Question Number	Scheme			Marks
7(a)	Conservation of Energy:			M1
	$\frac{1}{2}m\times 12^2 = \frac{1}{2}m\times 8^2 + mgh$			A1 A1
	(h =) 4.1 (m)			A1
				(4)
7(b)	Vertical distance:			M1
	$"4.1" = 12\sin\alpha\times 1.5 - \frac{g}{2}\times 1.5^2$			A1ft
	$\alpha = 57°$			A1
				(3)
7(c)	Equation in α and β only			M1
	Eg. Horizontally: $12\cos\alpha = 8\cos\beta$	Eg. Vertical and horizontal components: $\tan\beta = \frac{12\sin\alpha - 1.5g}{12\cos\alpha}\left(= -0.709....\right)$		A1ft
	$\beta = 35°$			A1
				(3)
7(d)	Max height, T	Times when $v = 8$	Times when $h = 4.08$	M1
	$2(1.5 - T)$	$T_2 - T_1$	$T_2 - T_1$	dM1
	$T = \frac{12\sin\alpha}{g}$	$0 = 8\sin\beta\, T - \frac{1}{2}gT^2$	$4.08 = 12\sin\alpha\, T - \frac{1}{2}gT^2$	A1ft
	0.94 (s)			A1
				(4)
				(14 marks)

Notes	
(a) M1	Energy equation with correct number of terms and dimensionally correct including mass. M0 if no energy equation used or for incorrect energy formulae.
A1	Unsimplified equation with at most one error.
A1	Correct unsimplified equation.
A1	4.1 or 4.08 only (2 or 3sf)
(b) M1	Complete method to find an equation in sin α only, using their h. This equation could be obtained by getting two equations in α and β, which don't require h, and eliminating β
A1ft	Correct equation, ft their h if used. ($\sin\alpha = 0.839$)
A1	57° or 57.1° (or 1.0 or 0.996 radians) [57.06178257…]
(c) M1	A method to reach an equation in α and β only. E.g. Equating horizontal speed in terms of α and β or finding the vertical velocity components at B, v_V, and then using $\tan\beta = \frac{\lvert v_V\rvert}{12\cos\alpha}$ or $\sin\beta = \frac{\lvert v_V\rvert}{8}$.
A1ft	A correct equation in α (need not be substituted) and β, ft their h and α
A1	35° or 35.4° (or 0.617 or 0.62 radians) [35.35311389…]
N.B.	v_V can be found in a number of ways [v_V = 4.628911565…] $v = u + at$: $v_V = 12\sin\alpha - 1.5g$ $v^2 = u^2 + 2as$: $v_V = \sqrt{(12\sin\alpha)^2 - 2g\times \text{their } h}$

	$s = vt - \frac{1}{2}at^2$: $h = 1.5v_V + \frac{1}{2}g \times 1.5^2 \Rightarrow v_V = \frac{h - \frac{1}{2}g \times 1.5^2}{1.5} = \frac{2h}{3} - \frac{3g}{4}$ $s = \left(\frac{u+v}{2}\right)t$: $h = \left(\frac{12\sin\alpha + v_V}{2}\right) \times 1.5 \Rightarrow v_V = \frac{4}{h} - 12\sin\alpha$
(d) M1	Method to find an appropriate time(s), *T*, that could be used to find the required time: E.g.time to maximum height, times to height 4.08, times to speed being 8. M0 for total flight time unless they go on to use appropriately.
dM1	A correct overall method to use their *T* to find the required time.
A1ft	Correct equation for their *T*, ft their *h*, α, β
A1	0.94 or 0.945 obtained from correct working. [0.9446758295…]

8. Three particles A, B and C, each of mass m, lie at rest in a straight line L on a smooth horizontal surface, with B **between** A and C.

Particles A and B are projected directly **towards** each other with speeds $5u$ and $4u$ respectively.

At the same instant, particle C is projected directly **away** from B with speed $3u$.

In the subsequent motion, A, B and C move along L.

Particles A and B collide directly.

The coefficient of restitution between A and B is e.

(a) Find

(i) the speed of A immediately after the collision,

(ii) the speed of B immediately after the collision.

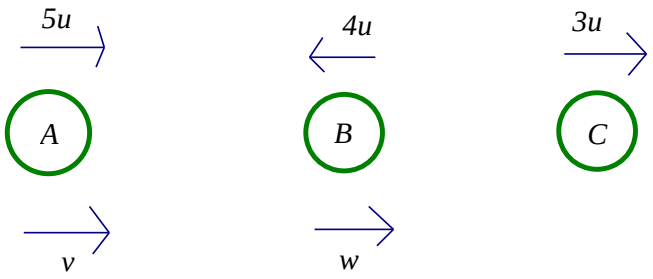
(7)

Given that the direction of motion of A is **reversed** in the collision between A and B, and that there is **no** collision between B and C,

(b) find the set of possible values of e.

(4)

(Total for Question 8 is 11 marks)

Question Number	Scheme	Marks
8(a)		
	CLM:	M1
	$5mu - 4mu = mv + mw \qquad (u = v + w)$	A1
	NEL:	M1
	$w - v = 9ue$	A1
	Solve for v or w	DM1
	$w = \frac{u}{2}(9e+1)$	A1
	$v = \left\|\frac{u}{2}(1-9e)\right\|$	A1
		(7)
8(b)	Use of $v < 0$ to find inequality involving e	M1
	$\frac{1}{9} < e$	A1
	Use of $w \leqslant 3u$	M1
	$\frac{1}{9} < e \leq \frac{5}{9}$	A1
		(4)

Notes	
(a) M1	Conservation of linear momentum. Needs all terms and dimensionally consistent but condone sign errors.
A1	Correct equation (m may be cancelled)
M1	Impact law. Condone sign errors but must not be reciprocal.
A1	Correct equation with directions consistent with momentum equation. **N.B.** Mark the equations even if inconsistent with any directions on their diagram
ddM1	Solve for v or w dependent on both previous M marks.
A1	Correct expression for speed of B after collision.
A1	Correct expression for speed of A; must include modulus as demand specifies speed.
(b) M1	Inequality considering direction of A reversed (i.e. their $v < 0$)
A1	Correct lower inequality. Must be strict inequality.
M1	Second inequality requiring speed of B to be less than or equal to the speed of C but condone strict inequality ($w < 3u$)
A1	cao