

Mark Scheme Momentum Paper Questions

Jan 2002—Jun 2008 (old spec)

Q4 Jun 2002

- 4(a)(i) length of card ✓
 [or distance travelled by trolley A] ✓
 time at which first light gate is obscured
 [or time taken to travel the distance] ✓
- (ii) time at which second light gate is obscured
 [or distance travelled after collision and time taken] ✓ (3)
- (b) momentum = mass × velocity ✓
 mass of each trolley ✓
 (check whether) $p_{\text{initial}} = p_{\text{final}}$ ✓ max(2)
- (c) incline the ramps ✓
 until component of weight balances friction ✓
 [or identify where the friction occurs ✓
 sensible method of reducing ✓] (2)
 (7)

2

- (a) kinetic energy changes to potential energy ✓
 potential energy calculated by measuring h ✓
 equate kinetic energy to potential energy to find speed ✓
 [or use h to find s ✓
 use $g \sin \theta$ for a ✓
 use $v^2 = u^2 + 2as$ ✓]
 [or use h to find s ✓
 time to travel s and calculate v_{av} ✓
 $v = 2v_{\text{av}}$ ✓] (3)
- (b)(i) $p (= mv) = 0.5(0) \times 0.4(0) = 0.2(0)$ ✓ N s (or kg m s⁻¹) ✓
- (b)(ii) (use of $m_p v_p = m_t v_t$ gives) $0.002(0) v = 0.2(0)$ ✓
 $v = 100 \text{ m s}^{-1}$ ✓ (4)
- (c)(i) kinetic energy is not conserved ✓
- (c)(ii) initial kinetic energy = $\frac{1}{2} \times 0.002 \times 100^2 = 10$ (J) ✓
 final kinetic energy = $\frac{1}{2} \times 0.5 \times 0.4^2 = 0.040$ (J) ✓
 hence change in kinetic energy ✓
 (allow C.E. for value of v from (b)) (4)

(11)

2

Q2 Jun 2003

- (a)(i) (gravitational) potential energy to kinetic energy ✓
- (ii) kinetic energy to heat energy
[or work done against friction] ✓ (2)
- (b) e.g. when using light gates
place piece of card on trolley of measured length ✓
card obscures light gate just before trolley strikes block ✓
calculate speed from length of card/time obscured ✓
- alternative 1: measured horizontal distance ✓
speed = distance/time ✓
time ✓
- alternative 2: measure h ✓
equate potential and kinetic energy ✓
 $v^2 = gh$ ✓
- alternative 3: data logger + sensor ✓
how data processed ✓
how speed found ✓ (3)
- (c) vary starting height of trolley
[or change angle] ✓
the greater the height the greater the speed of impact ✓
- [or alter friction of surface ✓
greater friction, lower speed ✓] (2)
- (7)

2

(a)(i) (use of $F = ma$ gives) $1.8 \times 10^3 = 900 a$ ✓

$a = 2.0 \text{ m s}^{-2}$ ✓

Q2 Jan 2004

(ii) (use of $v = u + at$ gives) $v = 2.0 \times 8.0 = 16 \text{ m s}^{-1}$ ✓

(allow C.E. for a from (i))

(iii) (use of $p = mv$ gives) $p = 900 \times 16$ ✓

$= 14 \times 10^3 \text{ kg m s}^{-1}$ (or N s) ✓ ($14.4 \times 10^3 \text{ kg m s}^{-1}$)

(allow C.E. for v from(ii))

(iv) (use of $s = ut + \frac{1}{2}at^2$ gives) $s = \frac{1}{2} \times 2.0 \times 8^2$ ✓

$= 64 \text{ m}$ ✓

(allow C.E. for a from (i))

(v) (use of $W = Fs$ gives) $W = 1.8 \times 10^3 \times 64$ ✓

$= 1.2 \times 10^5 \text{ J}$ ✓ ($1.15 \times 10^5 \text{ J}$)

(allow C.E. for s from (iv))

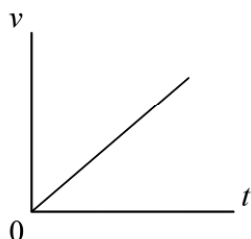
[or $E_k = \frac{1}{2}mv^2 = \frac{1}{2} \times 900 \times 16^2$ ✓

