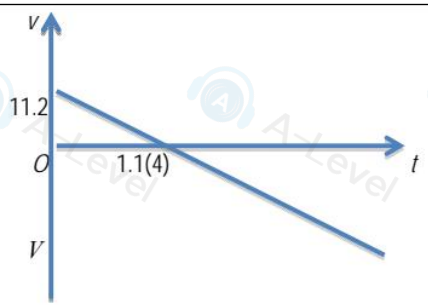
Question Number	Scheme	Marks
4(a)	$0^2 = 11.2^2 - 2gd$ $d = 6.4$ max ht. $= 3.6 + 6.4 = 10$ m	M1 A1 A1 A1 (4)
ALT	$11.2^2 = u^2 - 2g \times 3.6$ $u = 14$ $0^2 = 14^2 - 2gh$ $h = 10$ m	M1 A1 A1 A1 (4)
(b)	$10 = \frac{1}{2}gt^2$ $t = \frac{10}{7}$ Total $= 2 \times \frac{10}{7} = 2.9$ or 2.86	M1 A1 A1 **dM1** A1 (5)
(c)		B1 single line **dB1** $V <$ -11.2 B1 11.2 B1 1.1(4) (4) **13**
	Notes	
4(a)	M1 for a complete method to find d (d = distance from A to top) First A1 for a correct equation in d only. Second A1 for $d = 6.4$ Third A1 for 6.4 + 3.6 = 10 (m)	
ALT	M1 for a complete method (must have 2nd equation) to find h First A1 for $u = 14$ Second A1 for correct 2nd equation Third A1 for $h = 10$ (m)	
4(b)	First M1 for a complete method to find an intermediate time (A to top or A to O) First A1 for a correct equation or equations. Second A1 for any intermediate time (e.g. $_{A}t_{TOP} = {}^{8}/_{7}$, $_{A}t_{O} = {}^{2}/_{7}$, $_{A}t_{O} = {}^{18}/_{7}$, $_{A}t_{A} =$	

QUESTION NUMBER	SCHEME	MARKS
8(a)	Perp. to plane for P: $R = mg\cos a$	M1A1
	P: $T = mg\sin\alpha + F$ Q: $T = 0.5mg$ **N.B.** $mg\sin\alpha + F = 0.5mg$ scores M1A1 (LHS) B1 RHS)	M1 A1 B1
	Use of $F = \mu R$	B1
	$0.5mg = \frac{5mg}{13} + \mu\frac{12mg}{13}$	dM1
	$\mu = \frac{1}{8}$	A1
		(8)
8(b)	$mg\sin\alpha - F = ma$ $\left(a = \frac{7g}{26} \quad (\text{ms}^{-2})\right)$	M1 A1
	$V^2 = 0^2 + 2\left(\frac{7g}{26}\right)0.8$	M1
	$V = 2.1$ or 2.05	A1
		(4)
		(12)
	Notes for question 8	
(a)		
M1	Resolve perpendicular to find an expression for R in terms of m, condone sin/cos confusion and sign errors.	
A1	Correct unsimplified equation.	
M1	Form an equilibrium equation for P. Correct no. of terms, dimensionally correct. If $F=ma$ is used then a must be zero.	
A1	Correct unsimplified equation.	
B1	Correct equation	
B1	Use of $F = \mu R$, seen or implied, in an equation.	
dM1	Dependent on previous M mark, replace trig and form an equation in μ only.	
A1	Correct answer. Accept 0.125, 0.13	
(b)		
M1	Use of $F=ma$ for P. Correct no. of terms, dimensionally correct, ignore sin/cos confusion.	
A1	Correct equation, trig and F do not need to be substituted.	
M1	Use their calculated acceleration to form an equation in V. M0 if they use g.	
A1	Correct answer 2/3sf	

