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Mark Scheme (Results)

Summer 2015

Pearson Edexcel GCE in Mechanics 3 (6679/01)

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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 GCE 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:

<u>'M' marks</u>
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.

<u>'A' marks</u>
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.

<u>'B' marks</u>
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 $\sqrt{}$ 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 For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

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

7 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.
- Marks must be entered in the same order as they appear on the mark scheme.
- 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.

June 2015
6679 M3
Mark Scheme

Question Number	Scheme	Marks
1		
(a)	$0.5g = T = \frac{\lambda \times 0.3}{1.2}$	M1A1
	$\lambda = 2g = 19.6$	A1 (3)
(b)	$\frac{1}{2} \times \frac{19.6 \times x^2}{1.2} - \frac{1}{2} \times \frac{19.6 \times 0.4^2}{1.2} = 0.5 \times g \times (x + 0.4)$	M1A1ftA1
	$5x^2 - 3x - 2 = 0$	
	$(5x+2)(x-1) = 0$ or use of diff of 2 squares to obtain and then solve a linear equation	
	$x = 1$ $(x = -0.4$ need not be seen$)$	
	$AC = 2.2$ m	A1 (4) [7]

(a) M1 Use Hooke's law to obtain the tension and equate to the weight
A1 Correct equation
A1 Solve to get $\lambda = 19.6$ Accept 20 or $2g$

(b) M1 Attempt an energy equation with the difference of 2 EPE terms and a loss of GPE
EPE formula must be of the form $k\frac{\lambda x^2}{l}$
A1ft EPE terms correct follow through their λ
A1 GPE term correct, including all signs in the equation correct If x used for EPE and GPE A0 here
A1 Correct length AC If $\lambda = 20$ is used, this is p.a. and so scores A0

ALT: Find BC first: $\frac{1}{2} \times \frac{19.6 \times (h - 0.4)^2}{1.2} - \frac{1}{2} \times \frac{19.6 \times 0.4^2}{1.2} = 0.5gh$ M1A1A1
$BC = 1.4$ $AC = 2.2$ A1

Methods depending on SHM must prove SHM first, but if correct answer only is given award B1 (M1 on e-PEN)
By integration: Integrating and substituting yields an equation equivalent to the one shown - mark from here M1A1A1ft -1 each error ft on λ

Question Number	Scheme	Marks
2 (a)	$\text{Vol} = \pi\int_0^1 4\text{e}^{2x}\text{d}x$	M1
	$= \pi\left[2\text{e}^{2x}\right]_0^1$	DM1A1
	$= 2\pi\left(\text{e}^2 - 1\right)$ *	A1cso (4)
(b)	$\pi\int_0^1 4x\text{e}^{2x}\,\text{d}x$	M1
	$= 4\pi\left\{\left[x \times \frac{1}{2}\text{e}^{2x}\right]_0^1 - \int_0^1 \frac{1}{2}\text{e}^{2x}\text{d}x\right\}$	DM1
	$= 4\pi\left[\frac{1}{2}\text{e}^2 - 0\right] - 4\pi\left[\frac{1}{4}\text{e}^{2x}\right]_0^1$	A1
	$= \pi\left(\text{e}^2 + 1\right)$	A1
	x coord $= \dfrac{\pi\left(\text{e}^2+1\right)}{2\pi\left(\text{e}^2-1\right)}, \quad = \dfrac{e^2+1}{2\left(e^2-1\right)}$ oe	M1A1 (6)
		[10]

(a) M1 Using $\pi\int y^2\text{d}x$ with the equation of the curve, no limits needed

DM1 Integrating their expression for the volume

A1 Correct integration inc limits now

A1 Substituting the limits to obtain the GIVEN answer

(b) M1 Using $(\pi)\int xy^2\text{d}x$ with the equation of the curve, no limits needed, π can be omitted

DM1 Attempting to use integration by parts; allow $\pm$ between the two parts. No limits needed

A1 Correct integration, including limits; no substitution needed for this mark

A1 Correct after limits substituted

M1 Use of $\dfrac{\pi\int xy^2\text{d}x}{\pi\int y^2\text{d}x}$ with their $\pi\int xy^2\text{d}x$. π must be seen in both numerator and denominator or in neither. This mark is not dependent on the previous M marks

A1cao Correct answer.

