January 2015 (IAL)

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Mark Scheme (Results)

January 2015

Pearson Edexcel International A Level in Mechanics 3 (WME03/01)

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

PEARSON EDEXCEL IAL MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.

2. The Edexcel Mathematics mark schemes use the following types of marks:

'M' marks
These are marks given for a correct method or an attempt at a correct method. In Mechanics they are usually awarded for the application of some mechanical principle to produce an equation.
e.g. resolving in a particular direction, taking moments about a point, applying a suvat equation, applying the conservation of momentum principle etc.
The following criteria are usually applied to the equation.

To earn the M mark, the equation
(i) should have the correct number of terms
(ii) be dimensionally correct i.e. all the terms need to be dimensionally correct
e.g. in a moments equation, every term must be a 'force x distance' term or 'mass x distance', if we allow them to cancel 'g' s.
For a resolution, all terms that need to be resolved (multiplied by sin or cos) must be resolved to earn the M mark.

M marks are sometimes dependent (DM) on previous M marks having been earned.
e.g. when two simultaneous equations have been set up by, for example, resolving in two directions and there is then an M mark for solving the equations to find a particular quantity – this M mark is often dependent on the two previous M marks having been earned.

'A' marks
These are dependent accuracy (or sometimes answer) marks and can only be awarded if the previous M mark has been earned. E.g. M0 A1 is impossible.

'B' marks
These are independent accuracy marks where there is no method (e.g. often given for a comment or for a graph)

A few of the A and B marks may be f.t. – follow through – marks.

3. General Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod – benefit of doubt
- ft – follow through
- the symbol $\surd$ will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working

- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- * The answer is printed on the paper
- ⎿ The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. If a candidate makes more than one attempt at any question:
   - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
   - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

6. Ignore wrong working or incorrect statements following a correct answer.

General Principles for Mechanics Marking

(But note that specific mark schemes may sometimes override these general principles)

- Rules for M marks: correct no. of terms; dimensionally correct; all terms that need resolving (i.e. multiplied by cos or sin) are resolved.
- Omission or extra g in a resolution is an accuracy error not method error.
- Omission of mass from a resolution is a method error.
- Omission of a length from a moments equation is a method error.
- Omission of units or incorrect units is not (usually) counted as an accuracy error.
- DM indicates a dependent method mark i.e. one that can only be awarded if a previous specified method mark has been awarded.
- Any numerical answer which comes from use of g = 9.8 should be given to 2 or 3 SF.
- Use of g = 9.81 should be penalised once per (complete) question.

  N.B. Over-accuracy or under-accuracy of correct answers should only be penalised *once* per complete question. However, premature approximation should be penalised every time it occurs.
- In all cases, if the candidate clearly labels their working under a particular part of a question i.e. (a) or (b) or (c),……then that working can only score marks for that part of the question.
- Accept column vectors in all cases.
- Misreads – if a misread does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, bearing in mind that after a misread, the subsequent A marks affected are treated as A ft
- Mechanics Abbreviations

  M(A) Taking moments about A.

  N2L Newton's Second Law (Equation of Motion)

  NEL Newton's Experimental Law (Newton's Law of Impact)

  HL Hooke's Law

  SHM Simple harmonic motion

  PCLM Principle of conservation of linear momentum

  RHS, LHS Right hand side, left hand side.

Jan 2015
WME03/01 M3 (IAL)
Mark Scheme

Question Number	Scheme	Marks
1.	$3v\dfrac{\mathrm{d}v}{\mathrm{d}x}=\dfrac{9}{2}(26-x)$	M1
	$\dfrac{\mathrm{d}\left(\frac{1}{2}v^2\right)}{\mathrm{d}x}=\dfrac{3}{2}(26-x)$	
	$\dfrac{1}{2}v^2=\dfrac{3}{2}\left(26x-\dfrac{1}{2}x^2\right)\quad(+c)$	M1A1
	Max speed when accel is zero ie when $x=26$	B1
	$\dfrac{1}{2}\times32^2=\dfrac{3}{2}\times\dfrac{1}{2}\times26^2+c\quad\Rightarrow c=5$	A1
	$v^2=3\left(26x-\dfrac{1}{2}x^2\right)+10$	A1 (6)
	M1 NL2 with accel in a correct form- can be implied by subsequent working M1 integrate the equation wrt x A1 correct result after integrating - constant not needed B1 deduce max speed occurs when $x=26$ A1 a correct value for the constant A1 a correct expression for v^2 - can be in any form ALT for last 3 marks: M1 (B1 on e-pen) Complete square and equate constant part to 32^2 or use max of quadratic $=\dfrac{4ac-b^2}{4a}$ A1 correct c A1 correct expression for v^2	