$= 1.2 \times 10^5 \text{ J}$ ✓

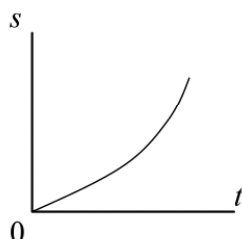
(allow C.E. for v from (ii))]

(9)

(b)



✓



✓

(2)

(c)(i) decreases ✓

air resistance increases (with speed) ✓

(ii) eventually two forces are equal (in magnitude) ✓

resultant force is zero ✓

hence constant/terminal velocity (zero acceleration)

in accordance with Newton's first law ✓

correct statement and application of Newton's first or second law ✓

max(5)

(16)

6

Q6 Jun 2004

(a) kinetic energy not conserved ✓
 [or velocity of approach is equal to velocity of separation] (1)

(b)(i) (use of $p = mv$ gives) $p = 4.5 \times 10^{-2} \times 60$ ✓
 $= 2.7 \text{ kg m s}^{-1}$ ✓

(ii) (use of $F = \frac{\Delta(mv)}{\Delta t}$ gives) $F = \frac{2.7}{15 \times 10^{-3}}$ ✓
 $= 180 \text{ N}$ ✓

[or $a = \frac{v - u}{t} = \frac{60}{15 \times 10^{-3}} = 4000 \text{ (m s}^{-1}\text{)}$

$F = (ma) = 4.5 \times 10^{-2} \times 4000 = 180 \text{ N}$] (4)

(c)(i) 180 N ✓
 (allow C.E. for value of F from (b) (ii))
 in opposite direction (to motion of the club) ✓

(ii) body A (or club) exerts a force on body B (or ball) ✓
 (hence) body B (or ball) exerts an equal force on body A (or club) ✓
 correct statement of Newton's third law ✓

max (4)
 (9)

Question 5																							
(a)	(i) (change in momentum of A) = - ✓ 25×10^3 ✓ kg m s^{-1} (or N s) ✓ (ii) (change in momentum of B) = $25 \times 10^3 \text{ kg m s}^{-1}$ ✓		4																				
		Q5 Jun 2005																					
(b)	<table border="1" style="width: 100%; text-align: center;"> <thead> <tr> <th></th> <th>initial vel/m s⁻¹</th> <th>final vel/m s⁻¹</th> <th>initial k.e./J</th> <th>final k.e./J</th> </tr> </thead> <tbody> <tr> <td>truck A</td> <td>2.5</td> <td>1.25</td> <td>62500</td> <td>15600</td> </tr> <tr> <td>truck B</td> <td>0.67</td> <td>1.5</td> <td>6730</td> <td>33750</td> </tr> <tr> <td></td> <td>✓</td> <td>✓</td> <td>✓</td> <td>✓</td> </tr> </tbody> </table>		initial vel/m s ⁻¹	final vel/m s ⁻¹	initial k.e./J	final k.e./J	truck A	2.5	1.25	62500	15600	truck B	0.67	1.5	6730	33750		✓	✓	✓	✓		4
	initial vel/m s ⁻¹	final vel/m s ⁻¹	initial k.e./J	final k.e./J																			
truck A	2.5	1.25	62500	15600																			
truck B	0.67	1.5	6730	33750																			
	✓	✓	✓	✓																			
(c)	not elastic ✓ because kinetic energy not conserved ✓ kinetic energy is greater before the collision (or less after) ✓ [or justified by correct calculation]		3																				

Question 1			
(a)	momentum ✓ kinetic energy ✓	Q1 Jun 2006	2
(b) (i)	450 m s ⁻¹ ✓ in the opposite direction ✓		4
(ii)	$\Delta p = 8.0 \times 10^{-26} \times 900$ ✓ $= 7.2 \times 10^{-23}$ N s ✓		
(c)	force is exerted on molecule by wall ✓ to change its momentum ✓ molecule must exert an equal but opposite force on wall ✓ in accordance with Newton's second or third law ✓		4
Total			10