Question Number	Scheme	Marks	Notes
7(a)	Use of $\mathbf{r}=\mathbf{r}_0+\mathbf{v}t$	M1	At least once. Must be adding, not subtracting
	$\mathbf{r}_A=(8\mathbf{i}+7\mathbf{j})+t(2\mathbf{i}-14\mathbf{j})$	A1	$\mathbf{r}_A$ correct $\begin{pmatrix}8+2t\\7-14t\end{pmatrix}$
	$\mathbf{r}_B=(\mathbf{i}+2\mathbf{j})+t(12\mathbf{i}-4\mathbf{j})$	A1	$\mathbf{r}_B$ correct $\begin{pmatrix}1+12t\\2-4t\end{pmatrix}$
	$\overrightarrow{BA}=(8\mathbf{i}+7\mathbf{j})+t(2\mathbf{i}-14\mathbf{j})-\left[(\mathbf{i}+2\mathbf{j})+t(12\mathbf{i}-4\mathbf{j})\right]$	M1	Need to see an indication of method as leading to a given answer
	$=(7-10t)\mathbf{i}+(5-10t)\mathbf{j}$	A1	Obtain **given answer** from correct working
		(5)	
(b)	Use of Pythagoras to equate distance to 2 km	M1	
	$(7-10t)^2+(5-10t)^2=2^2$	A1	Correct unsimplified equation in t
	$20t^2-24t+7=0$	M1	Form 3 term quadratic in t
	$(10t-7)(2t-1)=0$	DM1	Solve for t. Dependent on the preceding M1. Must see working if using an incorrect quadratic
	$t=\frac{7}{10}$ or $\frac{1}{2}$	A1	
	Time $=\frac{7}{10}-\frac{1}{2}$	DM1	Correct method to find the time interval. Dependent on the preceding M1
	$=\frac{2}{10}$ h (12 min)	A1	
		(7)	
		(12)	

Question Number	Scheme	Marks	Notes
5(a)	$\tan\theta=\frac{2}{3}$	M1	Use trig to find a relevant angle $(56.3°,\ 33.7°)$
	Angle is $\theta+90^\circ=123.69°$..	A1	124° or better (2.16 radians)
		(2)	
(b)	$\mathbf{F}_1+\mathbf{F}_2=(a\mathbf{i}+3\mathbf{j})+(-4\mathbf{i}+b\mathbf{j})\ (=k(3\mathbf{i}-2\mathbf{j}))$	M1	Resultant force seen or implied: must be the sum, NOT the difference As a column vector or in **i** / **j** form
	Use direction to form equation in a and b	M1	From ratio of scalars or 2 separate equations involving $k\neq1$
	$\frac{a-4}{3+b}=\frac{3}{-2}$	A1	Correct unsimplified equation
	$0=2a+3b+1$ Given answer	A1	Obtain **given answer** from correct working- need to see evidence
		(4)	
		(6)	

Question Number	Scheme	Marks	Notes
5a	Correct equation for $\mathbf{v}_P$ or find displacement	M1	Use of $\mathbf{r}_P = \mathbf{r}_0 + \mathbf{v}_P t$ to find $\mathbf{v}$. Allow for $\lambda(-\mathbf{i}-5\mathbf{j})$
	$\mathbf{v}_P = 3(6\mathbf{i}-(7\mathbf{i}+5\mathbf{j})) = -3\mathbf{i}-15\mathbf{j}$	A1	
	$\sqrt{(-3)^2+(-15)^2}$	M1	Use of Pythagoras to find magnitude of their $\mathbf{v}$
	$=\sqrt{234}=15.3\ \left(\text{km h}^{-1}\right)$ (or better)	A1	CSO $\left(3\sqrt{26}\right)$ A0 if it comes from $3\mathbf{i}+15\mathbf{j}$
			NB Could score the M marks in reverse order - find displacement in 20 minutes and then multiply by 3
		(4)	
5b	Use of $\mathbf{r}_P = \mathbf{r}_0 + \mathbf{v}_P t$: $\mathbf{r}_P = 7\mathbf{i}+5\mathbf{j}+t(-3\mathbf{i}-15\mathbf{j})$	M1	For their $\mathbf{v}_P$
	$\Rightarrow \mathbf{r}_P = (7-3t)\mathbf{i}+(5-15t)\mathbf{j}$	A1	Obtain **given answer** from correct working
		(2)	
5c	$\dfrac{(7-3t)}{(5-15t)}=\dfrac{16}{5}$	M1	Use given answer and direction to form equation in t
		A1	Correct unsimplified equation
	$35-15t=80-240t$	DM1	Solve for t. Dependent on the previous M1
	$t=0.2$	A1	
		(4)	
5d	P and Q in the same place at the same time	M1	Equate **i** or **j** components of position vectors and solve for t
	$\Rightarrow\ 7-3t=5+2t$ or $5-15t=-3+5t$	A1	Either
	$t=0.4$	A1	
	Check that the same value of t gives equal values for the other component	DM1	Dependent on the previous M mark
	$\mathbf{r}=(5.8\mathbf{i}-\mathbf{j})$ km	A1	Must be a vector
		(5)	
		[15]	

