CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Level

MARK SCHEME for the October/November 2013 series

9709 MATHEMATICS

9709/51 Paper 5, maximum raw mark 50

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M Method mark, awarded for a valid method applied to the problem. Method marks are not lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, e.g. by substituting the relevant quantities into the formula. Correct application of a formula without the formula being quoted obviously earns the M mark and in some cases an M mark can be implied from a correct answer.

A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated method mark is earned (or implied).

B Mark for a correct result or statement independent of method marks.

- When a part of a question has two or more "method" steps, the M marks are generally independent unless the scheme specifically says otherwise; and similarly when there are several B marks allocated. The notation DM or DB (or dep*) is used to indicate that a particular M or B mark is dependent on an earlier M or B (asterisked) mark in the scheme. When two or more steps are run together by the candidate, the earlier marks are implied and full credit is given.

- The symbol √ implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A or B marks are given for correct work only. A and B marks are not given for fortuitously "correct" answers or results obtained from incorrect working.

- Note: B2 or A2 means that the candidate can earn 2 or 0.
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  The marks indicated in the scheme may not be subdivided. If there is genuine doubt whether a candidate has earned a mark, allow the candidate the benefit of the doubt. Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored.

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ISW Ignore Subsequent Working

MR Misread

PA Premature Approximation (resulting in basically correct work that is insufficiently accurate)

SOS See Other Solution (the candidate makes a better attempt at the same question)

SR Special Ruling (detailing the mark to be given for a specific wrong solution, or a case where some standard marking practice is to be varied in the light of a particular circumstance)

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PA –1 This is deducted from A or B marks in the case of premature approximation. The PA –1 penalty is usually discussed at the meeting.

1	$T = 0.3 \times 5^2 / 0.6$	M1		Uses $acc^n = v^2/r$	
	$T = 12.5$ N	A1	[2]		**[2]**
2	**(i)** $OG(arc) = 0.6\sin(\pi/2)/(\pi/2)$	B1		0.38197...	
	$(0.6\pi + 2 \times 0.6)d$	M1		Moment equation	
	$= 2 \times 0.6 \times 0 + 0.6\pi \times 0.382$	A1			
	$d = 0.233$ m	A1	[4]	0.2333..	
	(ii) $\tan\theta = 0.233/0.6$	M1			
	$\theta = 21.2 / 21.3^\circ$ or 0.371 radians	A1ft	[2]	$\tan^{-1}$(cv(i)/0.6)	**[6]**
3	**(i)** $0.8v\mathrm{d}v/\mathrm{d}x = 4e^{-x} - 2.4x^2$	M1		N2L, terms different signs	
	$v\mathrm{d}v/\mathrm{d}x = 5e^{-x} - 3x^2$ AG	A1	[2]		
	(ii) $\int v\mathrm{d}v = \int (5e^{-x} - 3x^2)\mathrm{d}x$	M1		Attempts integration	
	$v^2/2 = -5e^{-x} - 3x^3/3$ (+c)	A1		Accept c omitted	
	$x = 0$, $v = 6$, hence c = 23	B1		Or uses limits 0 and 2	
	$v^2/2 = -5e^{-2} - 3x2^3/3 + 23$	M1		Puts $x = 2$ in $v(x)$ expression	
	$v = 5.35$ ms^{-1}	A1	[5]	$v = 5.352..$	**[7]**
4	**(i)** $V(vert) = 14\sin60 - 1.8g$	B1		–5.8756..	
	$V^2 = (-)5.8756^2 + (14\cos60)^2$	M1			
	$V = 9.14$ ms^{-1}	A1		9.1391..	
	$\tan\theta = (-)5.8756/(14\cos60)$	M1			
	$\theta = 40(.0)^\circ$ below horizontal	A1	[5]		
	(ii) $-2 = (14\sin60)t - gt^2/2$	M1		$-2 = ut - gt^2/2$ used vertically	
	$5t^2 - 12.124t - 2 = 0$	M1		Solves correct 3 term quadratic	
	$t = 2.58$ s	A1	[3]		**[8]**

