AQA Maths M2

Topic Questions from Papers

Circular Motion

Answers

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

(Q2, Jan 2006)

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

(Q6, Jan 2006)

3 (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
	$v = \sqrt{U^2 - gl}$	dM1 A1	4	solving for v or v^2 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 A1 dM1 A1	5	substituting for v^2 correct equation making T the subject correct expression for T. Simplification not necessary.
	Total		**9**	

(Q4, June 2006)

4 **(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
	$4704 \le \mu \times 11760$	M1		applying $F \le \mu R$
	$\mu \ge \frac{4704}{11760}$ AG	A1	3	correct result from correct working
	$\mu \ge 0.4$			
	Total		**7**	

(Q5, June 2006)

5 **(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**	

(Q3, Jan 2007)

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
	$\theta = 20^\circ$	A1F	5	earned in (b)
	Total		**11**	

(Q6, Jan 2007)

7 (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**	

(Q5, June 2007)

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:			
	$T\cos\theta = 3g$	M1A1		
	$\cos\theta = \frac{3}{5}$			
	$\theta = \cos^{-1}\frac{3}{5} = 53.1°$	A1	3	Do not condone 53°
(c)	$\therefore \sin\theta = \frac{4}{5}$	B1		
	Resolving horizontally for P:			
	$\frac{mv^2}{r} = T\sin\theta$	M1A1		M1 2 terms: 1 term correct, other term includes sin or cos
	$\frac{3v^2}{r} = \frac{4}{5} \times 5g$			
	$\frac{3 \times 4^2}{r} = 4g$			
	$r = \frac{48}{4g}$			
	$= 1.22$	A1	4	SC3 $1\cdot23$
	Total		**9**	

(Q8, June 2007)

9 (a)	Acceleration is $\frac{v^2}{r}$			
	$= \frac{2^2}{0.2}$	M1		
	$= 20$ m s^{-2}	A1	2	
(b)	$\theta = 30°$	B1		
	Resolve vertically:			
	$T_1 \cos\theta = mg$	M1		
	$T_1 \cos\theta = 4g$	A1		
	$T_1 = 45.3$ N	A1	4	AG
(c)	Resolve horizontally:			
	$T_1 \sin\theta + T_2 = \frac{mv^2}{r}$	M1A1		M1 for 3 terms, 2 correct
	$45.3\sin\theta + T_2 = 4 \times 20$			
	$T_2 = 57.4$ N	A1	3	Condone 57.3 N
	Total		**9**	

(Q5, Jan 2008)

10 (a)	Conservation of energy:			
	$\frac{1}{2}m\left(3\sqrt{ag}\right)^2 + mg2a = \frac{1}{2}mv^2$	M1A1		M1 for 3 terms: 2 KE and PE
	$\frac{9}{2}mga + 2mga = \frac{1}{2}mv^2$	A1		
	$v = \sqrt{13ag}$	A1	4	
(b)	At A, consider vertical forces:			
	$T - mg = \frac{mv^2}{a}$	M1A1		M1 for 3 terms, 2 correct
	$T = mg + 13mg$	m1		
	$T = 14mg$	A1ft	4	ft from (a)
	Total		**8**	

(Q7, Jan 2008)

11 **(a)**	At top, for complete revolutions:			
	$\frac{mv^2}{a} = mg$ where v is speed at top	M1		
	$\therefore\ v^2 = ag$	A1		
	Conservation of energy from B to top :			
	$\frac{1}{2}mv^2 + mg2a = \frac{1}{2}mu^2$	M1 A1		3 terms, 2 KE and PE
	$u^2 = 4ag + v^2$			
	$= 5ag$			
	$u = \sqrt{5ag}$	A1	5	AG
(b)	At C, speed of particle is $\sqrt{3ag}$	B1		
	Resolving horizontally at C:			
	$T = \frac{mv^2}{a}$	M1		Needs 2 correct terms
	$T = m\frac{3ag}{a}$			
	$T = 3mg$	A1	3	
(c)	No air resistance Bead is a particle	B1	1	
	Total		**9**	

(Q7, June 2008)

