OCR Maths M2

Topic Questions from Papers

Circular Motion

Answers

1	(i)	$T\cos\theta = 0.01 \times 9.8$	M1		resolving vertically	
		$8/10T = 0.01 \times 9.8$	A1		with $\cos\theta = 8/10$	
		$T = 0.1225$ N	A1	3	AG	
	(ii)	$T + T\sin\theta = ma$	M1		resolving horizontally	
		use of $mr\omega^2$	M1			
		$\omega = 5.72$ rads^{-1}	A1	3		
	(iii)	K.E.=½x0.01x$(r\omega)^2$	M1		½mv^2 with v=rw	
		K.E.= 0.0588	A1√	2	√0.0018 x their ω^2	**8**

(Q3, June 2005)

2	(i)	$R\cos30° = 0.1 \times 9.8$	M1		resolving vertically	
			A1			
		$R = 1.13$ N	A1	3		
	(ii)	$r = 0.8\cos30° = 0.693$ or $2\sqrt{3}/5$	B1		may be implied	
		$R\cos60° = 0.1 \times 0.693\ \omega^2$	M1		or $0.1v^2/r$ & $\omega = v/r$	
			A1			
		$\omega = 2.86$	A1	4		
	(iii)	$T = 1.96$ N	B1	1		
	(iv)	$R\cos30° = T\cos60° + 0.1x9.8$	M1			
			A1			
		$R = 2.26$ N	A1			
		$R\cos60° + T\cos30° = 0.1 \times v^2/r$	M1		or $mr\omega^2$ & use of $v = r\omega$	
			A1		with R=1.13 can get M1 only	
		4.43 ms^{-1}	A1	6		**14**
or	(iv)	LHS (or RHS)	M1*		method without finding R	
		$T + 0.1x9.8\cos60°$	A1		i.e. resolving along PA	
		RHS (or LHS)	M1*			
		$0.1 \times v^2/r \times \cos30°$	A1		r to be $0.8\cos30°$ for A1	
		solve to find v	M1*		depends on 2* Ms above	
		4.43 ms^{-1}	A1	(6)		

(Q8, Jan 2006)

3	(i)	$T = 4.9$ N	B1		B0 for 0.5g	**6**
		$T = 0.3 \times 0.2 \times \omega^2$	M1		or $0.3v^2/0.2$ and $\omega = v/0.2$	
			A1			
		$\omega = 9.04$ rads^{-1}	A1	4		
	(ii)	$\cos\theta = \sqrt{0.6}/0.8$ (0.968)	B1		(θ=14.5°) angle to vert. or equiv.	
		$T\cos\theta = 0.5 \times 9.8$	M1		angle consistent with diagram	
			A1		can be their angle	
		$T = 5.06$ N	A1	4		
	(iii)	$T\sin\theta = 0.5 \times v^2/0.2$	M1		must be a component of T	
			A1		($\sin\theta$ = ¼) can be their angle	
		$v = 0.711$ ms^{-1}	A1	3		**11**

(Q6, June 2006)

4	(i)	$T\sin30°$	B1			
		$T\sin30° = 0.3x0.4x2^2$	M1		resolving horizontally	
			A1			
		$T = 0.96$	A1	4		
	(ii)	$R + T\cos30° = 0.3x9.8$	M1		resolving vertically	
			A1			
		$R = 2.11$	A1√	3	√ their T (2.94−Tcos30°)	
	(iii)	$T_1\sin30° = 0.3 \times v^2/0.4$	M1		or $0.3x0.4x\omega^2$	
			A1		$(T_1 = 1.5v^2)$	
		$T_1\cos30° = 0.3 \times 9.8$	B1		$(T_1 = 1.96\sqrt{3} = 3.3948)$	
		$R = 0$	B1		may be implied or stated	
		$\tan30° = v^2/(0.4 \times 9.8)$ for elim of T_1	M1		and $v=0.4\omega$ $(\omega = 3.76)$	
		$v = 1.50$	A1	6		**13**

(Q7, Jan 2007)