1

Question Number	Scheme	Marks
3(a)	R$(\uparrow)$ $T_A\cos 30 = mg + T_B\cos 30$	M1A1
	NL2 $T_A\cos 60 + T_B\cos 60 = mr\omega^2$	M1A1
	$= m\times 2l\cos 60\omega^2$ or $ml\omega^2$	A1
	$T_A + T_B = 2ml\omega^2$	
	$T_A - T_B = \dfrac{2mg}{\sqrt{3}}$	
(i)	$T_A = \dfrac{m}{3}\left(3l\omega^2 + g\sqrt{3}\right)$ oe	DM1A1
(ii)	$T_B = \dfrac{m}{3}\left(3l\omega^2 - g\sqrt{3}\right)$ oe	A1 (8)
(b)	$T_B \geqslant 0 \Rightarrow 3l\omega^2 \geqslant g\sqrt{3}$	M1
	$\omega^2 \geqslant \dfrac{g\sqrt{3}}{3l}$ *	A1cso (2)
		[10]

(a) M1 Resolving vertically
A1 Correct equation
M1 NL2 along radius, acceleration in either form
A1 LHS correct
A1 Correct radius substituted and accel in $r\omega^2$. Can be awarded later by implication if work implies correct radius used.
DM1 Solving the two equations to obtain an expression for either tension. Depenent on both previous M marks
A1 Tension in *AP* correct – simplified to two terms
A1 Tension in *BP* correct – simplified to two terms

(b) M1 Using their tension in $BP \geqslant 0$ **must be** $\geqslant$ for this mark
A1cso Obtaining the GIVEN answer. Only error allowed is the expression for the tension in *AP*

1

Question Number	Scheme	Marks
4(a)	$\frac{63000}{kt^2} = 900\frac{dv}{dt}$	M1
	$-\frac{70}{kt}\ (+c) = v$	DM1A1ft
	$t = 1\ \ v = 0\ \Rightarrow c = \frac{70}{k}$	M1(either)
	$t = 4\ \ v = 10.5\ \Rightarrow -\frac{70}{4k} + c = 10.5$	A1(both)
	$-\frac{70}{4k} + \frac{70}{k} = 10.5$	
	$k = 5,\quad c = 14$	A1
	$v = 14 - \frac{14}{t}$ *	A1 cso (7)
(b)	$\frac{14}{t} > 0\ \ \Rightarrow v < 14$ or v never reaches 14	B1 (1)
(c)	$7 = 14 - \frac{14}{t}$	
	$\frac{14}{t} = 7\quad t = 2$	B1
	t 1 1.25 1.5 1.75 (2) v 0 2.8 4.666.. 6 7	
	$x = \frac{0.25}{2}\left(0 + 2\times 2.8 + 2\times 4.666... + 2\times 6 + 7\right)$	M1A1
	$X = 4.24175$ Accept 4.2 or 4.24	A1 (4) [12]

(a) M1 Forming an equation of motion with acceleration as $\frac{dv}{dt}$ 900 or m

DM1 Attempting the integration

A1 Correct equation. Constant of integration not needed

M1 Substituting either pair of given values

A1 Obtaining correct equations using each pair of values

A1 Obtaining correct values for c **and** k or use $k = 5,\quad c = \frac{70}{k}$

A1 Substituting these values to obtain the GIVEN answer
Misread eg 6300 for 63000: M1DM1A1M1A0A0A0

(b) B1 Must be clear that $v < 14$ not just never = 14 $\frac{14}{t} > 0$ essential

(c) B1 Showing that $t = 2$ when $v = 7$ Award if seen as upper limit for t in trapezium rule or values 1.25, 1.5, 1.75 seen for t

M1 Using the trapezium rule. Must have 4 intervals and values of t shown in the table.

