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Mark Scheme (Results)

Summer 2014

Pearson Edexcel GCE in Mechanics 2 (6678/01)

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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:

'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.
- 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.

Question Number	Scheme	Marks	Notes
1(a)	Moments about x axis: $3m\times5+2m\times4+km\times1=(5+k)m\times3$ $15+8+k=3k+15,$ $\quad k=4$	M1 A1 A1 (3)	Use moments to form an equation in k. All terms required. Condone sign errors on LHS. Condone 6+k. m not required. Could be in fraction form. Correct unsimplified equation. Allow with a common factor of g cso
(b)	Moments about y axis: $3m\times1+2m\times6+km\times a=(5+k)m\times3$ $3+12+4a=27,$ $\quad a=3$	M1 A1 A1 (3)	Use moments to form an equation in a and k (or their k) only. All terms required. m not required. Could be in fraction form. Condone 6+k. Correct unsimplified equation (follow their k if k substituted) Accept with a common factor of g. Allow after use of an incorrect value for k.
		[6]	

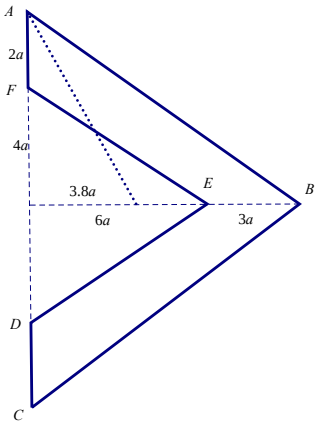
Alternative moments equations using axes through (3, 3):

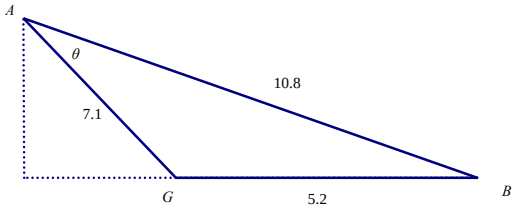
(a) Parallel to y axis $3m\times2+2m\times1=km\times2$

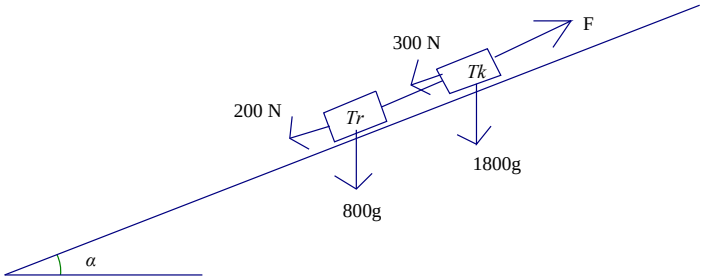
(b) Parallel to x axis $2m\times3=km(a-3)+3m\times2$

NB The vector equation on its own is not sufficient for M1 – they need to form separate equations. However, if they deduce the correct answer(s) from their vector equation full marks are available.

Question Number	Scheme	Marks	Notes
2(a)	Integrate: $\boldsymbol{v} = \left(t^3 - 2t^2\right)\mathbf{i} + \left(3t^2 - 5t\right)\mathbf{j} + \mathbf{C}$	M1	At least 3 powers going up. Condone errors in constants. Must be two separate component equations if not in vector form. Could be in column vector form. Allow with no "+ **C**"
		A2	-1 each integration error. i.e. All correct A1A1 1 error A1A0, 2 or more errors A0A0 Allow with no "+ **C**"
	$t = 3$: $\mathbf{v} = 9\mathbf{i} + 12\mathbf{j} + \mathbf{C} = 11\mathbf{i} + 10\mathbf{j}$ $\quad \mathbf{C} = 2\mathbf{i} - 2\mathbf{j}$	DM1	Substitute given values to find **C**. Dependent on the previous M mark
	$\mathbf{v} = \left(t^3 - 2t^2 + 2\right)\mathbf{i} + \left(3t^2 - 5t - 2\right)\mathbf{j}$	A1 (5)	Correct velocity (any equivalent form)
(b)	Parallel to **i** $\Rightarrow 3t^2 - 5t - 2 = 0$	M1	Set **j** component of their **v** equal to zero and solve for t Correct answers imply method, but incorrect answers need to show method clearly.
	$(3t+1)(t-2) = 0, \quad t = 2$	A1	Correct only. Ignore $-\frac{1}{3}$ if present.
	$\lvert\mathbf{v}\rvert = 8 - 8 + 2 = 2\,(\text{m s}^{-1})$	DM1	Substitute their t to find **v**. Dependent on the previous M mark.
		A1 (4)	The **answer must be a scalar** – the Q asks for speed. Results from negative t must be rejected.
		[9]	
	A candidate who has no "+C" can score at most M1A2M0A0 M1A0M1A0		

