

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International Advanced Level

MARK SCHEME for the October/November 2014 series

9709 MATHEMATICS

9709/51

Paper 5, maximum raw mark 50

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Mark Scheme Notes

Marks are of the following three types:

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.
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AG	Answer Given on the question paper (so extra checking is needed to ensure that the detailed working leading to the result is valid)
BOD	Benefit of Doubt (allowed when the validity of a solution may not be absolutely clear)
CAO	Correct Answer Only (emphasising that no “follow through” from a previous error is allowed)
CWO	Correct Working Only – often written by a ‘fortuitous’ answer
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)

Penalties

MR –1	A penalty of MR –1 is deducted from A or B marks when the data of a question or part question are genuinely misread and the object and difficulty of the question remain unaltered. In this case all A and B marks then become “follow through $\frac{1}{2}$ ” marks. MR is not applied when the candidate misreads his own figures – this is regarded as an error in accuracy. An MR –2 penalty may be applied in particular cases if agreed at the coordination meeting.
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.

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1	$X = 2V \cos 30$ $Y = 2V \sin 30 - g \frac{2^2}{2}$ $\tan 15 = \frac{\left(2V \sin 30 - g \frac{2^2}{2}\right)}{2V \cos 30}$ $V = 37.3$	B1 B1 M1 A1 [4]	$1.731V$ $V = 20$
2 (i)	Horizontal distance = $0.8 \times \frac{3}{4} \times \sin 30$ OR $0.8 \tan 30 \cos 30 - \frac{0.8}{4} \sin 30$ Mom. = $(0.6 \sin 30 \times 20 =) 6 \text{ Nm}$ AG OR Mom = $20 \cos 30 \times 0.8 \tan 30 - 20 \sin 30 \times \frac{0.8}{4}$ Mom = 6 Nm AG	M1 A1 [2] M1 A1	P to centre of mass (= 0.3 m) Resolves Wt // and perp axis and finds moments of both components
(ii)	$6 = F \times 0.8 \tan 30$ $F = 13(.0)$	M1 A1 [2]	Takes moments about P
3	$\frac{28e}{1.6} = 0.35g$ $e = 0.2$ $\frac{0.35v^2}{2} = 28 \times \frac{0.2^2}{2} \times 1.6 + 0.35 \times \frac{1.8^2}{2} - 0.35g \times 0.2$ $v = 1.11 \text{ m s}^{-1}$	M1 A1 M1 A1 A1 [5]	Equates λ_{ext}/l and weight $OP = 1.8 \text{ m}$ EE/KE/PE balance All correct terms with candidate's value of e
4 (i)	$ABCF$ area = 0.64 and $CDE = 0.36$ $(0.64 + 0.36)d = 0.64 \times \frac{0.4}{2} + 0.36 \times (0.4 + \frac{1.8}{3})$ $d = 0.488 \text{ m}$ AG	B1 M1 A1 A1 [4]	Both areas correct Table of moments idea All terms correct
(ii)	$0.488 \times 100 = 1.6T$ $T = 30.5 \text{ N}$ $(0.488 - 0.4) \times 100 = 1.6T$ $T = 5.5$	M1 A1 A1 [3]	Either limiting case (no turning about A) (no turning about F)

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5	(i)	$x \tan \alpha = 0$ so $\alpha = 0$ $\frac{gx^2}{2V^2 \cos^2 \theta} = 0.05x^2$ $V = 10 \text{ m s}^{-1}$	B1 M1 A1 [3]	Justification needed Comparison with standard eqn
	(ii)	$\frac{dy}{dx} = -0.1x$ $-0.1x = -\tan 60$ $y (= -0.05(10 \tan 60)^2) = -15$ $v^2 =$ $10^2 + 2g15$ $v = 20 \text{ m s}^{-1}$ OR $y' = 10 \tan 60$ $(10\sqrt{3})^2 = 2gh$ $y = -15$ $v^2 =$ $10^2 + (10\sqrt{3})^2$ $v = 20 \text{ m s}^{-1}$ OR $v \cos 60 = 10$ $v = 20 \text{ m s}^{-1}$ $10\sqrt{3} = 10t$ $t = \sqrt{3}$ $y = 10\sqrt{3} \times \frac{\sqrt{3}}{2}$ $y = 15 \text{ (below) or } -15$	M1 M1 A1 M1 A1 A1 [6] M1 M1 A1 M1 A1 A1 M1 A1 M1 A1 M1 A1	Uses Pythagoras ft candidate's value ($V(i), y$) $y' = B$'s downward velocity $= 10\sqrt{3}$ Negative, $y = -h$ Uses Pythagoras ft candidate's value ($V(i)$)
6	(i)	$0.6v \frac{dv}{dx} = 0.4v^{1/2}$ $3v^{1/2} \frac{dv}{dx} = 2$	M1 A1 [2]	Newton's 2nd law, $a = v \frac{dv}{dx}$
	(ii)	$3 \int v^2 dv = 2 \int dx$ $\frac{3v^3}{3} = 2x (+c)$ $\frac{3}{2}$ $3 \times \frac{1}{2} \times \frac{2}{3} = 2 + c$ $v = x^3$	M1 A1 M1 A1 [4]	Integrates Accept omission of $+c$ Evaluates $c (=0)$

