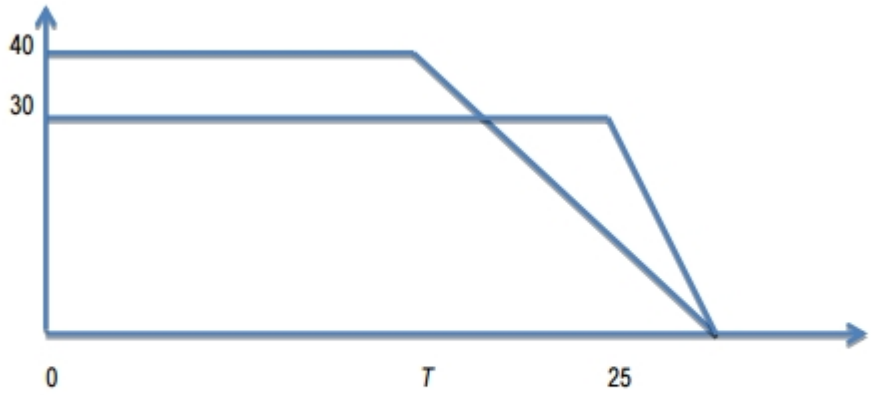
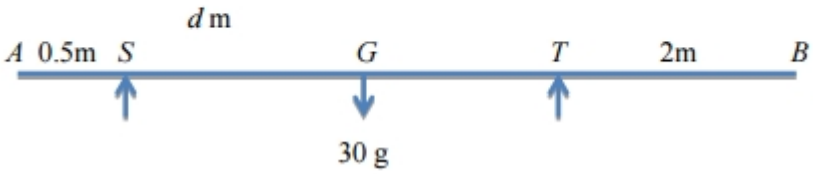
A level Applied Paper 3B Mechanics Practice Paper M16 MARK SCHEME

Question 1

Question Number	Scheme	Marks
(a)		B1 shape (*M*) B1 figs (40,*T*) B1 shape (*N*) B1 figs (30,25) (4)
(b)	**For N:** $\frac{1}{2}(25+25+t).30=975$ OR $\frac{1}{2}(25+t_1).30=975$ $t=15$ $t_1=40$ **For M:** $\frac{1}{2}(25+t+T).40=975$ OR $\frac{1}{2}(t_1+T).40=975$ $T=8.75$ ($8\frac{3}{4}$ or $\frac{35}{4}$ oe) ALTERNATIVE: They may find t or t_1, in terms of T, from their (*M*) equation, and substitute for t or t_1 in their (*N*) equation, and then solve for T: **For M:** $\frac{1}{2}(25+t+T).40=975$ OR $\frac{1}{2}(t_1+T).40=975$ $t=(\frac{1950}{40}-25-T)$ $t_1=(\frac{1950}{40}-T)$ **For N:** $\frac{1}{2}(25+25+t).30=975$ OR $\frac{1}{2}(25+t_1).30=975$ sub for t or sub for t_1 $T=8.75$ ($8\frac{3}{4}$ or $\frac{35}{4}$ oe)	M1 A1 **DM**1 A1 M1 A1 **DM**1 A1 (8) **12** M1 A1 **DM**1 A1 M1 A1 **DM**1 A1 (8) **12**
	Notes	
(a)	First B1 (*M*) for correct shape – *must start and finish on the axes*. Second B1 for 40 and *T* marked clearly (if delineators omitted B0) and correctly Third B1 (*N*) for correct shape – *must start and finish on the axes*. Fourth B1 for 30 and 25 (if delineators omitted B0) marked clearly and correctly **N.B.** If graphs do not cross and/or do not finish at the same point, max score is B1B1B0B1.	