12 **(a)**	40 revolutions per minute			
	= 80π radians per minute	B1		or $\frac{2}{3}$ rev per second
	$= \frac{4\pi}{3}$ radians per second	B1	2	AG
(b)	Resolve vertically:			
	$T\cos 30 = 6g$	M1A1		M1 1 term each side, 1 correct
	$T = 67.9$ N	A1	3	AG
(c)	Resolve horizontally:			
	$T\sin 30 = m\omega^2 r$	M1 A1		M1 1 term each side, 1 correct A1 $T\sin 30$
	$67.9 \sin 30 = 6 \times r \times \left(\frac{4\pi}{3}\right)^2$	A1		A1 RHS
	$r = 0.322$ m	A1	4	Condone 0.323 (using π as 3.14)
	Total		**9**	

(Q5, Jan 2009)

13 (a)	$\frac{1}{2}mv^2 = \frac{1}{2}m \times 8^2 - mg2$	M1 A1		M1 3 terms, 2 KE and 1 PE
	$v^2 = 64 - 39.2$ $= 24.8$ $v = 4.98$	A1	3	Accept $\sqrt{24.8}$
(b)	Using $F = ma$ radially: $R = mg\cos 60 + \frac{mv^2}{r}$	M1 A1 B1		M1 3 correct terms (not necessarily correct signs) B1 for 60°
	$= 6g\cos 60 + \frac{6 \times 24.8}{4}$ $= 66.6$ N	A1	4	
	Total		**7**	

(Q7, Jan 2009)

14 (a)	Resolving vertically: $T\cos 60 + T\cos 40 = mg$ $1.266\,T = 6g$ $T = 46.4$ N	M1A1 M1 A1	4	AG no marks if g deleted
(b)	Radius of circle is 0.6 tan 60 Horizontally:	B1		$r = 1.039$ or 1.04
	$\frac{mv^2}{r} = T\cos 50 + T\cos 30$	M1		Accept sin instead of cos for M1
	$\frac{6v^2}{1.039} = 46.4\cos 50 + 46.4\cos 30$ or 70.01	A1		
	$v^2 = 12.123$ Speed is 3.48 m s^{-1}	A1	4	
	Total		**8**	

(Q4, June 2009)

15 (a)	By conservation of energy to point where QP makes an angle θ with upward vertical:			
	$\frac{1}{2}mv^2 = \frac{1}{2}mu^2 - mga(1+\sin\theta)$	M1 A1		for 3 terms, 2 KE and 1 PE $mga\ (1+\sin\theta)$ term
	$v^2 = u^2 - 2ag(1+\sin\theta)$	A1		
	Resolve radially			
	$R = \frac{mv^2}{a} - mg\sin\theta$	M1A1		M1 for 3 terms, include $\sin\theta$ or $\cos\theta$
	$= \frac{mu^2}{a} - 3mg\sin\theta - 2mg$	A1	6	AG
(b)	When particle leaves the track, $R = 0$	M1		
	$0 = 3mg - 3mg\sin\theta - 2mg$	A1		
	$\sin\theta = \frac{1}{3}$	M1		SC3 $\sin^{-1}\frac{1}{3}$
	$\theta = 19.5°$	A1	4	accept 19.4° or $\theta = 0.340^c$
	Total		**10**	

(Q7, June 2009)

16 (a)	$r = 1.2\sin\theta$	B1	1	1.2 $\cos\theta$ 0 marks
(b)	Resolve horiz: $T\sin\theta = m\omega^2 r$	M1A1		$T\cos\theta = m\omega^2 r$ etc M1 (+ second M1)
	$T\sin\theta = 4\times5^2\times1.2\sin\theta$			
	$T = 120$	A1		
	Resolve vert: $T\cos\theta = 4g$	M1A1		
	$\cos\theta = 0.32666$			M1 for $\tan\theta = \frac{30\sin\theta}{g}$
	$\theta = 70.9°$ or 1.24^c	A1	6	
	Total		**7**	

(Q6, Jan 2010)