5	**(i)**		M1	Resolves vertically, 3 forces	
		$Tx(4/5) - Tx(3/5) = 0.2g$	A1		
		$T = 10$	A1	Maybe implied	
		$Tx(4/5) + Tx(3/5) = 0.2v^2 / (0.4 \times 3 / 5)$	M1	Resolves horizontally. N2L	
		$v = 4.1(0)$ ms^{-1}	A1 [5]		
	(ii)	$Tx(4 / 5) = 0.2g$	B1	$T = 2.5$	
		$Tx(3 / 5) = 0.2\omega^2 x(0.4 \times 3 / 5)$	M1	N2L horizontally, single force	
		$\omega = 5.59$ rads^{-1}	A1 [3]		**[8]**
6	**(i)**	$0.8T = 260 \times (DG) \times \cos\theta$	M1	Moments about D	
		DG = 1.7/2, θ = (30+D)	M1	Both needed	
		Angle BDC = 28°	DA1	D = 28.072..	
		$0.8T = 260 \times (1.7/2) \times \cos 58.07$	A1ft	ftcv(DG ≠ 0.8,1.5.1.7, $\theta \neq 30,28$)	
		T = 146 N AG	A1 [5]		
	OR	Moment of weight	M1		
		=(260cos30) × 0.75 – (260sin30) × 0.4	DA1	Difference of moments of perp components (116.87…)	
			M1	Moments about D	
		0.8T = 116.87..	A1	Needs no evaluation	
		T = 146 N AG	A1		
	(ii)	$F_r = 146\cos 30$	B1	126.52..	
		R = 260 + 146cos60	B1	333.04..	
		μ =(146cos30)/(260+146sin30)	M1	Denominator not 260	
		μ = 0.38(0)	A1 [4]		**[9]**

7	**(i)**		M1		PE/EE balance
		$0.4gd = 32(d–0.8)^2/(2 \times 0.8)$	A1		
		$20d^2 – 36d + 12.8 = 0$	M1		Solves 3 term quadratic
		$d = 1.31$ m only	A1	[4]	Other value 0.4876..
	OR	$0.4g(0.8 + e) = 32e^2/(2 \times 0.8)$	M1		PE/EE balance
		$20e^2 – 4e + 3.2 = 0$	A1		
		$e = 0.5(1)$ (also $–3.12$)	M1		Solves 3 term quadratic
		$d = 1.31$ m only	A1		
	(ii)		M1		EE/KE/PE balance
		$0.4v^2/2$ $= 0.4g \times 1 – 32(1–0.8)^2/(2 \times 0.8)$	A1		
		$v = 4$ ms^{-1}	A1	[3]	
	(iii)	Rebound $v = 0.8$	B1ft		ftcv(v(ii)) $\times \sqrt{\ }$ $(1–0.96) = 0.2$v(ii)
		$0 = 0.4 \times 0.8^2/2 + 32 \times 0.2^2/1.6–0.4gh$	M1		EE/PE/KE balance, $h = 0.232$
		OP $(=1–h) = 0.768$ m	A1	[3]	**[10]**

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	(iii)	Rebound v = 0.8	B1ft	ftcv(v(ii)) $\times \sqrt{\ }$ (1–0.96) = 0.2v(ii)	
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1		$T = 12 \times (0.6–0.4)/0.4$	M1		Uses $T = \lambda x$ /L, (=6)	3
		$6 = 0.1v^2/0.6$	M1		N2L 1 force and RA	
		$v = 6$ ms^{-1}	A1	[3]		
2	**(i)**	$0.5v\mathrm{d}v/\mathrm{d}x = 0.5g – 0.015x^2$	M1		N2L 2 forces	
		$v\mathrm{d}v/\mathrm{d}x = 10 – 0.03x^2$ AG	A1	[2]		
	(ii)	18.3 m	B1	[1]	$\sqrt{(10/0.03)} = 18.257..$	
	(iii)	$\int v\mathrm{d}v = \int (10–0.03x^2)\mathrm{d}x$	M1		Attempts to integrate	
		$v^2/2 = 10x – 0.03x^3/3$ (+c)	A1		Accept omission of c	
		$v^2/2 = 10 \times 18.3 – 0.03 \times 18.3^3/3$	M1		Uses ans (ii) in formula for v^2	
		$v = 15.6$ ms^{-1}	A1	[4]		7
3		$R\cos\theta = 0.5$ g (=5)	B1		Resolving vertically	
		$R\sin\theta = 0.5 \times 5^2 \times 0.4$ (= 5)	M1		Use of N2L horizontally with $\text{acc}^n = w^2 r$	
		$\tan\theta = (0.5 \times 5^2 \times 0.4)/(0.5\ g)$	M1		Eliminating R	
		$\theta = 45^\circ$ AG	A1			
		$R = 0.5\ g/\cos 45$	M1		$R^2 = (0.5 \times 5^2 \times 0.4)^2 + (0.5\ g)^2$	
		$R = 7.07$ N	A1	[6]	7.071..	6
4	**(i)**	$0.2a = 0.024t – 0.2\ g \times 0.3$	M1		Uses N2L	
		$a = 0.12t – 3$	A1			
		$\int \mathrm{d}v = \int (0.12t – 3)\mathrm{d}t,$ $v = 0.12t^2/2 – 3t + c$, $t = 0$, $v = 0.9$ hence $c = 0.9$	M1		Integrates and finds c	
		$v = 0.06(t^2 – 50t + 15)$ AG	A1	[4]		
	(ii)	$t^2 – 50t + 15 = 0$	M1		Solves 3 term quadratic	
		$t = 0.302$	A1	[2]	Smaller +ve root only	