Question Number	Scheme	Marks	Notes
3.(a)	Ratio of areas 54 : 24 : 30 (or equivalent)	B1	
	Distance of c of m from AC $3a$, $2a$	B1	
	The two B marks can be implied by a correct moments equation		All terms need to be there. Must be subtracting. Allow with g as a common factor. Allow use of an axis parallel to AC Allow in vector form.
	Moments about AC: $30d = 3a \times 54 - 2a \times 24 \left(= 114a\right)$	M1	
		A1	Correct unsimplified equation (allow in vector form)
	$d = \dfrac{114a}{30} = 3.8a$	A1 (5)	Accept any equivalent form
NB	If "a" does not appear in the solution at all, mark the work as a misread. If "a" appears and disappears then mark as given in the scheme.		

Question Number	Scheme	Marks	Notes
3(b)	Correct triangle and use of $\tan^{-1}$ or equivalent	M1	Find a relevant angle using their d. Condone ratio the wrong way up. Allow $\tan^{-1}\left(\frac{\text{their } d}{\text{their } \bar{x}}\right)$
alt1	$\tan^{-1}\left(\frac{3.8a}{6a}\right)$, $\tan^{-1}\left(\frac{6a}{3.8a}\right)$, 32.3… or 57.65….	A1	
	Required angle = $\tan^{-1}\left(\frac{9a}{6a}\right)-\tan^{-1}\left(\frac{3.8a}{6a}\right)=23.96.....=24°$	DM1 A1 (4)	Correct method for the required angle. Dependent on the previous M mark. Only. The Q asks for answers to the nearest degree.
alt2		M1	Identify the correct triangle and find the lengths of the sides
		A1	All correct (accept lengths as unsimplified calculations using Pythagoras)
	$\cos\theta=\frac{10.8^2+7.1^2-5.2^2}{2\times10.8\times7.1}$	DM1	Use trigonometry to find θ
	$\theta=24°$	A1	
		[9]	

Question Number	Scheme	Marks	Notes
4			
(a)	Constant speed $F = 200 + 800g\sin\alpha + 300 + 1800g\sin\alpha \left(= 1774\right)$	M1 A2	Complete method to an equation in "F". Requires all the terms, including resolution of the weights. Condone sign errors and sin/cos confusion. g missing from both weights is a single error. Penalise trig once only. -1 each error. i.e. A1A1 if no errors A1A0 one error seen, A0A0 two or more errors
	$40000 = Fv \left(= 1774v\right)$ $v = 22.5$	M1 A1 (5)	**Use of** $P = Fv$. Allow with F or their F. Independent of the first M1 Accept 23. (maximum 3sf following use of 9.8)
(b)	"1774" $- 300 - 1800g\sin\alpha \left(= 592\right) = 1800a$ $F = ma$: $a = \dfrac{F}{1800} = 0.32888... = 0.33 \left(\text{m s}^{-2}\right)$	M1 A2 A1 (4)	New equation of motion for the truck. Follow their 1774. Requires all the terms, including resolution of the weights. Condone sign errors and sin/cos confusion. Allow with their 1774. -1 each error. i.e. A1A1 no errors, A1A0 one error, A0A0 two or more errors Accept 0.329
		[9]	