17 (a)	Using conservation of energy:			
	$\frac{1}{2}mu^2 = \frac{1}{2}mv^2 - mgh$	M1A1		M1 for 3 terms, 2 KE and PE or 4 terms , 2 KE and 2 PE
	$\frac{1}{2}mu^2 = \frac{1}{2}mv^2 - mga(1-\cos\theta)$	M1A1		M1A1 for finding *h*
	$v^2 = u^2 + 2ga(1-\cos\theta)$			
	$v = \left(u^2 + 2ga[1-\cos\theta]\right)^{\frac{1}{2}}$	A1	5	AG
(b)	Using $F = ma$ radially,			
	$mg\cos\theta - \mathrm{N} = \frac{mv^2}{a}$	M1A1		M1 Correct 3 terms A1 Correct signs $(-\mathrm{N} \text{ or } +\mathrm{N})$
	Particle leaves surface of hemisphere when N = 0	B1		
	$mg\cos\theta = \frac{m}{a}\left(u^2 + 2ga[1-\cos\theta]\right)$	M1		
	$\cos\theta = \frac{u^2}{ga} + 2 - 2\cos\theta$			
	$\cos\theta = \frac{1}{3}\left(\frac{u^2}{ga} + 2\right)$	A1	5	
	Total		**10**	

(Q7, Jan 2010)

18 (a)	Using conservation of energy:			
	$\frac{1}{2}mv^2 = 3mg(1-\cos\theta)$	M1A1		M1 $\frac{1}{2}mv^2 = mgh$
	$v^2 = 6g(1-\cos 15)$	m1		
	$v = (6g[1-\cos 15])^{\frac{1}{2}}$ $= 1.42$	A1	4	SC3: 1.41
(b)	When particle is at rest,			
	resolve radially $T = mg\cos 15$	M1A1		M1 $T - mg\cos 15 = \frac{mv^2}{r}$ or $T = mg\sin 15$
	$22 = mg\cos 15$ $m = 2.32$	A1	3	
	Total		**7**	

(Q8, June 2010)

19	As particle moves, $T=\frac{mv^2}{r}$	M1		**or** using unknown as extension:
	If radius is r, extension is $r-1.2$	B1		If extension is x, radius is $1.2+x$ B1
	Using $T=\frac{\lambda x}{l}$:			Using $T=\frac{\lambda x}{l}$:
	$T=\frac{192(r-1.2)}{1.2}$	M1		$T=\frac{192x}{1.2}$ M1
	$=160(r-1.2)$	A1		$=160x$ A1
	$T=\frac{mv^2}{r}\Rightarrow 160(r-1.2)=\frac{8\times 3^2}{r}$	M1		$T=\frac{mv^2}{r}\Rightarrow 160x=\frac{8\times 3^2}{1.2+x}$ M1 M1
	$160r^2-192r=72$ (or $192r^2-230.4r=86.4$)	A1		$192x+160x^2=72$ A1
	$20r^2-24r-9=0$ $(10r+3)(2r-3)=0$	M1		$20x^2+24x-9=0$ $(10x-3)(2x+3)=0$ M1
	$r=1.5$ or -0.3 Radius is 1.5	A1	8	$x=0.3$ or -1.5 Radius is 1.5 A1
	Total		**8**	

(Q9, June 2010)

20 (a)	Resolve vertically $R=mg$ If the particle is on the point of sliding, $F=\mu R$	M1		Ignore all inequalities
	$\therefore F=0.3R=0.3mg$	A1		
	Resolving radially: $F=m\omega^2 r$ $0.3mg=m\omega^2\times 0.8$ $\omega^2=\frac{0.3\times g}{0.8}$	M1		
	$\omega=1.92$	A1	4	
(b)(i)	45 revolutions per minute = $\frac{90\pi}{60}$	M1		
	$=\frac{3\pi}{2}$ or 4.71 radians per second	A1	2	
(ii)	Resolving radially: $F=m\omega^2 r$			
	$m\mu g=m\left(\frac{3\pi}{2}\right)^2\times 0.15$	M1A1 A1		M1A1 either side correct A1 second side correct
	$\mu=\frac{\left(\frac{3\pi}{2}\right)^2\times 0.15}{g}$			
	$\mu=0.340$	A1	4	CAO (accept 0.339)
	Total		**10**	

