A level Applied Paper 3B Mechanics Practice Paper J13 MARK SCHEME

Question 1

Question Number	Scheme	Marks
(a)	$30^2 = 2a.300$ $a = 1.5$	M1 A1 (2)
(b)	$0^2 = 30^2 - 2 \times 1.25s$ OR $0 = 30 - 1.25t_2$ $s = 360$ $t_2 = 24$ $300 + 30T + 360 = 1500$ $\frac{(20+T+24+T)}{2} \times 30 = 1500$ $T = 28$ $T = 28$	M1 A1 M1 A1 A1 (5)
(c)	triangle, *drawn on the diagram*, with base coinciding with base of trapezium, top vertex above line $v = 30$ and meeting trapezium at least once V marked correctly	B1 DB1 (2)
(d)	$30 = 1.5t_1 \Rightarrow t_1 = 20$ $30 = 1.25t_2 \Rightarrow t_2 = 24$ $\frac{1}{2}(20 + 28 + 24)V = 1500$ $V = \frac{750}{18} = 41.67$ $= \frac{125}{3}$ (oe) 0r 42 (or better)	M1 A1 A1 M1 A1 A1 (6)

Question 2

Question Number	Scheme	Marks
(a)	$M(D)$, $8R = (80g \text{ x } 6) + (200g \text{ x } 4)$ $R = 160g,\ 1600,\ 1570$	M1 A1 A1 (3)
(b)	$(\uparrow)$, $2S = 80g + 200g$ $S = 140g,\ 1400,\ 1370$	M1 A1 (2)
(c)	$M(B)$, $Sx + (S \text{ x } 10) = (80g \text{ x } 8) + (200g \text{ x } 6)$ $140x + 1400 = 640 + 1200$ $140x = 440$ $x = \frac{22}{7}$	M1 A2 A1 (4) **9**

Question 3

Question Number	Scheme	Marks
	$(\uparrow)$, $T\cos 30 + F\cos 60 = 2g$ $(\rightarrow)$, $T\cos 60 - F\cos 30 = 0$ $F = g = 9.8$ $T = \sqrt{3}g = 17$ or 17.0	M1 A1 M1 A1 M1 A1 M1 A1 **8**
OR:	( ), $F = 2g\cos 60$ ( ), $T = 2g\cos 30$ $F = g = 9.8$ $T = \sqrt{3}g = 17$ or 17.0	M1 A1 M1 A1 M1 A1 M1 A1 **8**

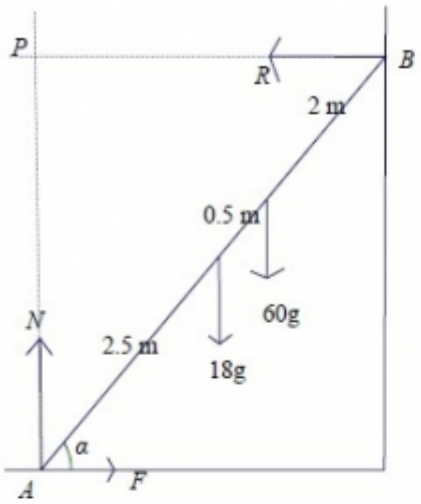
Question 4

Question Number	Scheme	Marks
	$12.6^2 = 2a.50 \qquad (\Rightarrow a = 1.5876)$	M1 A1
	$800g\sin 15 - F = 800a$	M1 A1
	$R = 800g\cos 15$	M1 A1
	$F = \mu R$	B1
	$800g\sin 15 - \mu 800g\cos 15 = 800 \text{ x } 1.5876$	M1
	$\mu = 0.1, 0.10, 0.100$	A1
		9