Question Number	Scheme	Marks
2	Area $= \int_1^3 y\,\mathrm{d}x = \int_1^3 \frac{3}{x^2}\,\mathrm{d}x$	
	$= \left[-3x^{-1}\right]_1^3 = -1-(-3) = 2$	B1
(i)	$\int_1^3 xy\,\mathrm{d}x = \int_1^3 x \times \frac{3}{x^2}\,\mathrm{d}x = \int_1^3 \frac{3}{x}\,\mathrm{d}x$	
	$\left[3\ln x\right]_1^3 \quad (=3\ln 3)$	M1A1
	$\overline{x} = \frac{3\ln 3}{2} \quad (=1.647....)$	M1A1
(ii)	$\int_1^3 \frac{1}{2}y^2\,\mathrm{d}x = \int_1^3 \frac{1}{2} \times \frac{9}{x^4}\,\mathrm{d}x$	
	$\frac{9}{2}\left[-\frac{x^{-3}}{3}\right]_1^3 = \frac{9}{2}\left[-\frac{1}{81}+\frac{1}{3}\right] = 1\frac{4}{9}$	M1A1
	$\overline{y} = \frac{1\frac{4}{9}}{2} = \frac{13}{18} \quad (= 0.722.....)$	DM1A1 (9)
	B1 for a correct area of R (may be embedded in the working) M1 attempting the integral $\int_1^3 xy\,\mathrm{d}x$ (integration to be seen) A1 correct integration and limits (substitution not needed) M1 divide by their area - denominator **must** be an area A1 correct value for $\overline{x}$ - can be exact or decimal 1.6 or better M1 attempting the integral $\int_1^3 \frac{1}{2}y^2\,\mathrm{d}x$ or $\int_1^3 y^2\,\mathrm{d}x$ (integration to be seen) A1 correct integration (of their integral) and limits shown DM1 divide by their area **must** have used $\int \frac{1}{2}y^2\,\mathrm{d}x$ A1 correct value for $\overline{y}$ - can be exact or decimal 0.72 or better	

Question Number	Scheme	Marks
3	$2T\cos 30 = T\cos 30 + mg$	M1A1
	$\frac{T\sqrt{3}}{2} = mg$	A1
	$3T\cos 60 = mr\omega^2$	M1A1
	$\frac{3}{2}\times\frac{2mg}{\sqrt{3}} = mr\omega^2$	A1
	$AB = 4a \quad \frac{r}{2a} = \tan 30 = \frac{1}{\sqrt{3}}$	
	$r = \frac{2a}{\sqrt{3}}$	
	$\frac{3g}{\sqrt{3}} = \frac{2a}{\sqrt{3}}\omega^2$	DM1 Dep on both prev M marks
	$\omega^2 = \frac{3g}{2a} \qquad \omega = \sqrt{\frac{3g}{2a}}$	A1 [8]
	M1 resolve vertically - both tensions resolved A1 fully correct equation A1 substitute for trig function M1 NL2 horizontally - tensions resolved, acceleration in either form A1 correct equation, r still present, acceleration $r\omega^2$ A1 correct equation with no trig function DM1 eliminate r and T to obtain an equation with ω, a, g and no other letters r need not be correct but do not allow $r = a$ A1 correct result For first 6 marks the equations can have T and $2T$ or two different tensions	