Question Number	Scheme	Marks	Notes
5(a)	Speed after impact = $\frac{2}{3}u$	B1	Allow for velocity $= -\frac{2u}{3}$
	Impulse = change in momentum = $\pm\left(m.\text{their}\frac{2}{3}u - m.(-u)\right)\left(=\frac{5}{3}mu\right)$	M1	Need to consider momentum before and after the collision and use change of direction.
	$\lambda = \frac{5}{3}$	A1 (3)	cso
(b)	Speed after second collision = $e^2u = \frac{4}{9}u$	B1	Allow negative
	Total time taken = $\frac{1}{u} + \frac{2}{eu} + \frac{1}{e^2u}\left(=\frac{1}{u}+\frac{3}{u}+\frac{9}{4u}\right)$	M1	Use of time $= \frac{\text{distance}}{\text{speed}}$ to find the total time in terms of u. (At least one term dealt with correctly)
		A2	-1 each error
Alt for M1A2	Ratio of times for the three sections is $\frac{1}{3}:1:\frac{3}{4}$	M1 A2	Or equivalent. -1 each error
	$\frac{4}{u}+\frac{9}{4u}=\frac{25}{4u}=3, \quad u=\frac{25}{12}$ o.e.	DM1 A1 (6)	Use total time = 3 and solve for u Accept 2.08 and 2.1 (or better)
		[9]	
	SC The candidate who only considers the first return to O can score the first M1 in (b) for $\frac{1}{u}+\frac{1}{eu}$ giving 1/6 marks		

Question Number	Scheme	Marks	Notes
6(a)	Considering energy: $\frac{1}{2}m\times14^2=\frac{1}{2}m\times10^2+mgh$ $h=\frac{48}{g}=4.90$	M1 A2 A1 (4)	All terms required. Terms need to be of the correct form but condone sign errors. -1 each error in the unsimplified equation Accept $\frac{48}{g}$. Maximum 3 s.f. if they go in to decimals.
alt(a)	Initial $v_y=14\sin\alpha$ Final $v_y=\sqrt{100-14^2\cos^2\alpha}$ $100-196\cos^2\alpha=196\sin^2\alpha-2gh$ $h=\frac{48}{g}=4.90$	M1A2 A1 (4)	Using $v^2=u^2+2as$ on the vertical components of speed. -1 each error in the unsimplified equation Accept in exact form. Maximum 3 s.f. if they go in to decimals.
NB	Using $v^2=u^2+2as$ with 10 and 14 is M0		
NB	In part (a) they must be solving the general case, not using 0.85. However, the marks in (b) are all available if they solve the specific case in (a).		
(b)	Vertical distance: $h=14\sin\alpha t-\frac{1}{2}\times9.8t^2$ $4.9t^2-11.9t+h=0$ $t=\frac{11.9\pm\sqrt{11.9^2-4\times4.9^2}}{9.8}$ $t=1.903.....$ Horizontal distance: $x=14\cos\alpha\times t$ =14.0 (m)	M1 A2 DM1 A1 M1 A1 A1 (8)	A complete method to find an equation in *t.* Must involve trig condone sin/cos confusion Correct in *h* or their *h*. -1 each error Solve a 3 term quadratic for *t*. Needs their value for *h* now. 1.9 or better Method for the horizontal distance. Condone consistent sin/cos confusion Correct for their positive *t* Accept 14

