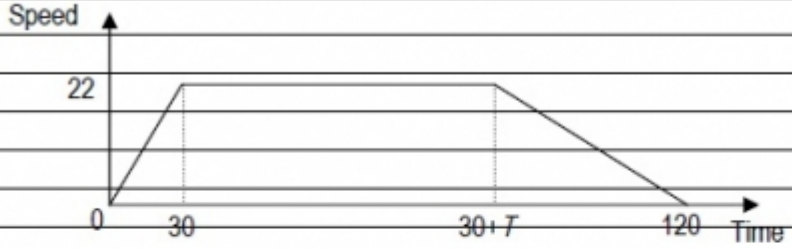
A level Applied Paper 3B Mechanics Practice Paper M13 MARK SCHEME

Question 1

Question Number	Scheme	Marks
(a)	$240=\frac{1}{2}(u+34)10$	M1 A1
	$u=14$	A1
		(3)
(b)	$34=14+10a \Rightarrow a=2$	M1 A1
	$120=14t+\frac{1}{2}\times 2\times t^2$	M1 A1
	$t^2+14t-120=0$	
	Solving, $t=-20$ or 6	DM1
	$t=6$	A1
	OR	
	$34=14+10a \Rightarrow a=2$	M1 A1
	$v^2=14^2+2\times 2\times 120 \Rightarrow v=26$	
	AND $26=14+2t$	M1 A1
	$t=6$	DM1 A1
		(6)
		[9]
Notes for Question		
Q (a)	First M1 for a complete method to produce an equation in u only. First A1 for a correct equation. ($u^2-48u+476=0$ oe is possible). Second A1 for $u = 14$.	
Q (b)	**EITHER** First M1 for an equation in a only. (M0 if $v = 34$ when $s = 120$ is used) First A1 for $a = 2$. (This may have been found in part (a)) Second M1 for a 3-term quadratic equation in t only, allow sign errors (must have found a value of a. (M0 if $v = 34$ when $s = 120$ is used) Second A1 for a correct equaton. Third M1 dependent on previous M1 for solving for t. Third A1 for $t = 6$ **OR** First M1 for an equation in a only. First A1 for $a = 2$. (This may have been found in part (a)) Second M1 for a complete method to obtain an equation in t only, allow sign errors. (must have found a value of a) Second A1 for a correct equaton. Third M1 dependent on previous M1 for solving for t. Third A1 for $t = 6$	

Question 2

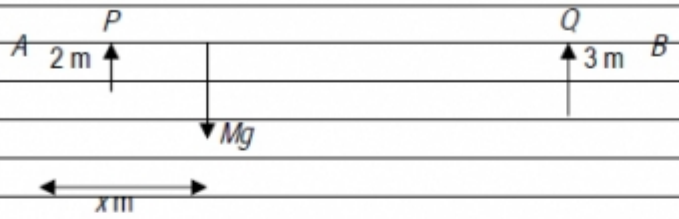
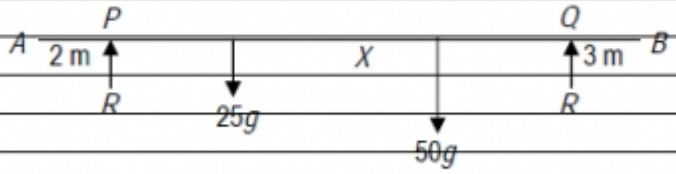
Question Number	Scheme	Marks
(a)	 Shape	B1
	Figures	B1
		(2)
(b)	$\frac{(120+T)22}{2} = 2145$	M1 A1
	$T = 75$	A1
		(3)
(c)	$\frac{(t+t-30)22}{2} = 990$	M1 A1
	$t = 60$	A1
	Answer $= 60 - 10 = 50$	A1
		(4)
(d)	$990 = 0.5a50^2$	M1
	$a = 0.79, 0.792, 99/125$ oe	A1
		(2)
		[11]