Question 5

Q	Scheme	Marks	
		B1	
(a)	$t=\frac{5}{4}$	M1	1.25
(b)	$\mathbf{r}=\left(2t^2-5t\right)\mathbf{i}+3t\mathbf{j}\left(+\mathbf{c}\right)$		Integrate the velocity vector
		A1	NB Also correct to use suvat with $\boldsymbol{a} = 4\mathbf{i}$ and $\boldsymbol{u} = -5\mathbf{i} + 3\mathbf{j}$.
		DM1	Correct
	$t=0 \quad 2\mathbf{i}+5\mathbf{j}=\mathbf{c}$	A1	Use $\mathbf{r}_0$ to find C
	$\mathbf{r}=\left(2t^2-5t\right)\mathbf{i}+3t\mathbf{j}+\left(2\mathbf{i}+5\mathbf{j}\right)$		oe
	$(2t^2 - 5t + 2)\mathbf{i} + (3t + 5)\mathbf{j}$	B1	
(c)	$\mathbf{r}_Q=11\mathbf{i}+2\mathbf{j}-2t\mathbf{i}+ct\mathbf{j}$		Correct **j** component of $\mathbf{r}_Q$
	$(11 - 2t)\mathbf{i} + (2 + ct)\mathbf{j}$		Do not actually require the whole thing - can answer the Q by considering only the **j** component.
	$\mathbf{r}_P=\left(2t^2-5t+2\right)\mathbf{i}+\left(3t+5\right)\mathbf{j}$		
	$\mathbf{r}_Q=\mathbf{r}_P=d\mathbf{i}+14\mathbf{j}$	$2t^2-5t$	
	$3t+5=14$ | $2t^2 - 3t - 9$	M1	Form an equation in t only
	$(2t + 3)(t - 3) = 0$		
	$t=3$		
	$t=3$ | A1 ft	A1	
	$2+ct=14 \Rightarrow c=4$	A1 ft	Their t
	$d=11-2\times3=5$ or		Their t
	$d=2\times3^2-5\times3+2\Rightarrow d=5$		
	Alt: $2t^2-5t+2=11-2t=d \Rightarrow t=\frac{11-d}{2}$		
	$2\left(\frac{11-d}{2}\right)^2-5\left(\frac{11-d}{2}\right)+2=d,$		
	$d^2-19d+70=0=(d-5)(d-14)$		

Question 6

Q	Scheme	Marks	
			
	$F = \mu N$	B1	Used. Condone an inequality.
	R$(\uparrow)$ $18g + 60g = N$ $=78g$	M1 A1	Resolve vertically
	R$(\rightarrow)$ $R = F = \mu N$		
P	$2.5 \times 18g\cos\alpha + 3 \times 60g\cos\alpha = 5F\sin\alpha$	M1A2	Moments equation. Condone sign errors. Condone sin/cos confusion
A	$18g \times 2.5\cos\alpha + 60g \times 3\cos\alpha = R \times 5\sin\alpha$		-1 each error
C	$\frac{1}{2}\cos\alpha \times 18g + 3\sin\alpha F + 2\sin\alpha R = 3\cos\alpha N$		
B	$5\cos\alpha N = 5\sin\alpha F + 2.5\cos\alpha \times 18g + 2\cos\alpha \times 60$		
W	$60g \times \frac{1}{2}\cos\alpha + 2.5N\cos\alpha = 2.5R\sin\alpha + 2.5F\sin\alpha$		
	$45\times\frac{3}{5}g + 180\times\frac{3}{5}g = 4R$	DM1	Eliminate α. Dependent on the second M1.
	$R = \frac{135}{4}g$		
	$78g\mu = \frac{135}{4}g$	DM1	Equation in μ only. (Dependent on the first two M marks.)
	$\mu = \frac{135}{4\times 78} = \frac{135}{312} = 0.432... = 0.43$	A1	NB g cancels. 0.43269..., $\frac{225}{520}$, $\frac{45}{104}$, awrt 0.433 Do not accept an inequality.
	NB If use just two moments equations, M1A2 for the better attempt, M1A1 for the other. Remaining marks as above.		

