Conservation of Momentum (From OCR 4728)

Q1, (Jun 2005, Q3)

(i)	Momentum before=$0.1\times4-0.2\times3$	B1		or Loss by $P=0.1\times4+0.1u$
	Momentum after = $-0.1u+0.2(3.5-u)$	B1		or Gain by $Q=0.2(3.5-u)+0.2\times3$
	$0.1\times4-0.2\times3=-0.1u+0.2(3.5-u)$	M1		For using the principle of conservation of momentum
	$u=3$ (positive value only)	A1	4	
				SR If mgv used for momentum instead of mv, then $u=3$ B1
(ii)		M1		For using $v^2=u^2+2as$ with $v=0$ (either case) or equivalent equations
	$0=3^2-10s_1$ and $0=0.5^2-10s_2$	A1 ft		ft value of u from (i)
	$0.9+0.025$	M1		For using $PQ=s_1+s_2$
	Distance is 0.925 m cao	A1	4	

Q2, (Jan 2007, Q4)

(i)	Momentum before collision = +/-(0.8 x 4 - 0.6 x 2)	B1		Or momentum change L $0.8x4 +/- 0.8v_L$ Accept inclusion of g in both terms
	Momentum after collision = $+/-0.8v_L$ + 0.6 x 2	B1		Momentum change N 0.6x2 + 0.6x2 Accept inclusion of g in both terms
		M1		For using the principle of conservation of momentum even if g is included throughout
	Speed is 1 ms^{-1}	A1	4	Accept -1 from correct work (g not used).
(ii)(a)	0.6x2 - 0.7x0.5	M1		Must be a difference. **SR** 0.6x1 - 0.7x0.5 M1
	Total is 0.85$kgms^{-1}$	A1		Must be positive
	Total momentum +ve after the collision.	DM 1		Or 0.6v + 0.7w is positive, confirming that the momentum is shared between two particles.
	If N continues in its original direction, both particles have a negative momentum.			No reference need be made to the physically impossible scenario where M and N both might continue in their original directions.
	N must reverse its direction.	A1	4	
(ii)(b)	0.6x2 - 0.7x0.5 (= 0.85) = 0.7v	A1ft		ft cv (0.85). Award M1 if not given in ii(a).
	Speed is 1.21ms^{-1}	A1	2	Positive. Accept (a.r.t) 1.2 from correct work

Q3, (Jun 2007, Q4)

(i)	*In Q4 right to left may be used as the positive sense throughout.*	M1	For using Momentum 'before' is zero
	0.18 x 2 – 3m = 0	A1	
	m = 0.12	A1	
		[3]	3 marks possible if g included consistently
(iia)	Momentum after = -0.18 x 1.5 + 1.5m	B1	
	0.18 x 2 – 3m = -0.18 x 1.5 + 1.5m	M1	For using conservation of momentum
	m = 0.14	A1	
		[3]	3 marks possible if g included consistently
(iib)	0.18 x 2 – 3m = (0.18 + m)1.5	B1ft	ft wrong momentum 'before'
	m = 0.02	B1	
	0.18 x 2 – 3m= - (0.18 + m)1.5	B1ft	
	m = 0.42	B1	
		[4]	0 marks if g included

Q4, (Jun 2009, Q5)

i	$0.5\times6 = 0.5v + m(v+1)$ $3 = 0.5v + mv + m$ $v(m + 0.5) = -m + 3$ AG		M1 A1 A1 [3]	Uses CoLM. Includes g throughout MR-1
ii	Momentum before = +/- $(4m - 0.5\times2)$ +/- $(4m - 0.5\times2) = mv + 0.5(v+1)$ $4m - 0.5\times2 = mv + 0.5(v+1)$ $v(m+0.5) = 4m - 1.5$		B1 M1 A1 A1 [4]	Includes g throughout MR-1 Needs opposite directions in CoLM on "before" side only. RHS in format am + b or b + am. Ignore values for a and b if quoted.
iii	$4m - 1.5 = - m + 3$ $5m = 4.5$ $m = 0.9$ kg $0.9 + v(0.9+0.5) = 3$ or $4\times0.9 - 1.5 = v(0.9+0.5)$ $v = (3-0.9)/(0.9+0.5) = 2.1/1.4$ $v = 1.5$ ms^{-1}	AG	M1 A1 M1 A1 [4]	Attempts to obtain eqn in 1 variable from answers in (i) and (ii) Ignore $m = -0.5$ if seen Substitutes for m=0.9 in any m, v equation obtained earlier.

