Mark Scheme Momentum Paper Questions
Jan 2002—Jun 2008 (old spec)

Question 4	**Q4 Jun 2002**	
(a)	velocity vector tangential to path and drawn from the ball, arrow in correct direction ✓ acceleration vector vertically downwards, arrow drawn and in line with ball ✓	**2**
(b) (i) (ii)	$s = \frac{1}{2}gt^2$ gives $t = \sqrt{\frac{2y}{g}} = \sqrt{\frac{2\times 24}{9.8(1)}}$ ✓ = 2.2(1) s ✓ v (= s/t) = 27/2.2(1) ✓ = 12(.2 m s^{-1}) or 12(.3) ✓ (ecf from (b)(i)) (answer only gets both marks)	**4**
	Total	**6**

2

Q2 Jan 2003

(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} ✓
$v = 2v_{av}$ ✓] *(3)*

(b)(i) p (= mv) = 0.5(0) × 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 m s^{-1} ✓ *(4)*

(c)(i) kinetic energy is not conserved ✓

(c)(ii) initial kinetic energy = ½ × 0.002 × 100^2 = 10 (J) ✓
final kinetic energy = ½ × 0.5 × 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 <u>horizontal distance</u> ✓
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 **Q2 Jan 2004**

(a)(i) (use of $F = ma$ gives) $1.8 \times 10^3 = 900\,a$ ✓
$a = 2.0\ \text{m s}^{-2}$ ✓

(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))

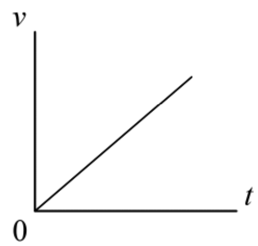
(iii) (use of $p = mv$ gives) $p = 900 \times 16$ ✓
$= 14 \times 10^3\ \text{kg m s}^{-1}$ (or N s) ✓ $(14.4 \times 10^3\ \text{kg m s}^{-1})$
(allow C.E. for v from(ii))

(iv) (use of $s = ut + ½at^2$ gives) $s = \frac{1}{2} \times 2.0 \times 8^2$ ✓
$= 64\ \text{m}$ ✓
(allow C.E. for a from (i))

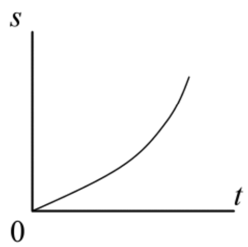
(v) (use of $W = Fs$ gives) $W = 1.8 \times 10^3 \times 64$ ✓
$= 1.2 \times 10^5\ \text{J}$ ✓ $(1.15 \times 10^5\ \text{J})$
(allow C.E. for s from (iv))

[or $E_k = ½mv^2 = ½ \times 900 \times 16^2$ ✓
$= 1.2 \times 10^5\ \text{J}$ ✓
(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)

 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) $p = 4.5 \times 10^{-2} \times 60$ ✓
$= 2.7\,\mathrm{kg\,m\,s^{-1}}$ ✓

(ii) (use of $F = \frac{\Delta(mv)}{\Delta t}$ gives) $F = \frac{2.7}{15 \times 10^{-3}}$ ✓
$= 180\,\mathrm{N}$ ✓
[or $a = \frac{v-u}{t} = \frac{60}{15 \times 10^{-3}} = 4000\,(\mathrm{m\,s^{-1}})$
$F = (ma) = 4.5 \times 10^{-2} \times 4000 = 180\,\mathrm{N}$] (*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) (ii)	(change in momentum of A) = – ✓ 25×10^3 ✓ kg m s^{-1} (or N s) ✓ (change in momentum of B) = 25×10^3 kg m s^{-1} ✓ **Q5 Jun 2005**	**4**
(b)	see table below	**4**
(c)	not elastic ✓ because kinetic energy not conserved ✓ kinetic energy is greater before the collision (or less after) ✓ [or justified by correct calculation]	**3**

(b)

	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
	✓	✓	✓	✓

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 ✓ **Q3 Jan 2008** 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 ✓	**max 5**
	(ii)	force is constant because water flows at a constant rate ✓	
(b)	(i)	(i) (use of $p = mv$) p = 18 × 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)		accelerates uniformly/constantly for first 20 s ✓ (quoting numerical value ok) travels at constant speed (of 15 m s^{-1}) ✓ **Q3 Jun 2008** decelerates (to rest) ✓ (**or** negative acceleration) (n.b. only need to see uniformly/constant once)	**3**
(b)	(i)	(use of $p = mv$) p = 1200 × 15 ✓ p = 18000 N s ✓	**4**
	(ii)	rate of change of momentum = 18000/20 = 900 N ✓	
	(iii)	(use of *distance* = *average speed* × *time*) distance = (15 + 0)/2 × 20 distance = 150 m ✓	
		Total	**7**

Question 6			
(a)		potential energy to kinetic energy ✓ (ignore mention of heat/sound)	**1**
(b)	(i)	gain of E_k = loss of E_p **Q6 Jun 2008** ½ mv^2 = *mgh* ½ × 250 × v^2 = 250 × 9.81 × 4.5 v^2 = 88.29 v = 9.4 m s^{-1} (if use g = 10 m s^{-2} then -1 (answer 1.06 m s^{-1}))	**4**
	(ii)	(use of $p = mv$) p = 250 × 9.4 = 2350 N s ✓ (if g = 10 m s^{-2} then get 2694 N)	
	(iii)	(use $m_1u = m_2v$) 2350 = (250 + 2000) v ✓ v = 1.0(4) m s^{-1} ✓ (if g = 10 m s^{-2} then get 1.06 m s^{-1}) **if** omit 250 kg then -1 (answer 1.18 m s^{-1})	
(c)	(i)	(use of $E_k = ½mv^2$) CE from (b) (iii) E_k = ½ × 2250 × 1.042 ✓ = 1200 J (1217 J) ✓	**4**
	(ii)	(use of *work done* = *force* × *distance*) (can use *force* = *mass* × *acceleration*) 1217 = *F* × 0.25 ✓ F = 4900 N ✓ if include loss of E_p then get 26940 N and full credit if use loss of E_p but ignore E_k then -1 mark	
(d)		resistive force from the ground will increase ✓ as pile gets deeper in the ground ✓	**2**
		Total	**11**