Motion Graphs

Mark Scheme 1

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

Time Allowed: **70 minutes**

Score: **/58**

Percentage: **/100**

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

1 **(a** speed = distance / time and velocity = displacement / time

speed is a scalar as distance has no direction **and**
velocity is a vector as displacement has direction B1 [2]

(b) (i) constant acceleration or linear/uniform increase in velocity until 1.1 s B1

rebounds or bounces or changes direction B1

decelerates to zero velocity at the same acceleration as initial value B1 [3]

(ii) $a = (v - u)/t$ or use of gradient implied C1

= (8.8 + 8.8) / 1.8 or appropriate values from line or = (8.6 + 8.6) / 1.8

= 9.8 (9.78) m s^{-2} or = 9.6 m s^{-2} A1 [3]

(iii) **1.** distance = first area above graph + second area below graph C1

= (1.1 × 10.8) / 2 + (0.9 × 8.8) / 2 (= 5.94 + 3.96) C1

= 9.9 m A1 [3]

2. displacement = first area above graph – second area below graph C1

= (1.1 × 10.8) / 2 – (0.9 × 8.8) / 2

= 2.0 (1.98) m A [2]

(iv) correct shape with straight lines and all lines above the time axis or all below M1

correct times for zero speeds (0.0, 1.15 s, 2.1 s) and peak speeds
(10.8 m s^{-1} at 1.1 s and 8.8 m s^{-1} at 1.2 s and 3.0 s) [2]

2 **(a** speed decreases/stone decelerates to rest/zero at 1.25 s B1

speed then increases/stone accelerates (in opposite direction) B1 [2]

(b) **(i)** $v = u + at$ (or $s = ut + \frac{1}{2}at^2$ **and** $v^2 = u^2 + 2as$) C

$= 0 + (3.00 - 1.25) \times 9.81$ C1

$= 17.2\ (17.17)\ \text{m s}^{-1}$ A1 [3]

(ii) $s = ut + \frac{1}{2}at^2$

$s = \frac{1}{2} \times 9.81 \times (1.25)^2$ [= 7.66] C1
$s = \frac{1}{2} \times 9.81 \times (1.75)^2$ [= 15.02] C1

(distance = 7.66 + 15.02)

[$v = u + at = 0 + 9.81 \times (2.50 - 1.25) = 12.26\ \text{m s}^{-1}$]

or
$s = \frac{1}{2} \times 9.81 \times (1.25)^2$ [= 7.66] (C1)
$s = 12.26 \times 0.50 + \frac{1}{2} \times 9.81 \times (3.00 - 2.50)^2$ [= 7.36] (C1)

(distance = 2 × 7.66 + 7.36)

Example alternative method:
$s = (v^2 - u^2)/2a = (12.26^2 - 0)/2 \times 9.81$ [= 7.66] (C1)
$s = (v^2 - u^2)/2a = (17.17^2 - 12.26^2)/2 \times 9.81$ [= 7.36] (C1)

(distance = 2 × 7.66 + 7.36)

22.7 (22.69 or 23) m A [3]

(iii) (s = 15.02 – 7.66 =) 7.4 (7.36) m *(ignore sign in answer)* A1

down A1 [2]

(c) straight line from positive value of v to t axis M1

same straight line crosses t axis at t = 1.25 s A1

same straight line continues with same gradient to t = 3.0 s A1 [3]

3	**(a**	<u>constant</u> rate of increase in velocity/acceleration from $t = 0$ to $t = 8\,s$	B1	
		<u>constant</u> deceleration from $t = 8\,s$ to $t = 16\,s$ or constant rate of increase in velocity in the opposite direction from $t = 10\,s$ to $t = 16\,s$	B1	[
	(b) **(i)**	area under lines to 10 s	C1	
		(displacement =) $(5.0 \times 8.0) / 2 + (5.0 \times 2.0) / 2 = 25\,m$ or ½ $(10.0 \times 5.0) = 25\,m$	A1	[2]
	(ii)	$a = (v - u) / t$ or gradient of line	C1	
		$= (-15.0 - 5.0) / 8.0$		
		$= (-) 2.5\,m\,s^{-2}$	A1	[2]
	(iii)	KE $= ½ mv^2$	C1	
		$= 0.5 \times 0.4 \times (15.0)^2 = 45\,J$	A	[2]
	(c)	(distance =) 25 (m) $(= ut + ½ at^2) = 0 + ½ \times 2.5 \times t^2$	C1	
		(t = 4.5 (4.47) s therefore) time to return = 14.5 s	A1	[2]

4 **(a) (i)** *either* rate of change of displacement
or (change in) displacement / time (taken) B1 [1]

(ii) speed has magnitude only B1
velocity has magnitude and direction B1 [2]

(b) (i) idea of area under graph / use of $s = \frac{(u+v)}{2} \times t$ C1

$s = \frac{(18+32)}{2} \times 2.5$ C1

$= 62.5$ m A1 [3]

(ii) $a = (18 - 32) / 2.5$ (= –5.6) C1
$F = ma$ C1
$F = 1500 \times (-) 5.6 = (-) 8400$ N A1 [3]

(c) arrow labelled A and arrow labelled F both to the left B1 [1]

5 **(a) (i)** velocity = rate of <u>change</u> of displacement
OR displacement <u>change</u> / time (taken) A1 [1]

(ii) acceleration = rate of <u>change</u> of velocity
OR <u>change</u> in velocity / time (taken) A1 [1]

(b) (i) initial constant velocity as straight line / gradient constant B1
middle section deceleration/ speed / velocity decreases / slowing down as gradient decreases B1
last section lower velocity (than at start) as gradient (constant and) smaller B1 [3]
[special case: all three stages correct descriptions but no reasons 1/3]

(ii) velocity = 45 / 1.5 = 30 m s^{-1} A1 [1]

(iii) velocity at 4.0 s is (122 – 98) / 2.0 = 12 (m s^{-1}) (allow 12 to 13) B1
acceleration = (12 – 30) / 2.5 = –7.2 m s^{-2} (if answer not this value then comment needed to explain why, e.g. difficulty in drawing tangent) A1 [2]

(iv) $F = ma$ C1
$= (-)1500 \times 7.2 = (-)11000$ (10800) N A1 [2]