Q5, (Jan 2012, Q1)

(i)	Total momentum before = $0.3 \times 2.2 + 0.5 \times 0.8$ Mom P after = $0.3 \times 2.2/2$ $0.3 \times 2.2 + 0.5 \times 0.8 = 0.3 \times 2.2/2 + 0.5v$ $v = 1.46$ ms^{-1}		B1 B1 M1 A1 **[4]**	Allow inclusion of g 0.33, accept $0.33g$ and negative term Allow $0.33g = 0.5gv - 0.5g \times 0.8$ M1 Allow from inclusion of g
(ii)	PQ = $3 \times 1.46 - 3 \times 2.2/2$ PQ = 1.08 m		M1 A1 **[2]**	$3(1.46 - 2.2/2)$ Accept $3 \times 1.46 - 2.2/2$

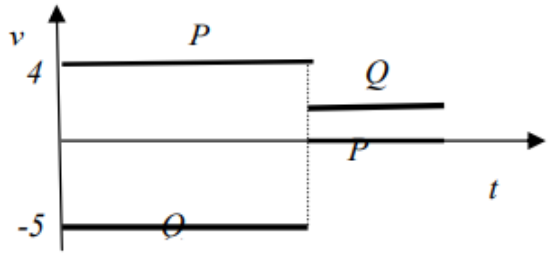
Q6, (Jun 2010, Q2)

	+/-(0.4x3 - 0.6x1.5)	B1	+/- 0.3
i	+/-(0.4x0.1 + 0.6v)	B1	Nb the terms have same signs
	(0.4x3 - 0.6x1.5) = +/-(0.4x0.1 + 0.6v)	M1	Equating their total mom before & after
	speed $\|v\| = 0.433$ ms^{-1}	A1	Accept 13/30 or 0.43 recurring, but not 0.43
	OR	[4]	
	+/- (0.4x3 – 0.4x0.1) = +/- 1.16	B1	Momentum change of P
	(0.6v + 0.6x1.5) = 0.6v + 0.9	B1	Momentum change of Q
	1.16 = +/-(0.6v + 0.9)	M1	Equating momentum changes
	speed $\|v\| = 0.433$ ms^{-1}	A1	0.26/0.6 = v
ii	+/-(0.4x0.1 - 0.6v)	B1	Nb the terms have different signs
	(0.4x3 - 0.6x1.5) = +/-(0.6v - 0.4x0.1)	M1	Must use +/- same before momentum as in (i)
	v = 0.567	A1	May be implied, or in any format
	PQ = 0.1x3 +0.567x3	M1	(0.1 + 0.567)x3
	PQ = 2 m	A1	Accept 2.00(1), 2.0, 2.00
	OR	[5]	
	+/- 0.4x3 + 0.4x0.1 and +/- 0.6v + 0.6x1.5	B1	Both must be correct
	1.24 = +/- 0.6v + 0.9	M1	Equating change in momentum
	v = 0.567	A1	May be implied, or in any format
	etc		

Q7, (Jun 2012, Q7)