(Q5, Jan 2011)

21 (a)	By conservation of energy $\frac{1}{2}m(5v)^2 = \frac{1}{2}m(3v)^2 + mg2a$ $8v^2 = 2ag$ $v = \sqrt{\frac{ag}{4}}$ or $\frac{1}{2}\sqrt{ag}$	M1 A1 A1 A1	4	M1 for 3 terms , 2 KE and PE
(b)	Greatest and least values of tension are at the highest and lowest points of its path At top, $T = \frac{m(3v)^2}{a} - mg$ $= \frac{5}{4}mg$ At B, $T = \frac{m(5v)^2}{a} + mg$ $= \frac{29}{4}mg$ Ratio is 29 : 5	M1 A1ft M1 A1ft A1	5	ft - must be positive tension CAO Condone 5 : 29 or 1:5.8
	Total		**9**	

(Q6, Jan 2011)

22 (a)	Resolving vertically $T\cos 30 + 20\cos 50 = 4g$ $T\cos 30 = 26.344$ $T = 30.4$ N	M1A1 A1 A1	4	M1: Three terms, which must include $4g$, $T\cos\theta$ or $T\sin\theta$ and $20\cos\theta$ or $20\sin\theta$, where θ = 30, 40, 50 or 60. A1: Correct terms A1: Correct equation A1: Correct final answer. Accept 30.4 or AWRT 30.42. Accept 30.4 or 30.5 or AWRT 30.45 from g = 9.81.
(b)	Horizontally: $\frac{mv^2}{r} = 20\cos 40 + T\cos 60$ $\frac{4\times 5^2}{r} = 30.53$ $r = 3.27537$ $= 3.28$	M1 A1F dM1 A1	4	M1: Three terms, which must include $\frac{mv^2}{r}$ or $\frac{4\times 5^2}{r}$, $T\cos\theta$ or $T\sin\theta$ and $20\cos\theta$ or $20\sin\theta$, where θ = 30, 40, 50 or 60. A1F: Correct equation. May include T, m and v. dM1: Substitution of values for T, m and v. Equation of form $\frac{4\times 5^2}{r}$ = number A1: Correct answer. Accept 3.27 or 3.28 or AWRT 3.28. Accept 3.27 or AWRT 3.27 from g = 9.81. **Note: Do not accept** $\frac{mv^2}{r} = 30.4$ **or similar.**
	Total		**8**	

(Q7, June 2011)

23 (a)	Using conservation of energy (lowest and highest points) $\frac{1}{2}mu^2 = \frac{1}{2}mv^2 + mg(2a)$	M1A1		M1: Equation for conservation of energy with two KE terms and one or two PE terms. May see m or 0.3. A1: Correct equation.
	$u^2 = v^2 + 4ag$ For complete revolutions, $v > 0$ $\therefore u^2 > 4ag$ $u > 2\sqrt{ag}$ **AG**	A1	3	A1: Correct result with statement of $v > 0$ and some intermediate working including $4ag$ term.
	Or Use of PE at top and KE at B Correct PE and KE Correct deduction including inequality	 (M1) (A1) (A1)		
(b)(i)	C of Energy $\frac{1}{2}mu^2 = \frac{1}{2}mv^2 + mga(1+\sin\theta)$	M1A1		M1: Equation for conservation of energy with two KE terms and one or two PE terms including a $\sin\theta$. May see m or 0.3. A1: Correct equation.
	$v^2 = \left(\sqrt{\frac{9}{2}ag}\right)^2 - 2ga(1+\sin\theta)$ $= \frac{5}{2}ag - 2ag\sin\theta$			
	Resolve radially $\pm R = -mg\sin\theta + \frac{mv^2}{a}$	M1A1		M1: Three term equation from resolving radially. Correct three terms, but condone signs and replacement of sin by cos. A1: Correct equation. May see m or 0.3.
	$= -mg\sin\theta + \frac{5}{2}mg - 2mg\sin\theta$ $= -3mg\sin\theta + \frac{5}{2}mg$			
	$= \left(\frac{3}{4} - \frac{9}{10}\sin\theta\right)g$ **OE** (must include g)	A1	5	A1: Simplified correct final answer. Condone $\left(\frac{9}{10}\sin\theta - \frac{3}{4}\right)g$
(ii)	When this reaction is zero, $\left(\frac{3}{4} - \frac{9}{10}\sin\theta\right)g = 0$	M1		M1: Putting their reaction equal to zero.
	$\sin\theta = \frac{5}{6}$ θ is 56.4° above horizontal	A1	2	A1: Correct angle. Accept AWRT 56.44.
	Total		**10**	