5 (i)	$5\cos30° = 0.3x9.8 + S\cos60°$	M1	res. vertically (3 parts with comps)
		A1	
	2.78 N	A1 **3**	
(ii)	$r = 0.4\sin30° = 0.2$	B1	may be on diagram
	$5\sin30° + S\sin60° = 0.3 \times 0.2 \times \omega^2$	M1	res. horizontally (3 parts with comps)
	9.04 $rads^{-1}$	A1 **3**	

(Q6, June 2007)

6 (i)(a)	$T\cos45° = 2.94$ $T = 4.16$ N	M1 A1 **2**	Resolving vertically **AG**
(b)	$T\cos45° + T = 0.3x1.96\omega^2$ (res. horiz.) $\omega = 3.47$ rad s^{-1}	M1 A1 A1 **3**	calculates $v = 6.81$ (Max 2/3)
(ii)(a)	$T\cos30° + T\cos60° = 2.94$ $T = 2.15$ N	M1 A1 A1 **3**	Resolving vertically
(b)	$T\cos30° + T\cos60° = 0.3v^2/1.5$ (res. horiz.) $v = 3.83$ m s^{-1}	M1 A1 A1 **3**	calculates $\omega = 2.56$ (Max 2/3) **11**

(Q6, Jan 2008)

7 (i)	$T\cos60° = S\cos60° + 4.9$	M1		Resolving vertically nb for M1:
		A1		(must be components – all 4 cases)
	$T\sin60° + S\sin60° = 0.5 \times 3^2/0.4$	M1		Res. Horiz. $mr\omega^2$ ok if $\omega \neq 3$
		A1		If equal tensions 2T=45/4 M1 only
	$(S + 9.8)\sin60° + S\sin60° = 45/4$	M1		
	$S = 1.60$ N	A1		
	$T = 11.4$ N	A1	**7**	
(ii)	$T\cos60° = 4.9$	M1		Resolving vertically (component)
	$T = 9.8$	A1		
	$T\sin60° = 0.5 \times 0.4\omega^2$	M1		Resolving horiz. (component)
		A1		
	$\omega = 6.51$ rad s^{-1}	A1	**5**	or 6.5 **12**

(Q6, June 2008)

8 (i)	0.8 S	B1	vert comp of S
	0.6 T	B1	vert comp of T
	$S\cos\alpha = T\cos\beta + 0.2 \times 9.8$	M1	
	$0.8S = 0.6T + 1.96$ aef	A1 **4**	**AG** $4S = 3T + 9.8$
(ii)	0.6 S	B1	
	0.8 T	B1	
	$0.2 \times 0.24 \times 8^2$	B1	3.072 384/125
	$S\sin\alpha + T\sin\beta = 0.2 \times 0.24 \times 8^2$	M1	must be $mr\omega^2$
	$6S + 8T = 30.72$	A1	aef
	eliminate S or T	M1	
	$S = 3.4$ N	A1	3.411
	$T = 1.3$ N	A1 **8**	1.282 **12**

(Q5, Jan 2009)

9 (i)	$T = 0.4 \times 0.6 \times 2^2$ $T = 0.96$ N	M1 A1 **2**	
(ii)	$S - T$ $S - T = 0.1 \times 0.3 \times 2^2$ $S = 1.08$	B1 M1 A1 A1 **4**	may be implied
(iii)	$v = r\omega$ $v_P = 0.6$ $v_B = 1.2$ $\frac{1}{2}\times0.1\times0.6^2 + \frac{1}{2}\times0.4\times1.2^2$ 0.306	M1 A1 A1 M1 A1 **5**	 (0.018 + 0.288) separate speeds **11**

(Q4, June 2009)

10 (i)	$\cos\theta = 3/5$ or $\sin\theta = 4/5$ or $\tan\theta = 4/3$ or $\theta = 53.1°$ $R\cos\theta = 0.2\times9.8$ $R = 3.27$ N or 49/15	B1 M1 A1 **[3]**	θ = angle to vertical
(ii)	$r = 4$ $R\sin\theta = 0.2\times4\times\omega^2$ $\omega = 1.81$ rad s^{-1}	B1 M1 A1 A1 **[4]**	
(iii)	$\varphi = 26.6°$ or $\sin\varphi = \frac{1}{\sqrt{5}}$ or $\cos\varphi = \frac{2}{\sqrt{5}}$ or $\tan\varphi = 0.5$ $T = 0.98$ or $0.1g$ $N\cos\theta = T\sin\varphi + 0.2\times9.8$ $N\times3/5 = 0.438 + 1.96$ $N = 4.00$ $N\sin\theta + T\cos\varphi = 0.2\times4\times\omega^2$ $4\times4/5 + 0.98\cos 26.6° = 0.8\omega^2$ $\omega = 2.26$ rad s^{-1}	B1 B1 M1 A1 A1 M1 A1 A1 **[8]**	φ = angle to horizontal Vertically, 3 terms may be implied Horizontally, 3 terms **15**

