Linear Momentum

Mark Scheme 3

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Dynamics
Sub Topic	Linear Momentum
Paper Type	Theory
Booklet	Mark Scheme 3

Time Allowed: **75 minutes**

Score: **/62**

Percentage: **/100**

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

1	**(a**	**(i)**	$v = u + at$	C1
			$= 4.23 + 9.81 \times 1.51$	M1
			$= 19.0(4)\ \mathrm{m\,s^{-1}}$ (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 $s = ut + ½\,at^2$ (or $v^2 = u^2 + 2as$ etc.)	
			$= 4.23 \times 1.51 + 0.5 \times 9.81 \times (1.51)^2$	C1
			$= 17.6$ 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
			$= 140$ N	A1
			(*Use of – sign max 2/4. Ignore –ve sign in answer*)	
			Direction: upwards	B1 [4]
		(ii)	$h = ½ \times (18.6)^2 / 9.81$	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]

2	**(a**	force = rate of change of momentum (allow symbols if defined)	B1	[1]
	(b) (i)	Δp = 140 × 10^{-3} × (5.5 + 4.0)	C1	
		= 1.33 kg m s^{-1}	A1	[2]
	(ii)	force = 1.33 / 0.04	M1	
		= 33.3 N	A0	[1]
	(c) (i)	taking moments about B	C1	
		(33 × 75) + (0.45 × g × 25) = F_A × 20	C1	
		F_A = 129 N	A1	[3]
	(ii)	F_B = 33 + 129 + 0.45g	C1	
		= 166 N	A1	[2]
3	**(a (i)**	path: reasonable curve upwards between plates	B1	
		straight and at a tangent to the curve beyond the plates	B1	[2]
	(ii)	**1.** (F =) $E.g$	B1	[1]
		2. (t =) L / v	B1	[1]
	(b) (i)	total momentum of a system remains constant **or** total momentum of a system before a collision equals total momentum after collision	M1	
		provided no external force acts on the system	A1	[2]
		(do not accept 'conserved' but otherwise correct statement gets 1/2)		
	(ii)	(Δp =) EqL / v allow ecf from **(a)(ii)**	B1	[1]
	(iii)	*either* charged particle is not an isolated system	M1	
		so law does not apply	A1	[2]
		or system is particle and 'plates'	(M1)	
		equal and opposite Δp on plates / so law applies	(A1)	

4	**(a)**	**(i)**	force is rate of change of momentum ……	B1	[1]
		(ii)	force on body A is equal in magnitude to force on body B (from A) ……	M1	
			forces are in opposite directions ……	A1	
			forces are of the same kind ……	A1	[3]
	(b)	**(i)**	1 $F_A = -F_B$ ……		[1]
			2 $t_A = t_B$ ……	B1	[1]
		(ii)	$\Delta p = F_A t_A = -F_B t_B$ ……	B1	[1]
	(c)		graph: momentum change occurs at same times for both spheres ……	B1	
			final momentum of sphere B is to the right ……	M1	
			and of magnitude 5 N s ……	A1	[3]

5	**(a**	**(i)**	*k* is the reciprocal of the gradient of the graph	C1	
			$k = \{32 / (4 \times 10^{-2}) = \}\ 800\ \text{N m}^{-1}$	A1	[2]
		(ii)	*either* energy = average force × extension *or* $\frac{1}{2}kx^2$		
			or area under graph line	C1	
			energy = $\frac{1}{2} \times 800 \times (3.5 \times 10^{-2})^2$ *or* $\frac{1}{2} \times 28 \times 3.5 \times 10^{-2}$	M1	
			energy = 0.49 J	A0	[2]
	(b)	**(i)**	momentum before cutting thread = momentum after	C1	
			$0 = 2400 \times V - 800 \times v$	M1	
			$v / V = 3.0$	A0	[2]
		(ii)	energy stored in spring = kinetic energy of trolleys	C1	
			$0.49 = \frac{1}{2} \times 2.4 \times (\frac{1}{3} v)^2 + \frac{1}{2} \times 0.8 \times v^2$	C1	
			$v = 0.96\ \text{m s}^{-1}$	A1	[3]
			(if only one trolley considered, or masses combined, allow max 1 mark)		

6 **(a)** constant gradient/straight line **B1 [1]**

(b) (1.2 s **A1**

(ii) 4.4 s **A1 [2]**

(c) *either* use of area under line *or h* = average speed x time **C1**

h = ½ x (4.4 – 1.2) x 32 **C1**

= 51.2 m **A1 [3]**

(allow 2/3 marks for determination of *h* = 44 m or *h* =58.4 m
allow 1/3 marks for answer 7.2 m)

(d) $\Delta p = m\Delta v$ OR $p = mv$ **C1**

= 0.25 x (28 + 12) **C1**

= 10 N s **A1 [3]**

(answer 4 N s scores 2/3 marks)

(e) (i) total/sum momentum before = total/sum momentum after **B1**

in any closed system **B1 [2]**

(ii) *either* the system is the ball and Earth **B1**

momentum of Earth changes by same amount **B1**

but in the opposite direction **B1**

or Ball is not an isolated system/there is a force on the ball (B1)

<u>Gravitational</u> force acts on the ball (B1)

causes change in momentum/law does not apply here (B1) **[3]**

(if explains in terms of air resistance, allow first mark only)