Question Number	Scheme	Marks	Notes
3.(a)	$7^2 = 2 \text{ x } 9.8h$	M1	Use of $v^2 = u^2 + 2as$ with $u = 0, v = 7$ or alternative complete method to find h.
	$h = 2.5$	A1	Condone $h = -2.5$ in the working but the final answer must be positive.
		(2)	
3.(b)	$9 \text{ x } 7 = 10.5\ u$	M1	Use CLM to find the speed of the blocks after the impact. Condone additional factor of g throughout.
	$u = 6$	A1	
	$0^2 = 6^2 - 2a \text{ x } 0.12$	M1	Use of $v^2 = u^2 + 2as$ with $u = 6, v = 0$ Allow for their u and $v = 0$ Allow for $u = 7, v = 0$ Accept alternative *suvat* method to form an equation in a. Condone use of 12 for 0.12
		A1	Correctly substituted equation in a with $u = 6, s = 0.12$ (implied by $a = 150$)
	$(\downarrow)\ 10.5g - R = 10.5 \text{ x } (-a)$	M1	Use of $F = ma$ with their $a \neq \pm g$. Must have all 3 terms and 10.5 Condone sign error(s)
	$(\downarrow)\ 10.5g - R = 10.5 \text{ x } (-150)$	A1	Unsimplified equation with a substituted and at most one error (their a with the wrong sign is 1 error)
		A1	Correct unsimplified equation with a substituted
	$R = 1680$ or 1700	A1	
		(8)	
	Alternative for the last 6 marks:		
	$\frac{1}{2} \times 10.5 \times 6^2 + 10.5 \times 9.8 \times 0.12 = R \times 0.12$	M2	Energy equation (needs all three terms)
		A3	-1 each error A1A1A0 for 1 error, A1A0A0 for 2 errors
	$R = 1680$ or 1700	A1	
		[10]	

General Principles for Mechanics Marking

Question Number	Scheme	Marks
1	$T\cos 70° + R = 40g$	M1A1
	$T\cos 20° = F$	M1A1
	$F = \frac{3}{4}R$	B1
	Eliminate R and solve for T	**DM**1
	$T = 250$ N or 246 N	A1
		7
	Notes	
1	First M1 for resolving vertically with usual rules (must be using either $20°$ or $70°$) First A1 for a correct equation Second M1 for resolving horizontally with usual rules (must be using either $20°$ or $70°$) Second A1 for a correct equation B1 for $F = \frac{3}{4}R$ seen (could be on a diagram) Third DM1 dependent on previous two M marks Third A1 for either 250 (N) or 246 (N)	
2a	$M(D),\ (1080\times 1)-(400\times 2) = R_C \times 3.5$	M1 A1
	$R_C = 80$ (N)	A1
	$M(C),\ (1080\times 2.5)+(400\times 5.5) = R_D \times 3.5$	M1A1
	$R_D = 1400$ (N)	A1 (6)
	OR $(\uparrow) R_C + R_D = 1480$	M1A1
2b	$R_C + (R_C + 520) = 1480$ OR $R_D + (R_D - 520) = 1480$	M1 A1
	$M(D),\ (1080 \times 1) - 400(x-4) = R_C \times 3.5$	M1 A1
	$x = 2.5$	A1 (5)
		11
	Notes	
2a	First M1 for a moments equation or a vertical resolution First A1 for a correct equation (R_C and/or R_D do NOT need to be substituted but if one is, it can be their value found from a previous equation)	