Notes for Question		
Q (a)	First B1 for a trapezium starting at the origin and ending on the *t*-axis. Second B1 for the figures marked (allow missing 0 and a delineator oe for *T*) (allow if they have used $T = 75$ correctly on their graph)	
Q (b)	First M1 for producing an equation in their *T only* by equating the area of the trapezium to 2145, with the correct no. of terms. If using a single trapezium, we need to see evidence of using ½ the sum of the two parallel sides or if using triangle(s), need to see ½ base x height. Second A1 cao for a correct equation in *T* (This is not f.t. on their *T*) Third A1 for $T = 75$. N.B. Use of a single *suvat* equation for the whole motion of the car e.g. $s = t(u+v)/2$ is M0	
Q (c)	First M1 for producing an equation in *t only* (they may use $(t - 30)$ oe as their variable) by equating the area of the trapezium to 990, with the correct no. of terms. If using a trapezium, we need to see evidence of using ½ the sum of the two parallel sides or if using triangle(s), need to see ½ base x height. First A1 for a correct equation. Second A1 for $t = 60$ (Allow 30 + 30). Third A1 for answer of 50. N.B. Use of a single *suvat* equation for the whole motion of the car e.g. $s = t(u+v)/2$ is M0. Use of the motion of the motorcycle is M0 (insufficient information). Use of $v = 22$ for the motorcycle is M0.	
Q (d)	First M1 for an equation in *a* only. First A1 for $a = 0.79, 0.792, 99/125$ oe N.B. Use of $v = 22$ for the motorcycle is M0.	

Question 3

Question Number	Scheme	Marks
(a)	For system, $(\uparrow)$, $T - 950g - 50g = 1000 \times -2$	M1 A1
	$T = 7800$ N	A1
		(3)
(b)	For woman, $(\uparrow)$, $R - 50g = 50 \times -2$	M1 A1
	$R = 390$ N	A1
		(3)
		[6]
	Notes for Question	
Q (a)	(In both parts, use the *mass* to decide which part of the system is being considered and M marks can only be scored if an equation contains only forces acting on that part of the system) M1 is for a complete method for finding T i.e. for an equation in T *only*, dimensionally correct, with the correct number of terms. First A1 for a correct equation. Second A1 for 7800 (N).	
Q (b)	M1 is for a complete method for finding R i.e. for an equation in R *only*, dimensionally correct, with the correct number of terms. First A1 for a correct equation. Second A1 for 390 (N). N.B. Equation for lift *only* is: $T - 950g - R = 950$ x (-2)	

Question 4

Question Number	Scheme	Marks
(a)		
	$\text{M}(P),\quad 50g\times 2 = Mg\times(x-2)$	M1 A1
	$\text{M}(Q),\quad 50g\times 3 = Mg\times(12-x)$	M1 A1
(i)	$M = 25$ (kg)	**DM**1 A1
(ii)	$x = 6$ (m)	**DM**1 A1
		(8)
(b)		
	$(\uparrow) R + R = 25g + 50g$	M1 A1 **ft**
	$\text{M}(A),\quad 2R + 12R = 25g\times 6 + 50g\times AX$	M1 A1 **ft**
	$AX = 7.5$ (m)	**DM**1 A1
		(6)
		[14]

Notes for Question		
Q (a)	First M1 for moments about P equation with usual rules (or moments about a different point AND vertical resolution and R then eliminated) (M0 if non-zero reaction at Q) Second M1 for moments about Q equation with usual rules (or moments about a different point AND vertical resolution) (M0 if non-zero reaction at P) Second A1 for a correct equation in M and same unknown. Third M1, dependent on first and second M marks, for solving for M Third A1 for 25 (kg) Fourth M1, dependent on first and second M marks, for solving for x Fourth A1 for 6 (m) N.B. No marks available if rod is assumed to be uniform but can score max 5/6 in part (b), provided they have found values for M and x to f.t. on. If they have just invented values for M and x in part (a), they can score the M marks in part (b) but not the A marks.	
Q (b)	First M1 for vertical resolution or a moments equation, with usual rules. First A1 **ft** on their M and x from part (a), for a correct equation. (must have *equal reactions* in vertical resolution to earn this mark) Second M1 for a moments equation with usual rules. Second A1 **ft** on their M and x from part (a), for a correct equation in R and same unknown length. Third M1, dependent on first and second M marks, for solving for AX *(not their unknown length)* with $AX \leq 15$ Third A1 for $AX = 7.5$ (m) N.B. If a single equation is used (see below), equating the sum of the moments of the child and the weight about P to the sum of the moments of the child and the weight about Q, this can score M2 A2 **ft** on their M and x from part (a), provided the equation is in one unknown. Any method error, loses both M marks. e.g. $25g.4 + 50g(x-2) = 25g.6 + 50g(12-x)$ oe.	

