B1
			negative horizontal line from 53 s with magnitude less than positive value and horizontal line to time = 100 s	B [4]

5	**(a)**	constant velocity / speed	B1	[1]
	2.	*either* constant / uniform decrease (in velocity/speed) *or* constant rate of decrease (in velocity/speed)	B1	[1]
	(b) (i)	distance is area under graph for both stages stage 1: distance (18 × 0.65) = 11.7 (m) stage 2: distance = (9 × [3.5 – 0.65]) = 25.7 (m) total distance = 37.(4) m *(–1 for misreading graph)* {for stage 2, allow calculation of acceleration (6.32 m s^{-2}) and then s = (18 × 2.85) + ½ × 6.32 (2.85)^2 = 25.7 m}	C1 A1	[2]
	(ii)	*either* $F = ma$ *or* $E_K = ½mv^2$ a = (18 – 0)/(3.5 – 0.65) E_K = ½ × 1250 × (18)^2 F = 1250 × 6.3 =7900 N *or* F = ½ × 1250 × (18)^2 / 25.7 = 7900 N *or* initial momentum = 1250 × 18 F = change in momentum / time taken F = (1250 × 18) / 2.85 = 7900	C1 C1 A1 (C1) (C1) (A1)	[3]
	(c) (i)	stage 1: *either* half / less distance as speed is half / less *or* half distance as the time is the same *or* sensible discussion of reaction time	B1	[1]
	(ii)	stage 2: *either* same acceleration and $s = v^2 / 2a$ *or* v^2 is ¼ ¼ of the distance	B1 B1	[2]
6	**(a**	force = rate of change of momentum (allow symbols if defined)	B1	[1]
	(b) (i)	$\Delta\rho$ = 140 × 10^{-3} × (5.5 + 4.0) = 1.33 kg m s^{-1}	C1 A1	[2]
	(ii)	force = 1.33 / 0.04 = 33.3 N	M1 A0	[1]
	(c) (i)	taking moments about B (33 × 75) + (0.45 × g × 25) = F_A × 20 F_A = 129 N	C1 C1 A1	[3]
	(ii)	F_B = 33 + 129 + 0.45g = 166 N	C1 A1	[2]

7	**(a)**	scalar ……	B1	
		scalar ……	B1	
		vector ……	B1	[3]
	(b) **(i)**	**1** gradient (of graph) is the speed/velocity (*can be scored here or in* ***2***)……		
		<u>initial gradient</u> is zero ……	B1	[2]
		2 gradient (of line/graph) becomes constant ……	B1	[1]
	(ii)	speed = (2.8 ± 0.1) m s^{-1} …… ……	A2	[2]
		(*if answer > ±0.1 but ≤ ±0.2, then award 1 mark*)		
	(iii)	curved line never below given line and starts from zero ……	B1	
		continuous curve with increasing gradient ……	B1	
		line never vertical or straight ……	B1	[3]