	N.B. If graphs done on separate diagrams, mark each and award the higher mark i.e. can score max 2/4 for part (a).	
(b)	**N.B.** When attempting to find the area of a triangle, must see ½ x …. to be able to award an M mark i.e. M0 if ½ is missing **N.B.** When attempting to find the area of a trapezium, must see something of the form : ½ x $(a + b)h$ to be able to award an M mark i.e. M0 if ½ is missing and bracket is not a **sum** First M1 for attempt at using 975m distance travelled by N to obtain an equation in one unknown *time* (usually extra time t after 25 s, but could, for example, be whole time t_1) .They may use the area under their graph or use *suvat* (**N.B.** Any single *suvat* equn using $s = 975$ is M0). First A1 for a correct equation in their unknown *time* e.g. $(30 \times 25) + ½\ 30t = 975$ **OR** $(30 \times 25) + ½\ 30\ (t_1 - 25) = 975$ Second M1, dependent on first M, for solving their equation Second A1 for a correct value for their unknown. Third M1 for attempt at using 975m distance travelled by M to obtain an equation in T and possibly one other unknown *time* (usually extra time t after 25 s, but could, for example, be whole time t_1). They may use the area under their graph or use *suvat* (**N.B.** Any *suvat* equn using $s = 975$ is M0) Third A1 for a correct equation in T and possibly their unknown. This A1 can be earned if they just have a letter for their unknown :- e.g. $40T + ½\ 40.(25 + t - T) = 975$ **OR** $40T + ½\ 40.(t_1 - T) = 975$ or for an incorrect numerical value in place of t or t_1. Fourth M1, dependent on first, second and third M's, for solving for T. Fourth A1 for 8.75 or 35/4 or any other equivalent SEE MARKS FOR ALTERNATIVE ABOVE.	

Question 2

Question Number	Scheme	Marks
	 $M(S)$: $Mg \leftrightarrow 0.5 = 30g(d-0.5)$ $M(T)$: $Mg \leftrightarrow 2 = 30g(4-d)$ dividing: $4 = \frac{(4-d)}{(d-0.5)}$ => (i) $d = 1.2$ => (ii) $M = 42$	M1 A1 M1 A1 **DM1** A1 A1

	Notes **N.B.** They may use a different variable, other than d, in their moments equations e.g. say they use $x = SG$ consistently, they can score all the marks for their two equations and if they eliminate x correctly, DM1 A1 (for M), and, if they found x correctly, then added 0.5 to obtain d, the other A1 also.	
	First M1 for moments about S (need correct no. of terms, so if they don't realise that the reaction at T is zero it's M0) *to give an equation in d and M only*.	
	First A1 for a correct first equation *in d and M only*. (A1 for both g's or no g's but A0 if one g is missing)	
	N.B. They may use 2 equations and eliminate to obtain their equation *in d and M only* e.g. $M(A)$ $0.5R_S = 30gd$ and (^) $R_S = 30g + Mg$ and then eliminate R_S. The M mark is only earned once they have produced an equation *in d and M only*, with all the usual rules about correct no. of terms etc applying to all the equations they use to obtain it.	
	Second M1 for moments about T (need correct no. of terms, so if they don't realise that the reaction at S is zero it's M0) *to give an equation in d and M only*	
	Second A1 for a correct second equation *in d and M only*. (A1 for both g's or no g's but A0 if one g is missing)	
	N.B. They may use 2 equations and eliminate to obtain their equation *in d and M only* e.g. $M(B)$ $2R_T = 30g(6 - d)$ and (^) $R_T = 30g + Mg$ and then eliminate R_T. The M mark is only earned once they have produced an equation *in d and M only*, with all the usual rules about correct no. of terms etc applying to all the equations they use to obtain it.	

	Third M1, dependent on 1st and 2nd M marks, for eliminating either M or d to produce an equation in either d only or M only.	
	Third A1 for (d =) 1.2 oe (**N.B.** Neither this A mark nor the next one can be awarded if there are any errors in the equations.) **Beware:** If one g is missing consistently from each of their equations, they can obtain $d = 1.2$ but award A0	
	Fourth A1 for (M =) 42	
	Scenario 1: Below are the possible equations, (if they don't use $M(S)$), any two of which can be used, by eliminating R_S, to obtain an equation *in d and M only*, for the first M1. N.B. If R_T appears in any of these and doesn't subsequently become zero then it's M0.	
	$M(A)$ $0.5R_S = 30gd$	
	$M(B)$ $5.5R_S = 30g(6 - d) + 6Mg$	
	$M(T)$ $3.5R_S = 30g(4 - d) + 4Mg$	
	(^) $R_S = 30g + Mg$	
	Scenario 2: Below are the possible equations, (if they don't use $M(T)$), any two of which can be used, by eliminating R_T, to obtain an equation *in d and M only*, for the second M1. N.B. If R_S appears in any of these and doesn't subsequently become zero then it's M0.	
	$M(A)$ $4R_T = 30gd + 6Mg$	
	$M(B)$ $2R_T = 30g(6 - d)$	
	$M(S)$ $3.5R_T = 30g(d - 0.5) + 5.5Mg$	
	(^) $R_T = 30g + Mg$	

