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Mark Scheme (Results)

Summer 2013

GCE Mechanics 5 (6681/01)

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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.

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: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- **A** marks: accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

3. 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. 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:
   - 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.

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

8. In some instances, the mark distributions (e.g. M1, B1 and A1) printed on the candidate's response may differ from the final mark scheme

General Rules for Marking Mechanics

- Usual rules for M marks: correct no. of terms; dim correct; all terms that need resolving (i.e. multiplied by cos or sin) are resolved.

- Omission or extra g in a resolution is accuracy error not method error.

- Omission of mass from a resolution is 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.

- 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.

Question Number	Scheme	Marks
1.	G.S. is $\mathbf{r} = \mathbf{A}e^{2t}$	B1
	$t = 0 : \mathbf{A}.\mathbf{j} = 0 \Rightarrow \mathbf{A} = p\mathbf{i} + r\mathbf{k}$	M1 A1
	$(p\mathbf{i} + r\mathbf{k}) \times \mathbf{j} = \mathbf{i} + \mathbf{k}$	M1 A1
	$-r\mathbf{i} + p\mathbf{k} = \mathbf{i} + \mathbf{k} \Rightarrow r = -1; p = 1$	M1
	$\mathbf{r} = (\mathbf{i} - \mathbf{k})e^{2t}$	A1
		(7)
		[7]
Notes for Question 1		
	B1 for $\mathbf{r} = \mathbf{A}e^{2t}$ oe. First M1 for *use* of initial conditions $t = 0$, $\mathbf{r}.\mathbf{j} = 0$. (M0 if no explicit **r** expression to sub into) First A1 for $\mathbf{A} = p\mathbf{i} + r\mathbf{k}$ (or $q = 0$) Second M1 for attempt at cross-product **r** x **j** when $t = 0$ (M0 if no explicit **r** expression to sub into) Second A1 for $(-r\,\mathbf{i} + p\,\mathbf{k})$ Third M1 for using the second condition to find values for p and r. Third A1 for a correct answer. N.B. All marks available apart from the final A1 if unsound work seen e.g. logs of vectors, provided that logs are removed at the start to give an explicit expression for **r** which can be evaluated in order to find the value of the constant.	

Question Number	Scheme	Marks
2.		
(a)	$I_G = \frac{1}{3}ma^2 + \frac{1}{3}ma^2 = \frac{2}{3}ma^2$ (perp axes)	M1 A1
	$I_G = \frac{2}{3}ma^2 + m(a\sqrt{2})^2 = \frac{8}{3}ma^2$ i.e. $k^2 = \frac{8}{3}a^2$ **	M1 A1
		(4)
(b)	$-mga\sqrt{2}\sin\theta = \frac{8}{3}ma^2\ddot{\theta}$	M1 A1
	$\ddot{\theta} = -\frac{3g\sqrt{2}}{8a}\theta$, for small θ	DM1
	$T = 2\pi\sqrt{\frac{8a}{3g\sqrt{2}}}$	M1 A1
		(5)
		[9]
Notes for Question 2		
2(a)	First M1 for use of perpendicular axes rule with appropriate no. of terms First A1 for correct expression for I_G (or from formulae sheet) Second M1 for use of parallel axes rule to obtain I_B Second A1 for PRINTED ANSWER. Alternative, using result(s) on formulae sheet: First M1A1 $I_{AB} = I_{BC} = 4/3ma^2$ (from formulae sheet) Second M1 for use of perpendicular axes rule with appropriate no. of terms $I_B = I_{AB} + I_{BC} = 8/3ma^2$	
2(b)	First M1 for moments equation (dim correct and *mg* resolved) First A1 for correct equation Second M1 dependent for use of $\sin\theta = \theta$ and SHM equation Third M1 for use of $T = 2\pi/\omega$ (only if proper SHM equn with -) Third A1 for answer.	