Question Number	Scheme	Marks
4 **(a)**	Length of string/half string = 10 m / 5 m (or extn = 5 m)	B1
	$T = \frac{\lambda x}{l} = \frac{20 \times 5}{5}, \ = 20$	M1, A1
	$2T\cos\alpha = mg$	M1
	$2 \times 20 \times \frac{4}{5} = mg$	A1ft
	Weight = 32 N (Accept mg = 32)	A1 (6)
(b)	PE lost $= "mg" \times 4$	
	EPE gained $= \frac{20 \times 5^2}{2 \times 5} - \frac{20 \times 1^2}{2 \times 5}$	
	$\frac{1}{2}mv^2 = "mg" \times 4 - \left(\frac{20 \times 5^2}{2 \times 5} - \frac{20 \times 1^2}{2 \times 5} \right)$	M1A1A1
	$\frac{16}{g}v^2 = 32 \times 4 - \left(\frac{20 \times 5^2}{2 \times 5} - \frac{20 \times 1^2}{2 \times 5} \right)$	DM1
	$v^2 = 5g$	
	$v = 7$, 7.0 or 7.00	A1 (5) [11]
(a)	B1 correct length of complete or half string or correct extension(need not be shown explicitly) M1 apply Hooke's law $x \neq 1$ A1 correct tension obtained M1 resolving vertically, both tensions resolved A1ft substitute their tension and $\cos\alpha = \frac{4}{5}$ A1 correct weight obtained (no ft)	
(b)	M1 energy equation with KE, PE and two EPE terms - all calculated with correct formulae A1A1 Deduct one A mark per error (if m is substituted early, ft their m) M1 Substitute their mass (not weight) A1 correct value for v 7, 7.0 or 7.00 only acceptable	

Question Number	Scheme	Marks
5 (a)	Small cone Large cone S	
	Mass $\frac{4}{3}\pi r^3\rho$ $\frac{1}{3}k\pi r^3\rho$ $\frac{1}{3}\pi r^3\rho(4+k)$	
	Ratio 4 k $4+k$	
	Disp from O $-r$ $\frac{kr}{4}$ $\bar{x}$	
	$-4r+\frac{k^2r}{4}=(4+k)\bar{x}$	M1A1A1
	$\bar{x}=\frac{(k^2-16)r}{4(4+k)}=\frac{1}{4}(k-4)r$	A1 (4)
(b)	k greatest when $\frac{\bar{x}}{r}=\frac{r}{4r}$	M1
	$\frac{1}{4}(k-4)=\frac{1}{4}$	A1ft
	Greatest $k=5$	A1 (3)
(c)	$\tan 12°=\frac{\bar{x}}{r}=\frac{1}{4}(k-4)$	M1A1ft
	$k=4.85$ 4.9 $(4.8502...)$	A1 (3) [10]
(a)	M1 moments equation about any (suitable) point. Volumes or ratio of volumes used. A1 LHS correct A1 RHS side A1 correct distance from O, inc use of $k > 4$ Single fraction only in the expression	
(b)	M1 using vertical through c of m passes through A to obtain a connection between $\bar{x}$ and r or a numerical value for $\bar{x}$ or any other complete valid method A1ft obtain a correct equation for k with their $\bar{x}$ A1 cao $k=5$ (inequality gets A0)	
(c)	M1 $\tan 12°=\frac{\bar{x}}{r}$ either way up A1ft substitute for $\bar{x}$ correct way up now A1 Final answer 4.9, 4.85 or better	

Question Number	Scheme	Marks
6		
(a)	$\frac{1}{2}mv^2 - \frac{1}{2}m\left(\frac{ag}{5}\right) = mga(1-\cos\theta)$	M1A1A1
	$v^2 = 2ag + \frac{ag}{5} - 2ag\cos\theta = \frac{ag}{5}(11-10\cos\theta)$ *	A1 (4)
(b)	$mg\cos\alpha\ (-R) = m\frac{v^2}{a}$	M1A1
	$g\cos\alpha = \frac{g}{5}(11-10\cos\alpha)$ or sub $\cos\alpha = \frac{v^2}{ag}$ in energy equation	M1 A1
	$\cos\alpha = \frac{11}{15}$	
	P leaves the sphere with speed $\sqrt{\frac{ag}{5}\left(11-\frac{22}{3}\right)} = \sqrt{\frac{11ag}{15}}$	DM1A1 (6)
(c)	Horiz comp = $\sqrt{\frac{11ag}{15}} \times \cos\alpha = \sqrt{\frac{11ag}{15}} \times \frac{11}{15}$	M1
	By cons of energy from top: $2mag = \frac{1}{2}mV^2 - \frac{1}{2}m\frac{ag}{5}$	M1
	$V^2 = \frac{21ag}{5}$	A1
	$\cos\theta = \sqrt{\frac{11ag}{15}} \times \frac{11}{15} \times \sqrt{\frac{5}{21ag}} = \sqrt{\frac{11}{63}} \times \frac{11}{15} = 0.30642...$	M1
	$\theta = 72.155...$ Accept 72^o or better	A1 (5)
		[15]
(a)	M1 **Energy** equation from start to general position - must have 2 KE terms and a loss of PE A1 LHS correct A1 RHS correct A1cso re-arrange to the given result	