A1 Correct numbers in the trapezium rule statement.
Values of v can be in the form $14 - \frac{14}{1.25}$ etc

A1 Correct final answer. It is an estimate, so 2 or 3 sf only.

Question Number	Scheme	Marks
5	Dist of c of m from $O = r\tan 30 = \frac{r}{\sqrt{3}}$	M1A1
	Ratio of masses $\quad M \quad kM \quad (1+k)M$ $\quad\quad 1 \quad k \quad 1+k$	
	Dist from $O \quad -\frac{1}{4}h \quad \frac{kh}{4} \quad \frac{r}{\sqrt{3}}$	
	M(O) $\quad -\frac{1}{4}h + \frac{k^2h}{4} = (1+k)\frac{r}{\sqrt{3}}$	M1A1A1ft
	$\frac{h}{4}(k^2-1) = (k+1)\frac{r}{\sqrt{3}}$	
	$k = \frac{4r}{h\sqrt{3}} + 1 \quad$ *	A1 [6]
Alt 1	By moments about A	
	$kMg\left(\frac{1}{4}kh\cos 30 - r\sin 30\right), \quad Mg\left(\frac{1}{4}h\cos 30 + r\sin 30\right)$	M1A1,M1A1
	$h\cos 30(k^2-1) = 4r\sin 30(k+1)$	A1ft
	$(k-1) = \frac{4r}{h}\tan 30$	
	$k = \frac{4r}{h\sqrt{3}} + 1 \quad$ *	A1

Question Number	Scheme	Marks
Alt 2	Find $\bar{x}$ first	
	M(0) $-\frac{1}{4}h + \frac{k^2h}{4} = (1+k)\bar{x}$	M1 A1
	$\bar{x} = \frac{h(k-1)}{4}$ oe	A1
	Then suspend: $\frac{\bar{x}}{r} = \tan 30$	M1
	$\frac{h(k-1)}{4r} = \frac{1}{\sqrt{3}}$ $(or \tan 30)$	A1ft
	$k = \frac{4r}{h\sqrt{3}} + 1$ *	A1

M1 Finding the distance of the c of m from *O* by using the angle given. Must use tan.

A1 Obtaining $\frac{r}{\sqrt{3}}$ (no approx allowed)

M1 Forming a moments equation using the three known distances; mass ratio only needed – do not penalise use of incorrect formulae

A1 LHS correct

A1ft RHS correct for their distance

A1cao Obtaining the GIVEN answer

ALT 1 Taking moments about *A*

M1 Attempting the LHS – must have two appropriate terms inc the necessary resolution

A1 Correct LHS

M1 Attempting the RHS – must have two appropriate terms inc the necessary resolution

A1 Correct RHS

A1ft Collecting the terms and cancelling *M*g

A1cao Completing to the GIVEN answer

ALT 2 Find $\bar{x}$ first

M1 First M mark on e-PEN: Attempting an equation to find $\bar{x}$ in terms of *h* and *k* - mass ratio as above

A1 First A mark on e-PEN: Correct equation

A1 Second A mark on e-PEN: Correct expression for $\bar{x}$ (as shown or equivalent)

M1 Second M mark on e-PEN: Using $\frac{\bar{x}}{r} = \tan 30$ (LHS either way up)

A1ft Third A mark on e-PEN: Substitute their $\bar{x}$; LHS must be the correct way up