(Q7, Jan 2010)

11 (i)	$T\cos45° + R\sin45° = mg$	*M1	3 terms
		A1	
	$T\sin45° - R\cos45° = ml\sin45°\omega^2$	*M1	3 terms; $a = r\omega^2$
		A1	
	$2T = \sqrt{2}mg + ml\omega^2$	Dep*M1	Method to eliminate R
	$T = m/2(\sqrt{2}g + l\omega^2)$	A1 **6**	**AG** www
(ii)	$R = 0$	B1	may be implied
	$2R = \sqrt{2}mg - ml\omega^2$	B1	
	or $T\cos45° = mg$		
	or $T = ml\omega^2$		
	Solve to find ω	M1	
	$\omega = 4.16$ rad s^{-1}	A1 **4**	**10**

(Q5, June 2010)

12	**(i)**		$3x_G = 2x0.3 + 1x0.6$ OR $3x_G = 2x0.3 + 0$ OR $3x_G = 4x0.3$ OR $3y_G = 1x0.3 + 1x0.6 + 0$ OR $3y_G = 4x0.3 - 1x0.3$ $x_G = 0.4$ (from AD) OR $x_G = 0.2$ (from BC) $y_G = 0.3$m from AB or CD $AG^2 = 0.4^2 + 0.3^2$ AG = 0.5 m	M1 A1 A1 M1 A1 **[5]**	Table of moments idea. M0 for reducing to 1D problem. Masses/weights may be included. Pythagoras with 2 appropriate distances. This may only be seen in (ii), allow M1A1 in this case.
	(ii)		$v = 0.5x3$ $v = 1.5$ ms^{-1}	M1 A1 **[2]**	Allow use of candidate's 0.2, 0.4, 0.3, 0.5

(Q1, Jan 2011)

13	**(i)**		$T_A\cos30 + T_B\cos60 = 0.4g$ $2T\cos30 + T\cos60 = 0.4g$ $T_B = 1.76$ N $T_A = 3.51$ N	M1 A1 A1 A1 **[4]**	Resolves vertically, 3 terms T = 1.756. Watch for MR of $T\cos30 + 2T\cos60 = 0.4g$ Accept 3.52
	(ii)		r = 0.5sin30 (= 0.25) $3.51\sin30 + 1.76\sin60 = 0.4\omega^2 0.5\sin30$ $\omega = 5.72$ rad s^{-1}	B1 M1 A1ft A1 **[4]**	 N2L radial, 3 terms cv(1.76, 3.51, 0.25) Accept 5.73

(Q3, Jan 2011)

14 i	$R\sin30 = 0.3g$	M1 A1	 R = 5.88 or 0.6g
	$R\cos30 = 0.3\omega^2 \times 0.12$	M1 A1	 accept $v^2/0.12$ for acceleration
	$\omega = 11.9$ rads^{-1}	A1 [5]	cao
ii	$S + R\cos30 = 0.3x2.1^2/0.2$	M1 A1	Resolve and use N2L on sphere Q, 3 terms needed
	$R = 5.88$	B1ft	ft cv(R) from (i)
	$S = 1.52$ N	A1 [4]	
iii	$v_P = 11.9x0.12$, or $h = 0.2/\tan30$ or $0.12/\tan30$ or $0.08/\tan30$	B1	cv(ω) from (i)
	$+/-(Q - P) =$ $0.5x0.3(2.1^2 - (11.9x0.12)^2)$ $+ (0.2/\tan30 - 0.12/\tan30) \times 0.3g$	M1 A2ft	Attempt to calculate KE or PE for both particles KE difference (ft on cv(ω)) or PE difference
	$Q-P = +/- 0.763$ J	A1 [5]	$Q - P = +/-(0.3556 + 0.4074)$