Question Number	Scheme	Marks
	Second A1 for $R_C = 80$ (N) Second M1 for a moments equation or a vertical resolution Third A1 for a correct equation (R_C and/or R_D do NOT need to be substituted but if one is, it can be their value found from a previous equation) Fourth A1 for $R_D = 1400$ (N) Enter marks for equations on ePEN, in the order they appear	
2b	First M1 for a moments equation or a vertical resolution First A1 for a correct equation (R_C and/or R_D do NOT need to be substituted but if one is, it can be their value found from a previous equation) Second M1 for a moments equation or a vertical resolution Second A1 for a correct equation (R_C and/or R_D do NOT need to be substituted but if one is, it can be their value found from a previous equation) Third A1 for $x = 2.5$ Enter marks for equations on ePEN, in the order they appear **N.B.** Equations may contain any or all of R_C, R_D or x for M marks but must contain only **one** of R_C or R_D to earn the A mark. **N.B.** If they assume that $R_D = 520$, they lose all the marks for part (b). **N.B** If they start with $2R = 1480$ and then add or subtract (or both) 520 to their R value, M0. **N.B.** If brackets are omitted in a moments equation e.g. $(520 + R_C).4$ is written as $520 + R_C.4$, the M mark can be scored	
3	$8mu - 4mu = 5mv$	M1A1
	$v = 0.8u$	A1
	For P: $-I = 4m(0.8u - 2u)$	M1 A1
	$I = 4.8mu$	A1
	OR For Q: $I = m(0.8u + 4u)$	M1 A1
	$I = 4.8mu$	A1
		6
	Notes	
3	First M1 for CLM with correct no. of terms, all dimensionally correct, to give an equation in m, u and their v only. Condone consistent g's or cancelled m's and sign errors. (N.B. The CLM equation could be obtained by equating the magnitudes of the impulses on each particle) First A1 for a correct equation (they may have - $5mv$) Second A1 for $0.8u$ or $-0.8u$ (as appropriate) Second M1 for using Impulse = Change in Momentum for either P or Q (M0 if *clearly* adding momenta or if g is included or if different mass in the two momentum terms) but condone sign errors.	

Question Number	Scheme	Marks
6(a)	$R+T\sin\theta=mg$	M1A1
	$T\cos\theta-F=0$	M1A1
	$F=\frac{1}{3}R$	B1
	Solve for T, in terms of mg	DM1
	$(T)=\frac{1}{3}mg$	A1 (7)
(b)	$F=\frac{1}{3}mg$	B1
	$F=\pm ma$ **OR** W.D. $=\pm Fd$	B1
	$\left(\frac{1}{2}u\right)^2=u^2-2(\frac{1}{3}g)d$ $\quad$ $\frac{1}{2}m\left(\frac{1}{2}u\right)^2=\frac{1}{2}mu^2-\frac{1}{3}mgd$	DM1A1
	$d=\frac{9u^2}{8g}$ oe $\quad$ $d=\frac{9u^2}{8g}$ oe	A1 (5)
		(12)
	Notes	
6(a)	M1: Vertical resolution, with correct terms, condone sign errors and sin/cos confusion. Allow if they use $\sin(\frac{3}{5})$ or similar.	
	A1: Correct equation	
	M1: Horizontal resolution, with correct terms, condone sign errors and sin/cos confusion. Allow if they use $\cos(\frac{4}{5})$ or similar.	
	A1: Correct equation	
	B1: Seen anywhere, including on a diagram	
	DM1: Dependent on both M's	
	A1:cao. Accept 0.33 mg or better.	
6(b)	B1: Seen anywhere, including on a diagram	
	B1: $F=\pm ma$ where F is friction, (allow + or −) **OR** Fd	
	DM1: Complete method, dependent on the previous B mark, using a new dimensionally correct acceleration, to produce an equation, with correct no. of terms, in d, u and g, condone sign errors. **OR**, using work-energy principle using Fd, where F is friction, to produce an equation, with correct no. of terms, in d, u and g, condone sign errors	
	A1: Correct equation	
	A1: cao (must be $d=$, seen or implied, **but allow s in the working**)	