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(iii)	$\int x^{-\frac{2}{3}} dx = \int dt$ $\left[\frac{\frac{1}{x^{\frac{2}{3}}}}{\frac{1}{3}} \right]_1^8 = t$ $t = 3$	M1 A1 A1 [3]	Integrates using $v = \frac{dx}{dt}$
7 (i)	$T = \frac{15 \left(\frac{0.4}{\cos \theta} \right)}{2}$ $T = \frac{3}{\cos \theta} \quad \text{AG}$ $T \cos \theta = mg$ $m = 0.3$	M1 A1 M1 A1 [4]	Uses $T = \frac{\lambda_{\text{ext}}}{2}$ Resolves vertically for P
(ii)	$r = 0.4 \tan \theta$ $\frac{0.3v^2}{r} = T \sin \theta \quad \text{OR} \quad 0.3\omega^2 r = T \sin \theta$ $0.3\omega^2 (0.4 \tan \theta) = \frac{3}{\cos \theta} \times \sin \theta$ $\omega = 5$ SC Candidates who choose at least two specific values of θ : Calculation of r twice Both calculations give $\omega = 5$	B1 M1 A1✓ A1 [4] B1 B1	Newton's 2 nd law with correct expression for radial accn, ft cv($m(i)$)
(iii)	$\text{EPE} = \frac{15 \left(\frac{0.4}{\cos \theta} \right)^2}{2 \times 2}$ $\text{KE} = \frac{0.3 (5 \times 0.4 \tan \theta)^2}{2}$ $\frac{15 \left(\frac{0.4}{\cos \theta} \right)^2}{2 \times 2} = \left(\frac{0.3 (2 \tan \theta)^2}{2} \right) \times 2$ $\cos^2 \theta \tan^2 \theta = 0.5 \quad \text{OR} \quad \sin^2 \theta = 0.5$ $\theta = 45$	B1 B1✓ M1 A1 [4]	ft candidate's value of ω Award if $\times 2$ is with wrong term www

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1	$V \sin \theta = \frac{2.4g}{2} \text{ or } 48 = V \cos \theta \times 2.4$ $\tan \theta = \frac{12}{\frac{48}{2.4}}$ $\theta = 31(.0)^\circ$	B1 M1 A1	[3]	$-V \sin \theta = V \sin \theta - 2.4g$
2 (i)	$\frac{0.2 \times 10^2}{2} = \frac{64e^2}{2 \times 0.8}$ $AP = 1.3$	M1 A1 A1	[3]	KE loss = EE gain $e = 0.5$
(ii)	$\frac{0.2 \times 10^2}{2} = \frac{64 \times 0.2^2}{2 \times 0.8} + \frac{0.2v^2}{2}$ $v = 9.17 \text{ ms}^{-1}$	M1 A1 A1	[3]	KE / EEbalance
3 (i)	$mv \frac{dv}{dx} = -mg - 0.02mv$ $\frac{v + 50g - 50g}{50g + v} \frac{dv}{dx} = -0.02$ $\left(\frac{500}{500 + v} - 1 \right) \frac{dv}{dx} = 0.02 \quad \text{AG}$	M1 DM1 A1	[3]	Newton's 2 nd law, 2 resistive forces. $-mg - 0.02mv = -0.02(50g + v)$ used
(ii)	$\int \frac{500}{500 + v} - 1 dv = \int 0.02 dx$ $\left[500 \ln(500 + v) - v \right]_{14}^0 = 0.02H$ $H = 9.62 \text{ m}$	M1 DM1 A1	[3]	Attempts integration Appropriate use of $v = 14, 0$
4 (i)	$V \sin \theta = 50 \sin 30 - 4g$ $V^2 = (50 \cos 30)^2 + (-15)^2$ $V = 45.8 \text{ ms}^{-1}$ $15 = 50 \sin 30 - gt$ $t = 1$	B1 M1 A1 M1 A1	[5]	-15
(ii)	$OP^2 = (4 \times 50 \cos 30)^2 + \left(4 \times 50 \sin 30 - \frac{4^2 g}{2} \right)^2$ $OP = 174 \text{ m}$	M1 A1	[2]	