(Q8, June 2011)

24	$R = mg$ $F = 0.85\ mg$ $\frac{mv^2}{r} = 0.85\ mg$ $v^2 = 34 \times 0.85 \times g$ $= 283.22$ $v = 16.8$ m s^{-1}	M1 A1 M1A1 m1 A1	 6	 condone $\frac{mv^2}{r} = 0.85R$ (for M1A1) dependent on both M1s
	Total		**6**	

(Q5, Jan 2012)

25 (a)	by conservation of energy: $\frac{1}{2}m(u)^2 = \frac{1}{2}m(v)^2 + mg2a$ $v^2 = u^2 - 4ag$	 M1 A1	 2	M1 for 3 terms, 2 KE and PE; not $v^2 = u^2 + 2as$
(b)(i)	at point A; $T_1 = \frac{m(v)^2}{a} - mg$ at point B; $T_2 = \frac{m(u)^2}{a} + mg$ $\frac{T_1}{T_2} = \frac{2}{5}$ $5\left(\frac{m(v)^2}{a} - mg\right) = 2\left(\frac{m(u)^2}{a} + mg\right)$ $5\left(\frac{m(u^2 - 4ag)}{a} - mg\right)$ $= 2\left(\frac{m(u)^2}{a} + mg\right)$ $5u^2 - 20ag - 5ag = 2u^2 + 2ag$ $3u^2 = 27ag$ $u = 3\sqrt{ag}$	M1A1 A1 B1 A1 m1 A1	 7	both signs incorrect M1 either correct M1A1 or $5T_A = 2T_B$ or $T_1 = 2T$, $T_2 = 5T$ CAO from ratio 2 : 5 or 5 : 2 and one tension equation correct condone $\sqrt{9ag}$
(ii)	$u^2 = v^2 + 4ag \rightarrow v = \sqrt{5ag}$ ratio $u : v = 3 : \sqrt{5}$	B1 B1	 2	condone $v^2 = 5ag$ accept 1.34 : 1 or 1 : 0.745
	Total		**11**	

(Q7, Jan 2012)

26 **(a)**	For particle *B*, tension in string = 2.1*g* N	B1		
	Resolve horizontally for particle *A*:			
	$m\omega^2 r = T$	M1		Or $m_1\omega^2 r = m_2 g$ or $\frac{m_1 v^2}{r} = m_2 g$ (condone lack of 1 and 2)
	$1.4\omega^2 \times 0.3 = 2.1g$	A1		
	$\omega^2 = 49$ Angular velocity is 7 rad/sec	A1	4	
(b)	Using $v = r\,\omega$: speed = 0.3×7	M1		
	= 2.1 m s^{-1}	A1	2	Part (b) marks can be awarded in (a)
(c)	Time taken is $2\pi / \omega$	M1		Or $\frac{2\pi r}{2.1}$
	$= \frac{2\pi}{7} = 0.898$ sec	A1	2	Accept $\frac{2\pi}{7}$ (0.895 M1A0)
	Total		**8**	

(Q5, June 2012)

27 **(a)**	Using conservation of energy:			
	$\frac{1}{2}mv^2 = mgh$	M1		M1 for 2 or 3 terms, 1 KE and 1 or 2 PE
	$\frac{1}{2}mv^2 = mg2.4(1-\cos 18)$	m1A1		m1A1 for finding *h*
	$v^2 = 4.8g(1-\cos 18)$ $= 2.302$			
	$v = 1.52$ m s^{-1}	A1	4	Condone 1.51
(b)	Resolving vertically:			
	$T = mg + \frac{mv^2}{a}$	M1 A1		Correct 3 terms Correct signs
	$= 22g + \frac{22 \times 2.302}{2.4}$			
	= 236.7… N	A1	3	
	= 237 N			Accept 236 N
	Total		**7**	