Question 3

Question Number	Scheme	Marks
(a)	$T - 0.5g - 1.5g = 2 \times 0.5$ $T = 20.6$ (N) or 21 (N)	M1 A1 A1 (3)
(b)	$R - 1.5g = 1.5 \leftrightarrow 0.5$ Force = 15.5 (N) or 15 (N) OR: $T - R - 0.5g = 0.5 \leftrightarrow 0.5$ Force = 15.5 (N) or 15 (N)	M1 A1 A1 (3) **OR** M1 A1 A1 (3) **6**
	Notes	
(a)	**N.B.** In both parts of this question use the mass which is being used to guide you as to which part of the system is being considered M1 is for an equation for whole system in T only, with usual rules First A1 for a correct equation Second A1 for 20.6 or 21	
(b)	First M1 is for an equation for the brick only (1st alternative) or for the scale pan only (2nd alternative) with usual rules. First A1 for a correct equation (in the second alternative T does not need to be substituted) Second A1 for 15.5 or 15	
	N.B. If R is replaced by $-R$ in either equation, can score M1A1. This would lead to $R = -15.5$ or -15. The second A1 can then only be scored if the candidate explains why the –ve sign is being ignored.	

Question 4

Question Number	Scheme	Marks
(a)	$F = \frac{1}{5}R$ $R = 1.5g$ $T - F = 1.5a$ $3g - T = 3a$ $T = 1.2g$ or 11.8 N or 12 N	M1 B1 M1 A1 M1 A1 **DM1** A1 (8)
(b)	$R = \sqrt{T^2 + T^2}$ or $2T\cos 45^0$ or $\frac{T}{\cos 45^0}$ $= 16.6$ (N) or 17(N) or $\frac{6g\sqrt{2}}{5}$ Direction is 45° below the horizontal oe	M1 A1 A1 B1 (4) **12**
	Notes	
(a)	First M1 for *use of* $F = \frac{1}{5}R$ in an equation. B1 for $R = 1.5g$ Second M1 for resolving horizontally with usual rules First A1 for a correct equation Third M1 for resolving vertically with usual rules Second A1 for a correct equation **N.B.** Either of the above could be replaced by a *whole system* equation: $3g - F = 4.5a$ **N.B.** All of the marks for the two equations can be scored if they consistently use $-a$ instead of a. Fourth M1 dependent on first, second and third M marks for solving their equations for T Third A1 for 1.2g, 11.8 (N) or 12 (N)	
(b)	First M1 for a complete method for finding the magnitude of the resultant (**N.B.** M0 if different tensions used), First A1 for $\sqrt{T^2 + T^2}$ or $2T\cos 45^o$ Second A1 for 16.6(N) or 17 (N) B1 for 45° below the horizontal or a diagram with an arrow and a correct angle. Ignore subsequent wrong answers e.g. a bearing of 225^0, which scores B0, as does SW etc.	

Question 5

Question Number	Scheme	Marks
	μR $R = 2g\cos 20^\circ + 40\cos 60^\circ$ $F = 40\cos 30^\circ - 2g\cos 70^\circ$ $\mu = \dfrac{40\cos 30^\circ - 2g\cos 70^\circ}{2g\cos 20^\circ + 40\cos 60^\circ}$ $= 0.73$ or 0.727	B1 M1 A2 M1 A2 M1 M1 A1 **10**
	Notes	
	B1 for μR seen or implied.	
	First M1 for resolving perpendicular to the plane with usual rules (must be using $2(g)$ with 20^0 or 70^0 and 40 with 30^0 or 60^0)	
	First and second A1's for a correct equation. A1A0 if one error	
	Second M1 for resolving parallel to the plane with usual rules (must be using $2(g)$ with 20^0 or 70^0 and 40 with 30^0 or 60^0)	
	Third and fourth A1's for a correct equation. A1A0 if one error	
	Third M1 independent for eliminating R to produce an equation in μ only. Does not need to be $\mu =$ ….	
	Fourth M1 independent for solving for μ	
	Fifth A1 for 0.727 or 0.73	
	N.B. They may choose to resolve in 2 other directions e.g. horizontally and vertically.	
	N.B. If F is replaced by $-F$ in the second equ^n, treat this as an error unless they subsequently explain that they have their F acting in the wrong direction, in which case they could score full marks for the question.	