(i)		Before mom = $0.2 \times 4 + 0.3 \times 2.5$ $0.2 \times 4 + 0.3 \times 2.5 = (0.2 + 0.3)v$ $v = 3.1$ ms^{-1}	B1 M1 A1 **[3]**	Accept with g Accept with g Exact. Award if g used and cancelled.
(ii)	(a)	$V_0 = 3.1$	B1 FT **[1]**	FT cv(v(i))
(ii)	(b)	$s = \int 3.1 - 3t^2 \, dt$ $s = 3.1t - 3t^3/3$ $(+c)$ CR = $[3.1t - t^3]_0^{0.3}$ CR = 0.903 m	M1* A1 FT D*M1 A1 **[4]**	Uses integration of velocity(t) FT cv(v(i)) or cv(V_0(iia)) Uses their s(0.3). Award if $+c$ never shown or assumed = 0 Ans <u>not</u> given, so explicit substitution not needed. Allow 0.90, not 0.9
(ii)	(c)	$a = d(V_0 - 3t^2)/dt$ $a = -6 \times 0.3$ $a = -1.8$ ms^{-2}	M1* D*M1 A1 **[3]**	Uses differentiation of v Substitutes t = 0.3 (no other value acceptable) Exact. Must be negative (accept deceleration is -1.8). Award if V_0 wrong but not if V_0 omitted.
(iii)		Mom $C = (0.2 + 0.3)(3.1 - 3 \times 0.3^2)$ Conservation of momentum used, no g $(0.2 + 0.3)(3.1 - 3 \times 0.3^2) = 1.5v - 0.5v$ $v = 1.415$ ms^{-1}	B1 M1 A1FT A1 **[4]**	1.415 Before momentum must be numerical, after momentum needs two terms in v (accept 2v or v) FT cv(before momentum) Exact. Accept 1.41 or 1.42.

Q8, (Jan 2013, Q6)

(i)		$0.3\text{x}4 - 0.2\text{x}5 = +/- (0.3+0.2)v$ $v = 0.4$ m s^{-1}	M1 A1 A1 **[3]**	Cons of momentum, no g*, common v "after" term $0.3\text{x}4 + 0.2\text{x}5 = +/- (0.3+0.2)v$ is M1A0A0 Must be positive *Allow g if fully cancelled in first line BOD
(ii)	**(a)**	Q (or P at rest) $0.3\text{x}4 - 0.2\text{x}5 = 0.2v$ $v = 1$ m s^{-1}	B1 M1 A1 A1 **[4]**	If P moves, allow 0.3vwhen considering M1 Cons of momentum, no g*, one "after" term $0.3\text{x}4 + 0.2\text{x}5 = 0.2v$ is M1A0A0 *Allow g if fully cancelled in first line BOD
(ii)	**(b)**	$4t + 5t = 3.6$ $t = 0.4$ $x_Q = 5\text{x}0.4$ (=2) T = (2/1 =) 2 s *OR* (Time =) $x/5 = (3.6 - x)/4$ $x = 2$ m $T = 2/1 = 2$ s	M1 A1 A1 A1 **[4]** M1 A1 A1 A1	Or $9t = 3.6$, Or both $3.6\text{-}x = 4t$ and $x = 5t$ Finds initial Q distance. 3.6 x 5 /(4+5) is M1A1A1 Equates pre-collision times x is distance Q travels before collision
(ii)	**(c)**		B1 B1 B1 B1 **[4]**	One horizontal, +ve v intercept One horizontal, –ve v intercept, terminates at same t One along t-axis, starts at same t as +ve line ends, label P One horizontal above t-axis, starts at same t as –ve line ends. (Ignore any values put on graphs)

Q9, (Jun 2013, Q1)