	(iii)	$0.024t = 0.3 \times 0.2$ g	M1		Equates tractive force and friction force	
		$t = 25$	A1	[2]		8
5	**(i)**	$v_v^2 = (15\sin 30)^2 + 2\text{ g} \times 20$	M1		$v_v = 21.3600..$	
		$V^2 = (15\cos 30)^2 + (15\sin 30)^2 + 2\text{ g} \times 20$	M1		V or θ from components, V by energy	
		$V = 25$ ms^{-1}	A1			
		$\theta (= \tan^{-1} 21.36/(15\cos 30) = 58.7^\circ$	A1	[4]	58.69..	
	(ii)	$-20 = (15\sin 30)t - gt^2/2$	M1		M1 maybe gained in **(i)**	
		$2t^2 - 3t - 8 = 0 \Rightarrow t(= 2.866..) = 2.89$	A1		A1 maybe gained in **(i)**	
	OR	$t = (15\sin 30)/10 + (25\sin 58.7)/10$	M1		Separating rise and fall times	
		$t = 2.89$	A1			
		$OP^2 = 20^2 + (15\cos 30 \times 2.886)^2$	M1		42.491..	
		$OP = 42.5$ m	A1	[4]		8
6	**(i)**	$0.4\text{ g} = 50e/0.8$	M1		Uses T = λ × /L (e = 0.064)	
		Moves down = 0.044 m	A1		(0.8 + 0.064 – 0.82)	
		$0.4 \times 1.5^2/2 + 0.4\text{ g} \times 0.044 + 50(0.82–0.8)^2/(2 \times 0.8)$	M1		Sets up 2EE/2KE/PE equation	
		$=0.4v^2/2 + 50 \times 0.064^2/(2 \times 0.8)$	A1			
		$v = 1.6(0)$ ms^{-1}	A1	[5]		
	(ii)	PE gain to reach O = $0.4\text{ g} \times 0.82$	B1		From initial position, (3.28J)	
		KE + EE = $0.4 \times 1.5^2/2 + 50(0.82 - 0.8)^2/(2 \times 0.8)$	M1 A1		At initial position, (0.4625J)	
		Shows by evaluation that insufficient energy		[3]		8

7 (i)	$\pi \times 0.5^2 \times 0.4 \times 0.2 + \pi \times 0.5^2 \times 0.4 \times 0.5/3$ $= (\pi \times 0.5^2 \times 0.4 + \pi \times 0.5^2 \times 0.4/3)$0G AG d = 0.275 m	M1 A1 A1	[3]	Uses table of moments idea	
(ii)	$(0.4 + 0.4)F = 0.5 \times 60$ F = 37.5	M1 A1	[2]	Takes moments	
(iii)	μ (= 37.5/60) = 0.625	B1 ft	[1]	cv(F)/60	
(iv)	F/R=(60sin30)/(60cos30) (= 0.577..) $0.577 \prec 0.625$ (or μ), no sliding AG $\tan\theta$ = (0.4 – 0.275)/0.5 $\theta = 14^\circ$ AG	M1 A1 M1 A1	[4]	Or quotes tan30 $\prec$ 0.625 Or 0.5tan30 = 0.288.. 0.4 – 0.29 $\prec$ 0.275, topples	10