Question 6

Q	Scheme	Marks	Notes
a	M(A): $d\cos\theta\times 5g = 4P$	M1	Terms must be dimensionally correct. Condone trig confusion
		A1	
	Resolving horizontally: $P\sin\theta = F$	B1	
	Resolving vertically: $P\cos\theta + R = 5g$	M1	Requires all 3 terms. Condone trig confusion and sign errors
		A1	Correct equation
		DM1	Substitute for P to find R or F Dependent on both previous M marks
	$R = 5g - \frac{5gd\cos^2\theta}{4}$	A1	One force correct. Accept equivalent forms e.g. $R = \frac{20g - 5gd + 20g\tan^2\theta}{4\left(1+\tan^2\theta\right)}$
	$F = \frac{5gd\cos\theta\sin\theta}{4}$	A1	Both forces correct. Accept equivalent forms e.g. $F = \frac{5gd\tan\theta}{4\sec^2\theta}$
		(8)	
a alt	M(B): $5g\cos\theta\times(4-d) + F\sin\theta\times 4 = R\cos\theta\times 4$	M1	Needs all three terms. Terms must be dimensionally correct. Condone trig confusion
		A1	At most one error
	Resolve parallel to the rod: $5g\sin\theta = R\sin\theta + F\cos\theta$	M1	Requires all 3 terms. Condone trig confusion and sign errors
		B1	At most one error
		A1	Correct equation
	$\Rightarrow R = 5g - \frac{F\cos\theta}{\sin\theta}$		
	$5g\cos\theta\times(4-d) + F\sin\theta\times 4$ $= 4\cos\theta\left(5g - \frac{F\cos\theta}{\sin\theta}\right)$	DM1	Eliminate one variable to find F or R Dependent on both previous M marks
	$4F\left(\sin\theta + \frac{\cos^2\theta}{\sin\theta}\right)$ $= 20g\cos\theta - 20g\cos\theta + 5gd\cos\theta$		
	$F = \frac{5gd\cos\theta\sin\theta}{4}$	A1	One force correct
	$R = 5g - \frac{5gd\cos^2\theta}{4}$	A1	Both forces correct
			See next page for part (b)

b	$\mu = \dfrac{\dfrac{5gd\cos\theta\sin\theta}{4}}{5g - \dfrac{5gd\cos^2\theta}{4}}$	M1	Use of $F = \mu R$
	$\dfrac{1}{2}\left(5g - \dfrac{5gd\cos^2\theta}{4}\right) = \dfrac{5gd\cos\theta\sin\theta}{4}$	A1	$\left(4 - d\cos^2\theta = 2d\cos\theta\sin\theta\right)$
	$4\times169 = 120d + 144d$	M1	Use $\tan\theta = \dfrac{5}{12}$ and solve for d
	$d = \dfrac{169}{66}$	A1	(= 2.6 m or better)
		(4)	
balt	$F = 5gd \times \dfrac{12}{13} \times \dfrac{5}{13} \times \dfrac{1}{4}\left(= \dfrac{75gd}{169}\right)$	M1	Use $\tan\theta = \dfrac{5}{12}$
	$R = 5g - \dfrac{5gd}{4} \times \dfrac{144}{169}$	A1	Both unsimplified expressions
	$75gd = \dfrac{1}{2}\left(5\times169g - 180gd\right)$	M1	Use of $F = \mu R$ and solve for d
	$150gd + 180gd = 845g$, $d = \dfrac{169}{66}$	A1	(= 2.6 m or better)
		(4)	
balt	$R = 5g - \dfrac{12}{13}P$, $F = \dfrac{5}{13}P$	M1	Substitute trig in their equations from resolving.
	$\dfrac{5}{13}P = \dfrac{1}{2}\left(5g - \dfrac{12}{13}P\right)$	M1	use $F = \mu R$ and solve for d
	$\Rightarrow P = \dfrac{65}{22}g$	A1	
	$d = \dfrac{4P}{5g\cos\theta} = \dfrac{169}{66}$	A1	
		[12]	