Question Number	Scheme	Marks
(b)	M1 NL2 along radius, acceleration in either form, R need not be shown, weight must be resolved A1 fully correct equation with or w/o R, accel now $\frac{v^2}{a}$ M1 elimination of v^2 or $\cos\alpha$ A1 correct equation after elimination DM1 substitute their $\cos\alpha$ to obtain an expression for v^2 Dep on both previous M marks A1 correct expression for v	
(c)	M1 obtaining an expression for the horiz comp of speed at P M1 use energy to obtain the speed when particle hits the floor A1 correct speed at floor M1 use horizontal speed and resultant speed to find the angle A1 correct angle 2 sf or more figures (g cancels) ALT: By SUVAT: M1 Horiz component M1 Vert component and complete attempt for speed at the floor (including the vertical height) A1 correct vert speed at floor M1 attempt angle using tan (either way up) A1 correct angle 2 sf or more figures (g cancels)	

Question Number	Scheme	Marks
7		
(a)	$T = \dfrac{\lambda a/5}{a}$	M1A1
	$T = mg\cos 60 = \dfrac{1}{2}mg$	
	$\dfrac{1}{2}mg = \dfrac{\lambda}{5} \quad \lambda = \dfrac{5}{2}mg$ *	M1A1 (4)
(b)	When string has length $\left(\dfrac{6a}{5} + x\right)$:	
	$\dfrac{1}{2}mg - \dfrac{5}{2}mg\left(\dfrac{a/5 + x}{a}\right) = m\ddot{x}$	M1A1A1
	$-\dfrac{5g}{2a}x = \ddot{x}$, $\Rightarrow$ SHM	DM1,A1
	Period = $2\pi\sqrt{\dfrac{2a}{5g}}$ *	A1 (6)
(c)	Max accel = $\omega^2 \times \text{amp} = \omega^2 \dfrac{a}{5} = \dfrac{5g}{2a} \times \dfrac{a}{5} = \dfrac{g}{2}$	M1A1 (2)
(d)	$x = \dfrac{a}{5}\sin \omega t$	
	$\dfrac{a}{10} = \dfrac{a}{5}\sin \omega t$	M1
	$\omega t = \sin^{-1} 0.5 = \dfrac{\pi}{6}$	
	$t = \dfrac{\pi}{6\omega} = \dfrac{\pi}{6}\sqrt{\dfrac{2a}{5g}}$	A1
	Total time = $t = \dfrac{\pi}{6}\sqrt{\dfrac{2a}{5g}} + \dfrac{\pi}{2}\sqrt{\dfrac{2a}{5g}} = \dfrac{2\pi}{3}\sqrt{\dfrac{2a}{5g}}$	M1A1 (4)
		[16]

Question Number	Scheme	Marks
(a)	M1 Hooke's Law used to find T at B A1 correct equation M1 eliminating T by use of resolving along the plane A1cso correct value for λ	
(b)	M1 NL2 along the plane when extension is $\frac{a}{5}+x$ - must have a tension and a component of the weight. Allow with $\ddot{x}$ or f (acceleration). A1A1 deduct one per error. (difference of forces wrong way round is one error only) mass x acceleration (not $\ddot{x}$) is also an error DM1 simplify to the correct form acceleration must be $\ddot{x}$ now A1cso correct final equation AND conclusion A1 correct period	
(c)	M1 obtaining the max acceleration, amp $\neq a$ A1 correct max acceleration (no ft)	
(d)	M1 using equation for x - sin or cos form and solving for t - must use radians and $\omega=\sqrt{\frac{5g}{2a}}$ amp $\neq a$ A1 correct value for t from their equation M1 complete to obtain the required time A1 correct total time If time from end point to $x=-\frac{a}{10}$ is found mark M1M1A1A1	