Question Number	Scheme	Marks	Notes
Alt (b)	Vertical speed = $\sqrt{100-(14\cos\alpha)^2}$ (=6.75) $v=u+at=14\times0.85-9.8t \quad (-6.75=11.9-9.8t)$ $t=1.903.....$ Horizontal distance: $x=14\cos\alpha\times t$ =14.0 (m)	M1 A2 DM1 A1 M1 A1 A1 (8)	A complete method to find the vertical component of the speed at *B*. Correct insimplified. -1 each error. Use their vertical component to find *t* 1.9 or better Method for the horizontal distance. Correct for their positive *t* Accept 14
		[12]	
NB	Candidates with a false method leading to 4.9 in (a) score at most M1A1A1DM1A0M1A1A0 if they use their result in (b). This error does not affect the alt (b) approach		

Question Number	Scheme	Marks	Notes
7(a)	Resolving vertically: $Y + P\cos\theta = W$	M1 A1	Needs all 3 terms. Condone sign errors and sin/cos confusion. Condone Wg
	Moments about A: $Wl\cos\theta = 2lP$	M1 A1	Terms need to be of the correct structure, but condone l implied if not seen.
	$P = \frac{W\cos\theta}{2} \Rightarrow Y = W - \frac{W\cos^2\theta}{2} = \frac{W}{2}\left(2 - \cos^2\theta\right)$ ****	DM1 A1 (6)	Substitute for P to obtain simplified Y Requires both preceding M marks Obtain **given result** correctly.
	NB $W + Y = P\cos\theta$ with correct conclusion is possible		
	They need to find two independent equations that do not include X. If they have equations involving X they need to attempt to eliminate X before they score any marks		
(b)	$\theta = 45° \Rightarrow Y = \frac{3W}{4}$	B1	
	$X = P\sin 45$	M1	Resolving horizontally. Accept in terms of θ.
	$= \frac{W\cos 45}{2}.\sin 45\left(= \frac{W}{4}\right)$	DM1 A1	Express X in terms of W. Accept in terms of θ. Requires preceding M mark. Correct unsimplified but substituted.
	Resultant at A = $\frac{W}{4}\sqrt{3^2 + 1^2} = \frac{W\sqrt{10}}{4}$ $(0.79W)$	DM1 A1 (6)	Use of Pythagoras with X, Y in terms of W only. Dependent on the first M1 Or equivalent $(0.79W$ or better)
	Alternative moments equations: about the centre $Pl + X\sin\theta l = y\cos\theta l$		
	About the point where the lines of action of P and X intersect $Y \times \frac{2l}{\cos\theta} = W\left(\frac{2l}{\cos\theta} - l\cos\theta\right)$		

Question Number	Scheme	Marks	Notes
8(a)	Work done against friction = Loss in GPE– Gain in KE $= 5\times 9.8\times 10\sin 25 - \frac{1}{2}\times 5\times 7^2 = 84.58...$	M1	Must be using Work-energy principle Needs to consider (work done) KE & GPE and no other terms. Condone sign errors. Watch out for incorrect solutions including both change in GPE and the work done against the weight – this is a method error.
		A2	-1 each error
	= 85 (J) (84.6)	A1 (4)	Max 3 s.f. Must be +ve. Accept as $10F = 84.6$ or equiv.
(b)	$F = \mu R = \mu \times 5g\cos 25$	M1 A1	Resolve to find $F_{max.}$ g missing is an accuracy error Correct unsimplified
	Work done = $10F = 10\mu \times 5g\cos 25$ = their85	M1 A1ft	Use of work done = force x distance to form an equation for μ Correct unsimplified equation for their $10F$
	$\mu = 0.19$	A1 (5)	Accept 0.190
		[9]	
altb	$F = \mu R = \mu \times 5g\cos 25$	M1 A1	Resolve to find $F_{max.}$ g missing is an accuracy error Correct unsimplified
	$v^2 = u^2 + 2as \rightarrow 49 = 20a \rightarrow a = \frac{49}{20}$	M1	**Complete** method to an equation in μ
	N2L $\rightarrow 5\times\frac{49}{20} = 5g\sin 25 - \mu\times 5g\cos 25$	A1	Correct unsimplified equation
	$\mu = 0.19$	A1 (5)	Accept 0.190

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