Question 7

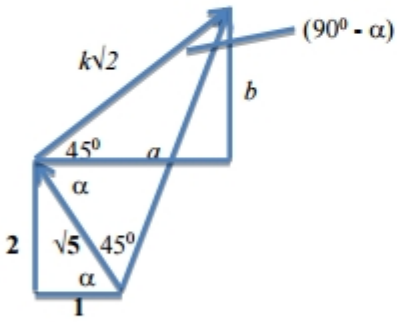
Question Number	Scheme	Marks
(a)	$\mathbf{F}_2 = k\mathbf{i} + k\mathbf{j}$	B1
	$(-1+a)\mathbf{i} + (2+b)\mathbf{j}$	M1
	$\frac{-1+a}{2+b} = \frac{1}{3}$	**DM1** A1
	$a = b = k = 2.5;\ \mathbf{F}_2 = 2.5\mathbf{i} + 2.5\mathbf{j}$	**DM1** A1; A1 (7)
	ALTERNATIVE:	
	$\mathbf{F}_2 = k\mathbf{i} + k\mathbf{j}$	B1
	$(-1+a)\mathbf{i} + (2+b)\mathbf{j} = p(\mathbf{i} + 3\mathbf{j})$	M1 for LHS
	$-1+a = p$	**DM1** A1
	$2+b = 3p$	
	$a = b = k = 2.5;\ \mathbf{F}_2 = 2.5\mathbf{i} + 2.5\mathbf{j}$	**DM1** A1; A1 (7)
(b)	$\mathbf{v} = 3\mathbf{i} - 22\mathbf{j} + 3(3\mathbf{i} + 9\mathbf{j})$	M1
	$= 12\mathbf{i} + 5\mathbf{j}$	A1
	$\lvert\mathbf{v}\rvert = \sqrt{12^2 + 5^2} = 13\ \text{ms}^{-1}$	M1 A1 **cso** (4)
		11

	Notes	
(a)	B1 for $\mathbf{F}_2 = k\mathbf{i} + k\mathbf{j}$ $(k \neq 1)$ seen or implied in working, including for an incorrect final answer, with the wrong k value. First M1 for adding the 2 forces (for this M mark we only need $\mathbf{F}_2 = a\mathbf{i} + b\mathbf{j}$), with $\mathbf{i}$'s and $\mathbf{j}$'s collected (which can be implied by later working) but allow a slip. (M0 if a and b both assumed to be 1) Second M1, dependent on first M1, for ratio of their cpts = 1/3 or 3/1 (Must be correct way up for the M mark) First A1 for a correct equation which may involve two unknowns Third M1, dependent on first and second M1, for solving for k oe Second A1 for a correct k value Third A1 for $2.5\mathbf{i} + 2.5\mathbf{j}$	

ALTERNATIVE: Using two simultaneous equations

B1 for $\mathbf{F}_2 = k\mathbf{i} + k\mathbf{j}$ ($k \neq 1$) seen or implied in working.
First M1 for adding the 2 forces (for this M mark we only need $\mathbf{F}_2 = a\mathbf{i} + b\mathbf{j}$), with **i**'s and **j**'s collected (LHS of equation) (M0 if *a* and *b* both assumed to be 1) but allow a slip
Second M1, dependent on first M1, for equating coeffs to produce *two* equations in 2 or 3 unknowns. Must have *p* and 3*p* (M0 if *p* is assumed to be 1 or *k*)
First A1 for two correct equations
Third M1, dependent on first and second M1, for solving for *k* oe
Second A1 for a correct k value
Third A1 for $2.5\mathbf{i} + 2.5\mathbf{j}$

ALTERNATIVE: Using magnitudes and directions



$\mathbf{F}_2 = k\mathbf{i} + k\mathbf{j}$, seen or implied — B1
Correct vector triangle — M1

$\dfrac{k\sqrt{2}}{\sin 45^0} = \dfrac{\sqrt{5}}{\sin(90^0 - \alpha)}$, $\alpha = \arctan 2$ — **DM1** A1

$2k = 5$

$k = 2.5$; $\mathbf{F}_2 = 2.5\mathbf{i} + 2.5\mathbf{j}$ — **DM1** A1; A1

(7)

