Mechanics 2 Circular Motion

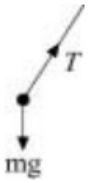
2(a)	$T\cos 30° = 2\times 9.8$ $T = \dfrac{2\times 9.8}{\cos 30°}$ AG	M1 A1		Resolving vertically with two terms Correct equation
	$T = 22.6$ N	A1	3	Correct T from correct working
(b)	$T\cos 60° = 2\times\dfrac{v^2}{0.6}$	M1		Resolving horizontally.
		A1		Correct equation
	$v = 1.84$ ms^{-1}	dM1		Solving for v
		A1	4	Correct v
	Total		**7**	

7(a)	$\frac{1}{2}mv^2 = \frac{1}{2}m\times 2^2 + mg(3-3\cos\theta)$	M1		Three term energy equation.
		A1		Correct equation
	$v^2 = 4 + 6g(1-\cos\theta)$	dM1		Solving for v^2
		A1	4	Correct result from correct working
(b)	$mg\cos\theta = m\dfrac{v^2}{3}$	M1		Resolving towards the centre
		A1		Correct equation
	$3g\cos\theta = 4 + 6g - 6g\cos\theta$	dM1		Solving for $\cos\theta$
	$\cos\theta = \dfrac{4+6g}{9g}$	A1		Correct $\cos\theta$
	$\theta = 44.6°$	A1	5	Correct angle
	Total		**9**	

4(a)	$\frac{1}{2}mU^2 = \frac{1}{2}mv^2 + mgl(1-\cos 60°)$	M1		three/four term energy equation with a trig term
	$U^2 = v^2 + gl$	A1		correct equation
		dM1		solving for v or v^2
	$v = \sqrt{U^2 - gl}$	A1	4	correct v in a simplified form
(b)	$T - mg\cos 60° = m\dfrac{v^2}{l}$	M1		resolving towards the centre of the circle with three terms
	$T = m\left(\dfrac{U^2-gl}{l} + \dfrac{g}{2}\right) = m\left(\dfrac{U^2}{l} - \dfrac{g}{2}\right)$	dM1		substituting for v^2
		A1		correct equation
		dM1		making T the subject
		A1	5	correct expression for T. Simplification not necessary.
(c)	$T - mg = m\dfrac{U^2}{l}$	M1		considering the vertical forces and using Newton's second law with $\dfrac{U^2}{l}$
	$T = m\left(\dfrac{U^2}{l} + g\right)$	A1	2	correct T
	Total		**11**	

6(a)	$a = \frac{14^2}{50} = 3.92$	M1		finding acceleration
		A1		correct acceleration
	$F = 1200 \times 3.92$ AG	dM1		use of $F = ma$
	$= 4704$ N	A1	4	correct force from correct working
(b)	$R = 1200 \times 9.8 = 11760$	B1		normal reaction
	$4704 \leq \mu \times 11760$	M1		applying $F \leq \mu R$ or $F = \mu R$
	$\mu \geq \frac{4704}{11760}$ AG			
	$\mu \geq 0.4$	A1	3	correct result from correct working
	Total		**7**	

3(a)	$mg\ 2a = \frac{1}{2} mv^2$	M1		Energy equation
		A1		
	$v = 2\sqrt{ga}$	A1	3	
(b)	$T - mg = \frac{mv^2}{2a}$	M1		All terms for M1, no component
		A1		
	$T = 3mg$	A1F	3	ft if $T > 0$
	Total		**6**	

6(a)	$\frac{40\times 2\pi}{60} = \frac{4\pi}{3}$ (rad/sec)	M1 A1	2	
(b)	$a=\omega^2 r = \left(\frac{4\pi}{3}\right)^2 \times 0.2$	M1		
	$= \frac{16\pi^2}{45}$	A1	2	Accept $0.356\,\pi^2$ (3sf)
(c)(i)		B1	1	
(ii)	**Vertically** No acceleration, forces balance $mg = T\cos\theta$	B1	1	
(iii)	**Horizontally**			
	$T\sin\theta = m\times\frac{16\pi^2}{45}$	M1 A1F		ft acceleration
	$T\cos\theta = mg$	m1		SC $\tan\theta = \frac{\omega^2 r}{g}$ 1st 3 marks for quoting and using correctly
	$\tan\theta = \frac{16\pi^2}{45g}$ or $\tan\theta = 0.358(08)$	A1F		ft provided M1
	$\theta = 20°$	A1F	5	earned in (b)
	Total		**11**	

5(a)	Using conservation of energy (lowest and highest points):	M1		
	$\frac{1}{2}m(7v)^2 = \frac{1}{2}mv^2 + 2mga$	A1A1		A1 for $7v$ and v
	$\frac{48}{2}v^2 = 2ga$	M1		Needs 48 or 24
	$\therefore v = \sqrt{\frac{ag}{12}}$	A1	5	AG
(b)	Velocity at A is $\sqrt{\frac{ag}{12}}$			
	Resolving vertically at A:	M1		3 terms
	$m\frac{v^2}{a} + R = mg$	A1,A1		A1 correct 3 terms, A1 correct signs
	$R = mg - \frac{m}{a}\times\frac{ag}{12}$			$\left(1-\frac{1}{12}\right)mg$ M1A2
	$= \frac{11}{12}mg$	A1	4	Condone $-\frac{11}{12}mg$
	Total		**9**	

8(a)	Q is in equilibrium $T = 5g = 49$ N	E1 B1	 2	Q at rest, or not moving AG
(b)	Resolving vertically for P: $T\cos\theta = 3g$ $\cos\theta = \frac{3}{5}$ $\theta = \cos^{-1}\frac{3}{5} = 53.1°$	 M1A1 A1	 3	 Do not condone 53°
(c)	$\therefore \sin\theta = \frac{4}{5}$ Resolving horizontally for P: $\frac{mv^2}{r} = T\sin\theta$ $\frac{3v^2}{r} = \frac{4}{5}\times 5g$ $\frac{3\times 4^2}{r} = 4g$ $r = \frac{48}{4g}$ $= 1.22$	B1 M1A1 A1	 4	 M1 2 terms: 1 term correct, other term includes sin or cos SC3 1·23
	Total		**9**	