Question 6			
		Q6 Jan 2007	
(a)	momentum is a vector quantity hence the momentum of one trolley is positive and the other negative or momenta cancel ✓✓		2
(b) (i)	momentum is conserved or correct use on Newton 3 (hence A must have the same magnitude of velocity after the collision as B but in opposite direction) since masses equal ✓✓		4
(ii)	collision is not likely to be elastic hence there is a decreases in E_k ✓✓ or energy lost to other forms (such as heat)		
(c)	time how long it takes trolley to travel a measured distance divide distance by time ✓✓✓		3
Total			9

Question 3			
(a) (i)	velocity/speed changes or acceleration ✓ the momentum decreases to zero ✓ because the wall exerts a force on the water ✓ hence water exerts an equal but opposite force on the wall ✓ in accordance with Newton's third law ✓ correct application of Newton's second law ✓	Q3 Jan 2008	max 5
(ii)	force is constant because water flows at a constant rate ✓		
(b) (i)	(i) (use of $p = mv$) $p = 18 \times 7.2$ ✓ $p = 130$ N s ✓		3
(ii)	force = 130 N ✓ (c.e. from (i))		
(c)	magnitude is greater ✓ because there is a bigger (rate of) change of momentum ✓ or velocity or acceleration		2
Total			10

Question 3		
(a)	<p>accelerates uniformly/constantly for first 20 s ✓ (quoting numerical value ok)</p> <p>travels at constant speed (of 15 m s^{-1}) ✓</p> <p>decelerates (to rest) ✓ (or negative acceleration)</p> <p>(n.b. only need to see uniformly/constant once)</p>	Q3 Jun 2008 3
(b) (i)	<p>(use of $p = mv$)</p> <p>$p = 1200 \times 15$ ✓</p> <p>$p = 18000 \text{ N s}$ ✓</p>	4
(ii)	rate of change of momentum = $18000/20 = 900 \text{ N}$ ✓	
(iii)	<p>(use of $\text{distance} = \text{average speed} \times \text{time}$)</p> <p>distance = $(15 + 0)/2 \times 20$</p> <p>distance = 150 m ✓</p>	
Total		7

Question 6		
(a)	potential energy to kinetic energy ✓ (ignore mention of heat/sound)	1
(b) (i)	<p>gain of $E_k = \text{loss of } E_p$</p> <p>$\frac{1}{2} mv^2 = mgh$</p> <p>$\frac{1}{2} \times 250 \times v^2 = 250 \times 9.81 \times 4.5$</p> <p>$v^2 = 88.29$</p> <p>$v = 9.4 \text{ m s}^{-1}$</p> <p>(if use $g = 10 \text{ m s}^{-2}$ then -1 (answer 1.06 m s^{-1}))</p>	Q6 Jun 2008 4
(ii)	<p>(use of $p = mv$)</p> <p>$p = 250 \times 9.4 = 2350 \text{ N s}$ ✓ (if $g = 10 \text{ m s}^{-2}$ then get 2694 N)</p>	
(iii)	<p>(use $m_1u = m_2v$)</p> <p>$2350 = (250 + 2000) v$ ✓</p> <p>$v = 1.0(4) \text{ m s}^{-1}$ ✓ (if $g = 10 \text{ m s}^{-2}$ then get 1.06 m s^{-1})</p> <p>if omit 250 kg then -1 (answer 1.18 m s^{-1})</p>	
(c) (i)	<p>(use of $E_k = \frac{1}{2} mv^2$)</p> <p>CE from (b) (iii)</p> <p>$E_k = \frac{1}{2} \times 2250 \times 1.042$ ✓ = 1200 J (1217 J) ✓</p>	4
(ii)	<p>(use of $\text{work done} = \text{force} \times \text{distance}$)</p> <p>(can use $\text{force} = \text{mass} \times \text{acceleration}$)</p> <p>$1217 = F \times 0.25$ ✓</p> <p>$F = 4900 \text{ N}$ ✓</p> <p>if include loss of E_p then get 26940 N and full credit</p> <p>if use loss of E_p but ignore E_k then -1 mark</p>	
(d)	<p>resistive force from the ground will increase ✓</p> <p>as pile gets deeper in the ground ✓</p>	2
Total		11