ALTERNATIVE: Using magnitudes and directions

B1 for $\mathbf{F}_2 = k\mathbf{i} + k\mathbf{j}$ seen or implied in working.
First M1 for a correct vector triangle (for this M mark we only need $\mathbf{F}_2 = a\mathbf{i} + b\mathbf{j}$). (M0 if *a* and *b* both assumed to be 1 and/or longest side is assumed to be $\sqrt{10}$)
Second M1, dependent on first M1, for using sine rule on vector triangle
First A1 for a correct equation. 45^0 may not appear exactly.
Third M1, dependent on first and second M1, for solving for *k* oe
Second A1 for a correct *k* value
Third A1 for $2.5\mathbf{i} + 2.5\mathbf{j}$

(b)	First M1 for use of $\mathbf{v} = \mathbf{u} + \mathbf{a}t$ with $t = 3$ First A1 for $12\mathbf{i} + 5\mathbf{j}$ seen or implied. However, if a wrong $\mathbf{v}$ is seen A0 Second M1 for finding magnitude of their $\mathbf{v}$ Second A1 for 13	

Question 8

Question Number	Scheme	Marks
(a)	$\tan\theta = \frac{5}{20}$ $\theta = 14.036..^{0}$ $\theta = 104^{0}$ nearest degree	M1 A1 A1 (3)
(b)	$\mathbf{p} = 400\mathbf{i} + t(15\mathbf{i} + 20\mathbf{j})$ $\mathbf{q} = 800\mathbf{j} + t(20\mathbf{i} - 5\mathbf{j})$	M1 A1 A1 (3)
(c)	Equate their **j** components: $20t(\mathbf{j}) = (800 - 5t)(\mathbf{j})$ $t = 32$ $\mathbf{s} = 800\mathbf{j} + 32(20\mathbf{i} - 5\mathbf{j})$ $= 640\mathbf{i} + 640\mathbf{j}$	M1 A1 M1 A1 (4) **10**
(a)	**Notes** **Allow column vectors throughout** M1 for $\tan\theta = \pm\frac{5}{20}$ or $\pm\frac{20}{5}$ (or any other complete method) First A1 for $\pm 14.04^{\circ}$ or $\pm 75.96^{\circ}$ Second A1 for 104°	
(b) **(i)** **(ii)**	M1 for clear attempt at either **p** or **q** (allow slip but t must be attached to the velocity vector and position vector and velocity vector must be paired up correctly) First A1 $400\mathbf{i} + t(15\mathbf{i} + 20\mathbf{j})$ "**p** =" not needed but must be clear it's P Second A1 $800\mathbf{j} + t(20\mathbf{i} - 5\mathbf{j})$ "**q** =" not needed but must be clear it's Q	
(c)	First M1 for equating their **j** components; allow **j**'s on both sides First A1 for $t = 32$ Second M1 independent for substituting their t value into their **q** from (b) Second A1 for $640\mathbf{i} + 640\mathbf{j}$	