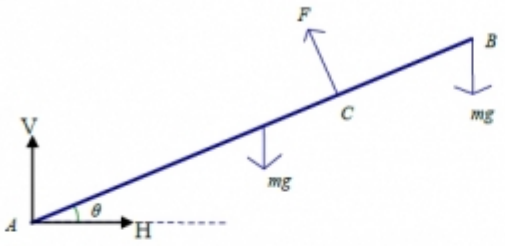
Question 5

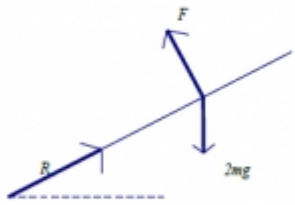
Question Number	Scheme	Marks
	$T\cos\alpha - F = 2g\cos 60^\circ$	M1 A1
	$T\sin\alpha + R = 2g\cos 30^\circ$	M1 A1
	$F = \frac{1}{3}R$	B1
	eliminating F and R	**DM1**
	$T = g(1+\frac{1}{\sqrt{3}})$, 1.6g (or better), 15.5, 15 (N)	**DM1** A1
		(8)
		[8]
Notes for Question		
Q	First M1 for resolving parallel to the plane with correct no. of terms and both T and $2g$ terms resolved. First A1 for a correct equation. (use of α instead of 30° or 60° or vice versa is an A error not M error; similarly if they use sin(3/5) or cos(4/5) when resolving, this can score M1A0) Second M1 for resolving perpendicular to the plane with correct no. of terms and both T and $2g$ terms resolved. Second A1 for a correct equation (use of α instead of 30° or 60° or vice versa is an A error not M error; similarly if they use sin(3/5) or cos(4/5) when resolving, this can score M1A0) B1 for $F = 1/3\ R$ seen or implied. Third M1, dependent on first two M marks and appropriate angles used when resolving in *both* equations, for eliminating *F and R*. Fourth M1 dependent on third M1, for solving for T Third A1 for 15(N) or 15.5 (N). N.B. The first two M marks can be for two resolutions in any directions. Use of tan α = 4/3 leads to an answer of 17.83…and can score max 7/8.	

Question 6

Question Number	Scheme	Marks
(a)	For A, $T = 2ma$	B1
	For B, $3mg - T = 3ma$	M1 A1
	$3mg = 5ma$	**DM1**
	$\frac{3g}{5} = a$ (5.9 or 5.88 m s^{-2})	A1
		(5)
(b)	$T = 6mg/5$; $12m$; $11.8m$	B1
		(1)
(c)	$F = \sqrt{T^2 + T^2}$	M1 A1 **ft**
	$F = \frac{6mg\sqrt{2}}{5}$; $1.7mg$ (or better); $16.6m$; $17m$	A1
	Direction clearly marked on a diagram, with an arrow, and 45° (oe) marked	B1
		(4)
		[10]
	Notes for Question	
Q (a)	B1 for $T = 2ma$ First M1 for resolving vertically (up or down) for B, with correct no. of terms. (allow omission of m, provided 3 is there) First A1 for a correct equation. Second M1, dependent on first M1, for eliminating T, to give an equation in a only. Second A1 for 0.6g, 5.88 or 5.9. N.B. 'Whole system' equation: $3mg = 5ma$ earns first 4 marks but any error loses all 4.	
Q (b)	B1 for $\frac{6mg}{5}$, $11.8m$, $12m$	
Q (c)	M1 $\sqrt{(T^2 + T^2)}$ or $\frac{T}{\sin 45°}$ or $\frac{T}{\cos 45°}$ or $2T\cos 45°$ or $2T\sin 45°$ (allow if m omitted) (M0 for $T \sin 45°$) First A1 ft on their T. Second A1 cao for $\frac{6mg\sqrt{2}}{5}$ oe, $1.7mg$ (or better), $16.6m$, $17m$ B1 for the direction clearly shown on a diagram with an arrow and 45° marked.	