(i)		$0.3u + 0.6 \times 0.8 = (0.3 + 0.6) \times 1$	M1	Momentum for Q/R, no g, at least 3 correct terms
			A1	NB 0.48 in "before" from 0.8×0.6; not $1.5 \times 0.1 + 1.1 \times 0.3$ (A0)
		$u = 1.4$ m s^{-1}	A1	
			[3]	
(ii)		$0.1 \times 1.5 + 0.3 \times 1.1 = \pm 0.1v + 0.3 \times 1.4$	M1	P,Q +ve "before", allow P –ve "after". Accept cv (1.4)
		$v = 0.6$	A1	Velocity of P, will be –ve if $-0.1v$ in momentum equation, accept $v = \pm 0.6$
		Momentum change $= \pm 0.09$ kg m s^{-1}	A1	Tolerate loss of – sign if "small – large" has +ve answer
		OR	**[3]**	
		Momentum change $Q = \pm 0.3(1.4 - 1.1) = \pm 0.09$	M1A1	Change for P is the change for Q
		Momentum change $P = \pm 0.09$	A1	
		OR		
		$0.1 \times 1.5 + 0.3 \times 1.1 + 0.6 \times 0.8 = (\pm)0.1v + 0.9(\times 1)$	M1A1	Overall equation
		Momentum change $P = \pm 0.09$	A1	From $\pm$ $(0.9 \times 1 - 0.3 \times 1.1 - 0.6 \times 0.8)$

Q10, (Jun 2014, Q4)

(i)		Calculation for both "before" Momentum (magnitudes)	M1	Must not include g	
		Compares both terms without arithmetic error	A1*		
		Shows direction of after total momentum conflicts with the before velocity/momentum of Q	D*A1	Vector nature of momentum by word or sign (+/-)	Explicit reference to after momentum or conservation of momentum essential.
			[3]		
(ii)		TMB = +/-(0.2 × 4 + 0.3 × (–2))	B1	Accept inclusion of g	
		$0.8 - 0.6 = 0.2v + 0.3v$	M1	Allow if g included in all terms	LHS must be difference for both M1 marks
		$v = 0.4$ m s^{-1}	A1	Not awarded if g included	
		$0.8 - 0.6 = -0.2v + 0.3v$	M1	Allow if g included in all terms	SC $0.8 - 0.6 = 0.2v - 0.3v$ M1
		$v = 2$ m s^{-1}	A1	Not awarded if g included	Speed = 2 **and** the direction of motion of Q is reversed A1
			[5]		

Q11, (Jun 2015, Q2)

(i)		Before momentum = +/–$(0.4u – 0.3 \times 8)$	B1		Accept inclusion of g, including final A1
			M1	Uses momentum cons. 4 non-zero terms	
		$0.4u – 0.3 \times 8 = –0.4u + 0.3 \times 8$	A1ft	ft candidates "before" expression	
		$u = 6$	A1		
			[4]		
(ii)		After momentum = +/–$9m$	B1		No marks if g included, even if apparently cancelled
			M1	Uses momentum conservation 3 non-zero terms	
		$0.3 \times 8 – 3m = 9m$	A1ft	ft candidates "after" expression	
		$m = 0.2$	A1		
			[4]		

Q12, (Jun 2016, Q4)

i		0.8x6 - 0.2x2 (=4.4)	**B1**	Before momentum, signs different, no *g*
			M1	Uses momentum conservation, no *g*
		0.8x6 - 0.2x2 = 0.8x4 + 0.2*v* (= 4.4)	**A1**	
		$v = 6$ m s^{-1}	**A1**	*B*'s "after" velocity
			[4]	
ii		After mass = 0.3+0.1	**B1**	
		0.3x5 (+0.1x0) = (0.3+0.1)*v*	**M1**	No *g*
		$v = 3.75$ m s^{-1}	**A1**	*CD* "after" velocity
			[3]	
iii		Least final speed *B* = 4	**B1**	It cannot be less than the speed of *A*
		0.2x6+(0.3+0.1)x3.75 = 0.2x(*v* ≥ 4) + 0.4*V*	**M1**	Momentum, *B* and *CD* particles, essentially 4 non-zero terms with distinct velocities. Letters used at this stage should be checked against values used later.
		0.2x6+(0.3+0.1)x3.75 = 0.2x4+0.4*V*	**A1**√	ft cv (*v*(i) and *v*(ii))
		$V = 4.75$ m s^{-1}	**A1**	
			[4]	