Question 9

Q	Scheme	Marks	Notes
a	Horizontal motion: $x = 3t$	B1	
	Vertical motion: $y = 4t - \frac{g}{2}t^2$	M1	Correct use of *suvat*. Condone sign error(s)
		A1	
	$\left(y = 4\times\frac{x}{3} - \frac{g}{2}\times\frac{x^2}{9}\right)$, $\lambda = -\left(\frac{4\lambda}{3} - \frac{g\lambda^2}{18}\right)$	M1	Use $y = -x$ and form an equation in one variable
	, $\frac{7\lambda}{3} = \frac{g\lambda^2}{18}$	M1	solve for λ
	$\lambda = \frac{42}{g}$ or 4.3 (4.29)	A1 (6)	Not $\frac{30}{7}$
alta	Horizontal motion: $x = 3t$	B1	
	Vertical motion: $y = 4t - \frac{g}{2}t^2$	M1	Correct use of *suvat*. Condone sign error(s)
		A1	
	$\Rightarrow -3t = 4t - \frac{1}{2}gt^2$, $\left(t = \frac{14}{g}\right)$	M1	Use $y = -x$ and form an equation in one variable
	$\lambda = 3t$	M1	Solve for λ
	$\lambda = 4.3$ (4.29)	A1 (6)	
b	At A: $v \rightarrow 3\ (\text{m s}^{-1})$	B1	
	$v\uparrow \quad 4 - g\times\frac{14}{g}$	M1	Complete method using *suvat* to find $v\uparrow$ with their t or λ
	$= -10\ (\text{m s}^{-1})$	A1	Accept +10 with direction confirmed by diagram
	Speed $= \sqrt{(\text{their } 10)^2 + (3)^2}$	DM1	Dependent on the first M1 in (b)
	$= \sqrt{109}\ (\text{m s}^{-1})$	A1	(10.4) Allow for $v\uparrow = 10$
	$\tan^{-1}\left(\frac{\text{their } 10}{3}\right)$ or $\tan^{-1}\left(\frac{3}{\text{their } 10}\right)$	DM1	Use trig to find a relevant angle. Dependent on the first M1 in (b)
	Direction $= 73.3°$ below the horizontal	A1	(1.28 radians) Accept direction $3\mathbf{i} - 10\mathbf{j}$ Do not accept a bearing
		(7)	
Alt b	Loss in GPE : $mg\lambda = 42m$	B1	
	Gain in KE : $\frac{1}{2}mv^2 - \frac{1}{2}m\times 25$	M1	Terms must be dimensionally correct. Condone sign error.
		A1	
	Solve for v: $42 = \frac{1}{2}v^2 - \frac{25}{2}$	M1	
	$v = \sqrt{109}$	A1	
	$v\cos\theta = 3$	M1	Use trig. to find a relevant angle
	$\theta = 73.3°$ below the horizontal	A1 (7)	Accept correct angle marked correctly on a diagram.
		[13]	

Question 10

Q	Scheme	Marks	Notes
a	$t=0,\ v=11\ \Rightarrow r=11$	B1	
	$t=2,\ v=3\ \Rightarrow 4p+2q+11=3,$	M1	Accept $4p+2q+r=3$
	$4p+2q=-8$	A1	Any equivalent unsimplified form with 11 used
	Differentiate to find acceleration	M1	OR use symmetry, $t=4, v=11$
	$a=2pt+q$	A1	$\Rightarrow 11=16p+4q+11\ ,\ 4p+q=0$
	$t=2,\ a=0\ \Rightarrow 4p+q=0$	DM1	2nd eqn in p & q and solve for p & q Dependent on both previous m marks
	$\Rightarrow -q+2q=-8,\ q=-8,\ p=2$	A1	
	$\left(v=2t^2-8t+11\right)$		
	$t=3,\ a=4t-8=4\,(\text{ms}^{-2})$	A1	
		(8)	
a alt	Min speed at $t=2\ \Rightarrow$ $v=\left(pt^2+qt+r\right)=k\left(t-2\right)^2+c$	B1	
		M1	Completed square form.
	$v=k\left(t-2\right)^2+3$	A1	Correct completed square form
	$t=0,\ v=11\ \Rightarrow 4k+3=11,$	M1	Solve for k
	$k=2$	A1	$v=2\left(t-2\right)^2+3\left(=2t^2-8t+11\right)$
	Differentiate to find acceleration	DM1	Dependent on both previous m marks
	$a=4\left(t-2\right)$	A1	
	$t=3,\ a=4\,(\text{m s}^{-2})$	A1	
		(8)	
b	Integrate: $\int 2\left(t-2\right)^2+3\text{d}t=\frac{2}{3}\left(t-2\right)^3+3t\left(+C\right)$ or $\int 2t^2-8t+11\text{d}t=\frac{2}{3}t^3-4t^2+11t\left(+C\right)$	M1	follow their coefficients found in (a) Accept in p, q, r
	At most one error seen	A1ft	For their coefficients
	All correct	A1ft	For their coefficients provided $\neq 0$
	$\left[\frac{2}{3}\left(t-2\right)^3+3t\right]_2^3=\left(\frac{2}{3}+9\right)-\left(0+6\right)$ or $\left[\frac{2}{3}t^3-4t^2+11t\right]_2^3$ $=\left(18-36+33\right)-\left(\frac{16}{3}-16+22\right)$	DM1	Use of $t=2, t=3$ as limits on a definite integral (or subtract distances to cancel C). Dependent on having integrated. Allow with p, q, r

Q	Scheme	Marks	Notes
	$3\frac{2}{3}$ (m)	A1	Accept exact equivalent or 3.7 or better
		(5)	
		[13]	