Question 7

Question Number	Scheme	Marks	Notes
a			
	Moments about A:	M1	Moments about A. Requires all three terms and terms of correct structure (force x distance). Condone consistent trig confusion
	$bF = a\cos\theta mg + 2a\cos\theta mg (= 3a\cos\theta mg)$	A2	-1 each error
	$F = \frac{3amg\cos\theta}{b}$ ***Answer given***	A1 [4]	
b	$\rightarrow: \quad H = F\sin\theta = \frac{3amg\cos\theta\sin\theta}{b}$	M1	Resolve horizontally. Condone trig confusion
		A1	RHS correct. Or equivalent.
	$\uparrow: \quad 2mg = \pm V + F\cos\theta$	M1	Resolve vertically. Condone sign error and trig confusion
		A1	Correct equation
	$\pm V = 2mg - \frac{3amg\cos\theta}{b}\times\cos\theta \left(= 2mg - \frac{3amg\cos^2\theta}{b}\right)$	A1 [5]	RHS correct. Or equivalent

Question Number	Scheme	Marks	Notes
c	$\dfrac{2mg-\dfrac{3amg\cos^2\theta}{b}}{\dfrac{3amg\cos\theta\sin\theta}{b}}=\tan\theta$ $\dfrac{2b-3a\cos^2\theta}{3a\cos\theta\sin\theta}=\dfrac{\sin\theta}{\cos\theta}$ $\Rightarrow 2b-3a\cos^2\theta=3a\sin^2\theta\Rightarrow 2b=3a,\ \dfrac{a}{b}=\dfrac{2}{3}$	M1 A1 DM1 A1 [4]	Use of tan, either way up. V, H, F substituted. Correct for their components in θ only Simplify to obtain the ratio of a and b, or equivalent
c alt 2	The centre of mass of the combined rod + particle is $\dfrac{3}{2}a$ from A  3 forces in equilibrium must be concurrent $\Rightarrow b=\dfrac{3}{2}a$ $\Rightarrow\dfrac{a}{b}=\dfrac{2}{3}$	M1A1 M1 A1 [4]	Not on the spec, but you might see it.
alt c 3	R acts along the rod, so resolve forces perpendicular to the rod. $F=mg\cos\theta+mg\cos\theta$ $2mg\cos\theta=\dfrac{3amg\cos\theta}{b}$ $\Rightarrow\dfrac{a}{b}=\dfrac{2}{3}$	M1 A1 DM1 A1 [4]	Resolve and substitute for F Eliminate θ

Question Number	Scheme	Marks	Notes
alt c 4	R acts along the rod. Take moments about C $mg\cos\theta\ \ 2a-b\ =mg\cos\theta\ \ b-a$ $2a-b=b-a,\quad\Rightarrow\dfrac{a}{b}=\dfrac{2}{3}$	M1 A1 DM1A1 [4]	Moments about B gives $2a-b\ \ F=amg\cos\theta$ and substitute for F
c alt 5	Resultant parallel to the rod $\Rightarrow R=2mg\sin\theta$ And $V^2+H^2=R^2$ $2mg\sin\theta\ ^2=\left(\dfrac{3amg\cos\theta\sin\theta}{b}\right)^2+\left(2mg-\dfrac{3amg\cos^2\theta}{b}\right)^2$ Eliminate θ $\Rightarrow\dfrac{a}{b}=\dfrac{2}{3}$	M1 A1 DM1 A1 [4]	Substitute for V, H and R in terms of θ

Question 8

Question Number	Scheme	Marks
(a)	$t = 0$ gives $\mathbf{v} = \mathbf{i} - 3\mathbf{j}$	B1
	speed $= \sqrt{1^2 + (-3)^2}$	M1
	$= \sqrt{10} = 3.2$ or better	A1
		(3)
(b)	$t = 2$ gives $\mathbf{v} = (-3\mathbf{i} + 3\mathbf{j})$	M1
	Bearing is 315°	A1
		(2)
(c)(i)	$1 - 2t = 0 \Rightarrow t = 0.5$	M1 A1
(ii)	$-(3t - 3) = -3(1 - 2t)$	M1 A1
	Solving for t	**DM**1
	t = 2/3, 0.67 or better	A1
		(6)
		[11]
	Notes for Question	
Q (a)	B1 for **i** – 3**j**. M1 for √ (sum of squares of cpt.s) A1 for √10, 3.2 or better	
Q (b)	M1 for clear attempt to sub $t = 2$ into given expression. A1 for 315.	
Q (c)	**(i)** First M1 for $1 - 2t = 0$. First A1 for $t = 0.5$. N.B. If they offer two solutions, by equating both the **i** and **j** components to zero, give M0. **(ii)** First M1 for $\frac{1-2t}{3t-3} = \pm(\frac{-1}{-3})$ o.e. (Must be an equation in t *only*) First A1 for a correct equation (the + sign) Second M1, dependent on first M1, for solving for t. Second A1 for 2/3, 0.67 or better.	