A1cao Final A mark on e-PEN: Obtaining the GIVEN answer

Question Number	Scheme	Marks
6 (a)	$T_A=\frac{20x}{2.5}\ (=8x)\qquad T_B=\frac{18(2-x)}{1.5}\ (=12(2-x))$	
	$\frac{20x}{2.5}=\frac{18(2-x)}{1.5}$	M1A1
	$x=\frac{12}{10}=1.2$	A1
	$AO=3.7$ m	A1ft (4)
(b)	$\frac{18(0.8-y)}{1.5}-\frac{20(1.2+y)}{2.5}=0.5\ddot{y}$	M1A1A1
	$-40y=\ddot{y}\ \therefore$ SHM (or $\ddot{y}=(-20/m)y$	A1cso (4)
(c)	(Max) speed $=\frac{6}{0.5}=12$ m s^{-1}	B1
	$\omega=\sqrt{40}=2\sqrt{10}$	B1ft
	$12=a\times 2\sqrt{10}$	M1
	$a=\frac{6}{\sqrt{10}}$ or $\frac{3\sqrt{10}}{5}$ m (accept 1.897... ie 1.9, 1.90 or better)	A1ft (4)
(d)	$1.2=a\sin\omega t$	M1(their a,ω)
	$t=\frac{1}{2\sqrt{10}}\sin^{-1}\left(\frac{1.2\sqrt{10}}{6}\right)$	M1(must use radians)
	$t=0.1082...$ s (Accept 0.11 or better)	A1cso (3) [15]

(a) M1 Using Hooke's law to find **both** tensions and equating them. The extension in *BP* can be used instead of the extension in *AP*. ALT: Use both extensions and use $e_a+e_b=2$ later

A1 Correct equation

A1 Correct value found for either extension

A1ft Correct length for *AO*; follow through their extension

(b) M1 Forming an equation of motion at a general point. Difference of 2 tensions, both including. the variable. Use of a instead of $\ddot{x}$ can score M1A1A0A0 max (ie an A error)

A1 A1 A1A1 fully correct; A1A0 one error May have m instead of 0.5 Extensions measured from O

A1cso A correct simplified equation. Any equivalent form, including having m instead of 0.5. There must be a concluding statement.

(c) B1 Correct speed following impulse Can be awarded if seen in (b) or (d)

B1ft Correct value of ω; must be numerical. FT from (b) Can be awarded if seen in (b) or (d)

M1 Using $v_{\max}=a\omega$ (their values). By energy – equation must have all terms

A1ft Correct value of a any equivalent form including decimals. Follow through their ω

(d) M1 Using $y=a\sin\omega t$ with their a and ω If $y=a\cos\omega t$ is used there must be some indication of moving from the time obtained to the required time.

M1 Solving their equation to find a time. **Must** use radians

A1cso Correct time, min 2 sf. ω and a must have been obtained from correct work.

Question Number	Scheme	Marks
7 (a)	$\frac{1}{2}mv^2 - \frac{1}{2}m\frac{rg}{4} = mgr(1-\cos\theta)$	M1A1A1
	$v^2 = \frac{rg}{4}(9-8\cos\theta)$ *	A1 (4)
(b)	$(R) + mg\cos\theta = \frac{mv^2}{r}$	M1A1
	$R = 0 \quad mg\cos\alpha = \frac{mg}{4}(9-8\cos\alpha)$	DM1
	$12\cos\alpha = 9$	
	$\cos\alpha = \frac{3}{4}$ or 0.75	A1 (4)
(c)	Initial vert comp of speed $= \sqrt{\frac{3g}{8}}\sin\alpha = \sqrt{\frac{3g}{8}} \times \frac{\sqrt{7}}{4} \quad (=1.2679...)$	M1A1
	$\frac{7}{8} = 1.2679...t + \frac{1}{2}gt^2$	M1
	$7 = 10.143...t + 39.2t^2$	
	$39.2t^2 + 10.143...t - 7 = 0$	
	$t = \frac{-10.143 \pm \sqrt{10.143^2 + 4\times 7\times 39.2}}{2\times 39.2}$	DM1
	$t = 0.3125...$	A1
	Horiz speed $= \sqrt{\frac{3g}{8}}\cos\alpha = \frac{1}{4}\sqrt{\frac{27g}{8}}$	
	$AC = \frac{1}{4}\sqrt{\frac{27g}{8}} \times 0.3125 + r\sin\alpha = 0.4493 + 0.3307 = 0.78$ m	M1A1cso (7) [15]

