

Topic X8 Mechanics (Post-TT A) [56] MARKSCHEME

1.

1	$\mathbf{r} = (-4.5\mathbf{i} + 3\mathbf{j})$	B1	1.1b
	Use of $\mathbf{r} = \mathbf{u}t + \frac{1}{2}\mathbf{a}t^2$	M1	3.1b
	$(-4.5\mathbf{i} + 3\mathbf{j}) = 3\mathbf{u} + 0.5(\mathbf{i} - 2\mathbf{j}) 3^2$	A1ft	1.1b
	$\mathbf{u} = (-3\mathbf{i} + 4\mathbf{j})$	A1	1.1b
		(4)	

2.

(i)	$x = v\cos\theta t$	B1	
	$y = v\sin\theta t - \frac{1}{2} \times 9.8 t^2$	B1	or g
	substitute $t = x/v\cos\theta$	M1	
	$y = x\tan\theta - 4.9x^2/v^2 \cos^2 \theta$	A1 4	AG
(ii)	Sub $y = -h$, $x = h$, $v = 14$, $\theta = 30$	M1	signs must be correct
	$-h = h/\sqrt{3} - h^2/30$	A1	aef
	solving above	M1	
	$h = 47.3$	A1 4	
(iii)	$v_v^2 = (14\sin 30^\circ)^2 - 2 \times 9.8 \times (-47.3)$	M1	$14\cos 30^\circ t = 47.3$ ft & $v_v = 14\sin 30^\circ - 9.8t$
	(double negative needed) ft their -47.3	A1 ft	$t = 3.90$ (or $dy/dx = 1/\sqrt{3} - x/15$ etc ft)
	$v_v = \pm 31.2$	A1	$v_v = \pm 31.2$ ($\tan \alpha = 1/\sqrt{3} - 47.3/15$)
	$\tan^{-1}(31.2/14\cos 30^\circ)$	M1	$\tan^{-1}(31.2/14\cos 30^\circ)$
	$\alpha = 68.8^\circ$ below horiz/21.2° to d'vert.	A1 5	68.8°/.....
(iv)	$\frac{1}{2}mv^2 + mv \times 9.8 \times 47.3 = \frac{1}{2}mv^2$	M1	ft ($12.1^2 + 31.2^2$)
	$v = 33.5$	A1 2	15

3.

2	Differentiate wrt t	M1	1.1a
	$\mathbf{a} = (2t - 3)\mathbf{i} - 12\mathbf{j}$	A1	1.1b
	$(2t - 3)^2 + (-12)^2$	M1	1.1b
	$(2t - 3)^2 + (-12)^2 = (6.5 / 0.5)^2$ oe	M1	2.1
	$4t^2 - 12t - 16 = 0$	A1	1.1b
	$(t - 4)(t + 1) = 0$	M1	1.1b
	$t = 4$	A1	1.1b
		(7)	

4.

4(a)	Moments about A (or any other complete method)	M1	3.3
	$T \cos 30^\circ \times (1 \sin 30^\circ) = 20g \times 1.5$	A1	1.1.b
	$T \cos 30^\circ \times (1 \sin 30^\circ) = 20g \times 1.5$	A1	1.1.b
	$T = 679$ or 680 (N)	A1	1.1.b
		(4)	
(b)	Resolve horizontally	M1	3.1b
	$X = T \cos 60^\circ$	A1	1.1b
	Resolve vertically	M1	3.1b
	$Y = T \cos 30^\circ - 20g$	A1	1.1b
	Use of $\tan \theta = \frac{Y}{X}$ and sub for T	M1	3.4
	49° (or better), below horizontal, away from wall	A1	2.2a
		(6)	
(c)	Tension would increase as you move from D to C	B1	3.5a
	Since each point of the rope has to support the length of rope below it	B1	2.4
		(2)	
(d)	Take moments about G , $1.5Y = 0$	M1	3.3
	$Y = 0$ hence force acts horizontally.*	A1*	2.2a
		(2)	

5.

6i	$4.9 = \mu \times 14.7$ $\mu = 1/3$	AG	M1 A1	Uses $F = \mu R$ Allow 0.333 or 0.3 recurring
6iia	$R + 4.9 \sin 30 = 14.7$ $R = 12.25$ N $F = 12.25 \times 1/3$ $F = 4.08(333...) \text{ N}$ [or 49/12 N]		[2] M1 A1 A1 M1 A1	3 force vertical equation Accept 12.2 or 12.3 Uses $F = \mu R$ with new R {may be seen in part b}
6iib	$m = 14.7/9.8 = 1.5$ kg $4.9 \cos 30 - 4.08(333...) = 1.5a$ $a = 0.107 \text{ ms}^{-2}$		[5] B1 M1 A1 A2	N2L horizontally with 2 relevant forces, including $4.9 \sin / \cos 30$ Allow cv(F) SR Award A1 if $m=14.7$ used SR A1 for 0.11, 0.109 or art 0.011 from $m = 14.7$
6iic	$\mu R = (14.7 - 4.9 \cos 30)/3$ Horizontal component of force = $4.9 \sin 30$ Horizontal component of force < $\textcircled{3}R$ Friction = 2.45 N		[5] B1 B1 M1 A1 [4]	3.49, accept 3.5 2.45, accept 2.4 or 2.5 Comparing two values Not 2.4 or 2.5; Explicit (M1 essential)