Question 9

Question Number	Scheme	Marks	Notes
a	$v=0=2t^2-14t+20$ $=2\ t-2\ \ t-5$ $t=2$ or $t=5$	M1 M1 A1 [3]	Set $v=0$ Solve for t
	There are many different approaches to part (b). The allocation of the two M marks is M1: A method to find the time when the velocity is a minimum M1: Evaluate the speed at that time		
e.g. b	$t=0$, $v=20$ (m s^{-1}) $a=4t-14=0$ $t=\frac{7}{2}$, $v=2\times\frac{3}{2}\times\frac{-3}{2}=\frac{-9}{2}$ Max speed = 20 ms^{-1}	B1 M1 M1A1 A1 [5]	 Must see ±4.5 Clearly stated & correct conclusion. Depends on the two M marks. From correct solution only.
balt1	$t=0$, $v=20$ (m s^{-1}) Sketch with symmetry about their $t=3.5$ v(their 3.5) -4.5 Max speed = 20 ms^{-1}	B1 M1 M1 A1 A1 [5]	 Evaluate v at min. Correct work Clearly stated & correct conclusion. Depends on the two M marks. From correct solution only.
b alt 2	$t=0$, $v=20$ (m s^{-1}) Justification of minimum or tabulate sufficient values to confirm location Evaluate v at min. Correct work Correct conclusion. Depends on the two M marks	B1 M1 M1 A1 A1 [5]	 Clearly stated & from correct solution only.

Question Number	Scheme	Marks	Notes
b alt 3	$t=0$, $v=20$ (m s^{-1}) Complete the square as far as $\left(t-\frac{7}{2}\right)^2$ $2\left(t-\frac{7}{2}\right)^2-\frac{9}{2}$ Max speed = 20 ms^{-1}	B1 M1 M1A1 A1 [5]	 Clearly stated & correct conclusion. Depends on the two M marks. From correct solution only.
c	$\int 2t^2-14t+20\ dt=\frac{2}{3}t^3-7t^2+20t(+C)$ Distance $=\left[\frac{2}{3}t^3-7t^2+20t\right]_0^2-\left[\frac{2}{3}t^3-7t^2+20t\right]_2^4$ $=2\times\left[\frac{2}{3}t^3-7t^2+20t\right]_0^2-\left[\frac{2}{3}t^3-7t^2+20t\right]_4$ $=2\left[\frac{16}{3}-7\times4+40\right]-\left[\frac{2\times64}{3}-7\times16+80\right]=24$ (m)	M1 A1 M1 A1 A1 [5]	Integration. Need to see majority of powers going up All correct. Condone C missing Correct method to find the distance, for their 2 Correct unsimplified

Question 10

Question Number	Scheme	Marks	Notes
a	Conservation of energy: $\frac{1}{2}mu^2 + mg \times 8 = \frac{1}{2}m\ 2u\ ^2$ $mu^2 + 16mg = 4mu^2$ $16mg = 3mu^2, \quad u = \sqrt{\frac{16g}{3}}$ $u = 7.2$	M1 A2 -1ee DM1 A1 [5]	Energy equation must contain the correct terms, but condone sign error. Correct unsimplified Solve for u Accept 7.23. Accept $\sqrt{\frac{16g}{3}}$
b	Vertical distance: $-8 = u\sin\theta \times 2 - \frac{g}{2} \times 4$ $\sin\theta = \frac{2g-8}{2u} = 0.802...$ $\theta = 53.3°$	M1 A2 -1ee A1 [4]	Condone sign errors or trig error. u must be resolved. Correct equation for their u. or $53°$
c	Min speed at max height, i.e. $u\cos\theta$ $= 4.3$ (m s^{-1})	M1 A1 [2]	Condone consistent trig confusion with part (b) or 4.32 (ms^{-1})