(a) M1 Attempting an energy equation. 2KE terms needed and a PE term.
Award if mass missing throughout, but **not** for use of $v^2 = u^2 + 2as$

A1 KE terms correct (and subtracted) Mass not needed if M mark earned

A1 PE correct Again, mass not needed if M mark earned

A1cso Obtaining the GIVEN answer

(b) M1 Attempting an equation of motion along the radius. Accel in either form, $(\pm)R$ may be included.

A1 Correct equation, with or without $(\pm)R$

DM1 Set $R = 0$ and substitute for v

A1 $\cos\alpha = 3/4$ obtained

(c) M1 Attempting the initial vertical component of the speed

A1 Correct vertical component - decimal or exact

M1 Using $s = ut + \frac{1}{2}at^2$ to form a quadratic in t, with *their* vertical speed and attempt at the vertical distance **Must** satisfy $0.5 < \text{distance} < 1$

DM1 Solving their quadratic; formula must be shown (and correct) if answer is incorrect, but allow with $+\sqrt{....}$ instead of $\pm\sqrt{....}$

A1 Correct t. Give by implication if stored on a calculator and final answer correct
Second solution need not be shown; ignore any shown

M1 Using the horizontal speed and completing to obtain the required distance.

A1 $AC = 0.78$ **must** be 2 sf.

ALT for (c):

M1A1 As main method above

M1 Use the horizontal speed and distance travelled as a projectile to get an expression for t and substitute in $s = ut + \frac{1}{2}at^2$ Vertical distance must be between 0.5 and 1

DM1 Solve their quadratic - see above

A1 Correct (projectile) distance

M1A1 As main method above

7(c) Using energy etc:

M1	Using energy to get the speed at the floor. Can be from the top or the point of leaving the surface
A1	Correct speed at floor
M1	Using the horizontal component of the speed and Pythagoras to obtain the vertical component at the floor
M1	Using $v = u + at$ vertically to get t
A1	Correct t
M1A1	Complete as main method

1

Other alternative Methods

Question 4(a) **by definite integration**

$900\frac{dv}{dt} = \frac{63000}{kt^2}$	M1
$\int_0^{10.5} dv = \int_1^4 \frac{70}{kt^2} dt$	
$[v]_0^{10.5} = \left[-\frac{70}{kt}\right]_1^4$	DM1A1 Integration, limits not needed
$10.5\ (-0) = -\frac{70}{4k} + \frac{70}{k}$	M1 Substitute limits
$k = 5$	A1 Correct value
$\int_0^v dv = \int_1^t \frac{14}{t^2} dt$	A1 Integrate again with limits as shown
$v = 14 - \frac{14}{t}$ *	A1 Obtain GIVEN answer

OR:

$900\frac{dv}{dt} = \frac{63000}{kt^2}$	M1
$\int_0^v dv = \int_1^t \frac{70}{kt^2} dt$	
$[v]_0^v = \left[-\frac{70}{kt}\right]_1^t$	DM1A1 Integration, limits not needed
$v = \frac{70}{k}\left[-\frac{1}{t}\right]_1^t = \frac{70}{k}\left(1 - \frac{1}{t}\right)$	M1 Substitute limits and $v = 10.5,\ t = 4$
$k = 5$	A1 Correct value
$v = \frac{70}{5}\left(1 - \frac{1}{t}\right)$	A1 substitute
$v = 14 - \frac{14}{t}$ *	A1 Obtain GIVEN answer

Question 6(c) **by reference circle**

M1 Finding the required angle in radians.

M1 Using the period $\left(\frac{2\pi}{\omega}\right)$ and their angle to find the required time.

A1 Correct time.

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