(Q6, June 2011)

15	(i)	(a)	$\sin\theta = ½$ or $\theta = 30$	B1	θ is angle with horizontal. May have angle with vertical. May be seen later.
			$T\cos\theta = 0.2 \times 1.2\cos\theta \times 2.5^2$	M1	Attempt at resolving horizontally.
			$T = 1.5$ N	A1	cv(r) but not $r = 1.2$
				A1	Rounding to 1.5
				[4]	
	(i)	(b)		M1	Attempt at resolving vertically.
			$R + T\sin\theta = 0.2g$	A1 FT	FT on cv(T)
			$R = 1.21$ N	A1	
				[3]	
	(ii)		$r = \sqrt{1.2^2 - 0.6^2} = 1.2\cos\theta$	B1	May been seen in **(i)**, must be used in here.
			$R = 0$	B1	May be implied.
			$T_1\sin\theta = 0.2g$	B1	
			$T_1\cos\theta = 0.2 \times v^2/r$ or $0.2 \times r\omega^2$	M1	Attempt at resolving.
			$v = 4.2$ ms^{-1}	A1	
				[5]	

(Q4, Jan 2012)

Question			Answer	Marks	Guidance
16	(i)		$\sin\theta = 0.8$ or $\cos\theta = 0.6$ or $\tan\theta = 4/3$ or $\theta = 53.1$	B1	θ is angle AP makes with horizontal
				*M1	Attempt to resolve horizontally and use N2L with a version of acceleration, not just a. Allow $T_A = T_B$ for M1 only.
			$T_A\cos\theta + T_B\cos\theta = 2 \times 1.2 \times 4^2$	A1	Use their θ
				*M1	Attempt to resolve vertically
			$T_A\sin\theta = T_B\sin\theta + 2g$	A1	Use their θ
			Solve simultaneously to get at least T_A or T_B	Dep*M1	
			$T_A = 44.25$ and $T_B = 19.75$	A1	For both. Allow 44.2, 44.3, 19.7, 19.8
				[7]	
	(ii)		$T_B = 0$	B1	May be implied
				*M1	Attempt to resolve horizontally and use N2L with a version of acceleration, not just a
			$T_A\cos\theta = 2v^2/1.2$	A1	Use their θ
			$T_A\sin\theta = 2g$	B1	Use their θ
			Solve for v or ω	Dep*M1	
			$v = 2.97$	A1	
				[6]	

(Q5, June 2012)

17	**(i)**	**(a)**	0.8F + 0.6R = 0.4g 4F + 3R = 19.6 **[AG]**	M1 A1 **[2]**	Attempt to resolve vertically www	
	(i)	**(b)**	0.8R – 0.6F = 0.4 x 4.5^2/3 Solve for R or F F = 1.516 R = 4.512 Use μ = F/R to get μ = 0.336 **[AG]**	M1 A1 M1 A1 A1 B1 **[6]**	Attempt with three terms. aef including cos, sin correct angle Use 2 relevant resolutions.	
	(ii)		0.6R - 0.8F = 0.4g R = 11.8 or F = 3.98 0.8R + 0.6F = 0.4 x 3 x ω^2 ω = 3.14 rad s^{-1}	M1 A1 A1 M1 A1 A1 **[6]**	Resolve vertically, three terms N2L, resolve horizontally, three terms	

(Q8, Jan 2013)

18		**(i)**	Vertical force = mg	*B1	
			Horizontal force = $m \times 0.4 \times 7^2$	*M1A1	
			Uses vertical force = μ × horizontal force	dep*M1	Dependent on B1 and M1
			$\mu = 0.5$	A1	If a value for m used B0M1A0M1A0 max.
				[5]	
		(ii)	$mg = T \times 0.3/0.5$	B1	
				*M1	Resolve T and equate to mass × ($r\omega^2$ or v^2/r)
			$m \times 0.4\,\omega^2 = T \times 0.4/0.5$	A1	
			Solve for ω or v	dep*M1	
			$\omega = 5.72$ rad s^{-1}	A1	allow $7\sqrt{6}/3$ If a value for m and/or T used B0M1A0M1A0 max.
				[5]	

(Q5, June 2013)