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5 (i)	$T = \frac{12(d-0.6)}{0.6} = \frac{21(d-0.7)}{0.7}$ $d = 0.9$ $T = \frac{12(0.2-0.6)}{0.6} = \frac{21(0.2-0.7)}{0.7}$ $W = 12$	M1 A1 M1 A1	[4]	Uses $T = \frac{\lambda \text{ ext}}{l}$ either string Must be total length, not extension Equation with both sides correct Finds either Tension (= 6)
	(ii) $\text{PE} = 0.2 \times 12 \quad (= 2.4)$ $\frac{12 \times 0.1^2}{2 \times 0.6} + 12 \times 0.2 = \frac{\frac{12}{g} v^2}{2} + \frac{12 \times 0.3^2}{2 \times 0.6} + \frac{21 \times 0.2^2}{2 \times 0.7}$ $v = 1.29 \text{ ms}^{-1}$	B1 $\frac{1}{2}mv^2$ M1 A1 A1	[4]	fit their value of d and their value of W PE / KE / EE balance
6 (i)	$\frac{0.2 \times 1.5^2}{0.5} = \text{Fr}$ $\mu \left(= \frac{\text{Fr}}{0.2g} \right) = 0.45$	M1 A1	[2]	Newton's 2nd law, $\text{acc} = \frac{v^2}{r}$ Fr = 0.9 N
	(ii) $R = 0.2g - \frac{0.2g}{2} \sin 30$ $\text{Fr} = 0.45 \times 1.5$ $\frac{0.2g}{2} \cos 30 \pm 0.675 = 0.2\omega^2 0.5$ $\omega = 3.93 \text{ (greatest)}$ $\omega = 1.38 \text{ (least)}$	M1 A1 M1 A1 A1	[5]	1.5 0.675 Either
(iii)	$\frac{0.2g}{2} \cos 30 = 0.2\omega^2 0.5$ $\omega = 2.94$	M1 A1	[2]	

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7 (i)	$OG \text{ (sector)} = \frac{2 \times 0.35 \sin \frac{2\pi}{3}}{3 \times \frac{2\pi}{3}}$ $\text{Area (sector)} = \frac{0.35^2 \times \frac{4\pi}{3}}{2}$ $OG \text{ (triangle)} = \frac{2 \times 0.35 \cos \frac{\pi}{3}}{3} \quad \text{and}$ $\text{Area (triangle)} = \frac{0.35^2 \sin \frac{2\pi}{3}}{2}$ $0.096482... \times 0.256563... -$ $0.116666... \times 0.053044...$ $= d(0.256563... + 0.053044...)$ $d = 0.06(00)\text{m} \quad \text{AG}$	B1 B1 B1 M1 A1 A1		0.096482... 0.256563... 0.116666... 0.053044...
(ii) a	$F \times 0.35 \cos \frac{\pi}{3} = 0.06 \times 14$ $F = 4.8$	M1 A1	[2]	
(ii) b	$F \sin \frac{\pi}{3} \times \left(0.35 + 0.35 \sin \frac{\pi}{3} \right)$ $+ F \cos \frac{\pi}{3} \times 0.35 \cos \frac{\pi}{3} = 14 \times 0.06$ $F = 1.29 \text{ N}$ OR $F \times 0.35 + Fr \times 0.35 = 14 \times 0.06$ $0.35F + 0.35F \sin \frac{\pi}{3} = 14 \times 0.06$ $F = 1.29 \text{ N}$	M1 A1 A1 (M1) (A1) (A1)	[3]	Moments about point of contact Moments about O As $Fr = F \sin \frac{\pi}{3}$