(Q6, June 2012)

28 (a)	Resolve vertically: $T\cos\theta = mg$ $34\cos\theta = 2\times 9.8$ $\cos\theta = \dfrac{19.6}{34}$ $\theta = 54.8^\circ$	M1 A1 A1	3	M1 for $T\cos\theta$ or $T\sin\theta$ and mg
(b)	Resolve horizontally for particle: $\dfrac{mv^2}{r} = T\sin\theta$ $v^2 = \dfrac{34\sin 54.8\times 0.8}{2}$ $v^2 = 11.113$ Speed is 3.33 m s^{-1}	M1 A1 ft from **(a)** A1	3	M1 for $T\cos\theta$ or $T\sin\theta$ Accept 3.34
(c)	Time taken is $2\pi r / v$ $= 1.51$ sec	M1 A1ft	2	Or find ω and use $\dfrac{2\pi}{\omega}$
	Total		**8**	

(Q6, Jan 2013)

29 (a)	Using conservation of energy: $\frac{1}{2}mv^2 = \frac{1}{2}mu^2 - mgh$ $\frac{1}{2}\times 3\times v^2 = \frac{1}{2}\times 3\times 4^2 - 3\times g\times 1.2(1-\cos 25)$ $v^2 = 4^2 - 2.4\times g(1-\cos 25)$ $v^2 = 16 - 2.2036$ $v = 3.71\text{m s}^{-1}$	M1 M1 A1 A1	4	for 3 terms, 2 KE and 1 PE M1A1 for finding h [M1 for $1.2(1-\cos 25\ or\ \sin 25)$] Accept 3.7, 3.70, 3.72
(b)	Resolving radially: $T = mg\cos 25 + \dfrac{mv^2}{a}$ $= 26.645 + 34.491$ $= 61.1$ N	M1A1 A1	3	M1 accept $\cos 25$ or $\sin 25$, + or − sign and $\neq 2$ A1 fully correct and substituted Accept 61.0 or 61
	Total		**7**	

(Q7, Jan 2013)

30	In limiting equilibrium, using $F = \mu R$ Frictional force is $0.2 \times mg$ Resolve horizontally $\frac{m \times 15^2}{r} = 0.2 \times mg$ $r = \frac{15^2}{0.2 \times g}$ $= 114.79$ $= 115$	M1A1 M1 A1	4	
	Total		**4**	

(Q5, June 2013)

31 (a)	Using conservation of energy: $\frac{1}{2}m(5u)^2 = \frac{1}{2}m(2u)^2 + 2amg$ $\frac{1}{2} \times 21 \times u^2 = 2ag$ $u = \sqrt{\frac{4ag}{21}}$	M1A1 M1 A1	4	M1 for 3 [or 4] terms: 2 KE and 1[or 2] PE M1A1 for finding h
(b)	Using conservation of energy with speed at point S to be V: $\frac{1}{2}m(5u)^2 = \frac{1}{2}m(V)^2 + amg(1 + \cos 60)$ $\frac{1}{2}mV^2 = \frac{1}{2}m(5u)^2 - 1\frac{1}{2}amg$ $V^2 = 25 \times \left(\frac{4ag}{21}\right) - 3ag$ $V^2 = \frac{37ag}{21}$ Resolving radially at point S: $R = -mg\cos 60 + \frac{m(V)^2}{a}$ $= -\frac{1}{2}mg + \frac{37mg}{21}$ $= \frac{53}{42}mg$ or $1.26mg$	M1 A1 M1A1 A1	5	**Or** $\frac{1}{2}m(V)^2 = amg(1 - \cos 60°) + \frac{1}{2}m\left(2\sqrt{\frac{4ag}{21}}\right)^2$
	Total		**9**	

(Q8, June 2013)