Question 7

Question Number	Scheme	Marks
(a)	$\frac{(\mathbf{i}-4\mathbf{j})-(4\mathbf{i}-8\mathbf{j})}{0.5};(\pm 6\mathbf{i} \pm 8\mathbf{j})$	M1 A1
	$\sqrt{(\pm 6)^2+(\pm 8)^2}=10$	M1 A1 (4)
(b)	$\mathbf{r}=(4\mathbf{i}-8\mathbf{j})+t(-6\mathbf{i}+8\mathbf{j})$ $=(4\mathbf{i}-8\mathbf{j})-6t\mathbf{i}+8t\mathbf{j}$ $=(4-6t)\mathbf{i}+(8t-8)\mathbf{j}$ *	M1 A1 (2)
(c)	At 10 am, $\mathbf{r}=-2\mathbf{i}$ At 10.30 am, $\mathbf{r}=-5\mathbf{i}+4\mathbf{j}$ $\mathbf{l}=k\mathbf{i},\ k<-2$ $k=-5-4=-9$ $\mathbf{l}=-9\mathbf{i}$	M1 A1 A1 DM1 A1 (5)
		11

Question 8

Question Number	Scheme	Marks
(a)	Inextensible string	B1 (1)
(b)	$4mg - T = 4ma$ $T - 2mg\sin\alpha - F = 2ma$	M1A1 M1A1 (4)
(c)	$F = 0.25R$ $R = 2mg\cos\alpha$ $\cos\alpha = 0.8$ or $\sin\alpha = 0.6$ Eliminating R, F and T $a = 0.4g = 3.92$	B1 B1 B1 M1 A1 (5)
(d)	$v^2 = 2 \times 0.4gh$ $-2mg\sin\alpha - F = 2ma'$ $a' = -0.8g$ $0^2 = 0.8gh - 2 \times 0.8g \times s$ $s = 0.5h$ $XY = 0.5h + h = 1.5h$	M1 M1 A1 M1 A1 A1 (6) **16**

Question 9

Q.	Scheme	Marks	
(a)	$2 = -2u\sin\theta + \frac{1}{2}g\times 4$	M1	Vertical distance. Condone sign errors. Must have used $t = 2$, but could be using $u_y = u\sin\theta$
	$\left(-2 = u\sin\theta t - \frac{1}{2}gt^2\right)$	A1	All correct
	$u\sin\theta = g - 1$		
	$2u\cos\theta = 8 \quad (u\cos\theta = 4)$	B1	Horizontal distance. Accept $u_x = 4$ o.e.
	$(u\cos\theta t = 8)$		
	$\tan\theta = \frac{g-1}{4} = 2.2$ *	M1	Divide to obtain expression for $\tan\theta$
		A1	**Given answer** It is acceptable to quote and use the equation for the projectile path. Incorrect equation is 0/5.
(b)	$u\cos\theta = 4$	M1	Use the horizontal distance and θ to find u 9.67 or 9.7
	$u = \frac{4}{\cos\theta} = 9.66... = 9.7$	A1	NB $\theta = 65.6°$ leading to 9.68 is an accuracy penalty.
	OR use components from (a) and Pythagoras.		
(c)	$6 = (1-g)T + \frac{1}{2}\times 9.8T^2$	M1	Equation for vertical distance $= \pm 6$ to give a quadratic in T. Allow their u_y
	$4.9T^2 - 8.8T - 6 = 0$		
	$T = \frac{8.8 \pm \sqrt{\left[(-)8.8\right]^2 + 24\times 4.9}}{9.8}$	DM1	Solve a 3 term quadratic
	$T = 2.323... = 2.32$ or 2.3	A1	2.3 or 2.32 only
(d)	$v^2 = 8.8^2 + 2g\times 6$ or $v = -8.8 + gT$	M1	Use *suvat* to find vertical speed
		A1	Correct equation their u_y, T
	$v = 13.96...$		
	Horiz speed = 4		
	$\tan\alpha = \frac{v}{4}$	DM1	Correct trig. with their vertical speed to find the required angle.
		A1	Correct equation
	$\alpha = 74.01... = 74°$	A1	$74°$ or $74.0°$. Allow 106.
	Alternative:		
	$\frac{1}{2}m(9.8664)^2 + 6mg = \frac{1}{2}mv^2$	M1	Conservation of energy to find speed
	$v = 14.52719...$	A1	
	$\cos\alpha = \frac{4}{14.5}$	DM1	Correct method for α
		A1	
	$\alpha = 74.01... = 74°$	A1	Allow 106