Question Number	Scheme	Marks
3.	$\frac{\mathrm{d}m}{\mathrm{d}t} = c \Rightarrow m = m_0 + ct$	
	$(m+\delta m)(v+\delta v) - mv = (mg - mkv)\delta t$	M1 A1
	$m\delta v + v\delta m = (mg - mkv)\delta t$	M1 A2
	$\frac{\mathrm{d}v}{\mathrm{d}t} + kv + \frac{v}{m}\frac{\mathrm{d}m}{\mathrm{d}t} = g$	
	$\frac{\mathrm{d}v}{\mathrm{d}t} + v\left(k + \frac{c}{m_0 + ct}\right) = g$ **	DM1 A1
		(7)
		[7]
Notes for Question 3		
	First M1 for $\frac{\mathrm{d}m}{\mathrm{d}t} = c$ and integrating First A1 for $m = m_0 + ct$ Second M1 for impulse-momentum equation (correct number of terms, excluding any $\delta m\delta v$ or $\delta m\delta t$ terms) Second and third A1: (-1 each error) **OR**: Second M1 for $mg - mkv = \frac{\mathrm{d}}{\mathrm{d}t}(mv)$ Second and third A1 for $mg - mkv = v\frac{\mathrm{d}m}{\mathrm{d}t} + m\frac{\mathrm{d}v}{\mathrm{d}t}$ (-1 each error) Third M1, dependent on second M1, for sub. for m . Third A1 for PRINTED ANSWER	

Question Number	Scheme	Marks
4.		
(a)	$(3\mathbf{i} - 2\mathbf{j} + \mathbf{k}) + (-2\mathbf{i} + \mathbf{j} - \mathbf{k}) + \mathbf{F}_3 = \mathbf{0}$	M1
	$\mathbf{F}_3 = (-\mathbf{i} + \mathbf{j})$ (N)	A1
		(2)
(b)	$(-2\mathbf{i} + 3\mathbf{j}) \times (3\mathbf{i} - 2\mathbf{j} + \mathbf{k}) + (3\mathbf{i} + 2\mathbf{k}) \times (-2\mathbf{i} + \mathbf{j} - \mathbf{k}) + \mathbf{r} \times (-\mathbf{i} + \mathbf{j}) = \mathbf{0}$	M1
	$(3\mathbf{i} + 2\mathbf{j} - 5\mathbf{k}) + (-2\mathbf{i} - \mathbf{j} + 3\mathbf{k}) + (-z\mathbf{i} - z\mathbf{j} + (x+y)\mathbf{k}) = \mathbf{0}$	A2,1,0
	$1 - z = 0,\ 1 - z = 0,\ -2 + x + y = 0$	M1
	$\mathbf{r} = (2\mathbf{i} + \mathbf{k}) + t(-\mathbf{i} + \mathbf{j})$ is a solution	A1
	OR Use Concurrency Principle	
		(5)
(c)	$\mathbf{F}_1 + \mathbf{F}_2 + \mathbf{F}_4 = (3\mathbf{i} + \mathbf{j} + \mathbf{k}) \Rightarrow \mathbf{F}_4 = (2\mathbf{i} + 2\mathbf{j} + \mathbf{k})$	M1 A1
	$\mathbf{r}_1 \times \mathbf{F}_1 + \mathbf{r}_2 \times \mathbf{F}_2 + (\mathbf{i} - 2\mathbf{j} + 3\mathbf{k}) \times (2\mathbf{i} + 2\mathbf{j} + \mathbf{k}) = (\mathbf{i} + \mathbf{j} + \mathbf{k}) \times (3\mathbf{i} + \mathbf{j} +$	M1
	$(3\mathbf{i} + 2\mathbf{j} - 5\mathbf{k}) + (-2\mathbf{i} - \mathbf{j} + 3\mathbf{k}) + (-8\mathbf{i} + 5\mathbf{j} + 6\mathbf{k}) = (2\mathbf{j} - 2\mathbf{k}) + \mathbf{G}$	A2,1,0 **ft on a**
	$\mathbf{G} = (-7\mathbf{i} + 4\mathbf{j} + 6\mathbf{k})$	A1
	$\lvert\mathbf{G}\rvert = \sqrt{(-7)^2 + 4^2 + 6^2} = \sqrt{101}$ (Nm)	M1 A1
		(8)
		[15]
Notes for Question 4		
4(a)	M1 for $\Sigma\mathbf{F}_i = \mathbf{0}$ A1 for **(-i + j)**	
4(b)	**In (b) condone consistent use of F x r.** First M1 for M(O) or M(P_1) or M(P_2) (must be using correct forces) First A1 and Second A1 -1each product. Second M1 for changing equation to $\mathbf{r} = \mathbf{a} + \lambda\mathbf{F}_3$ Third A1 for any correct equation. **OR:** Use Concurrency Principle First M1 for $\mathbf{r}_1 + s\mathbf{F}_1 = \mathbf{r}_2 + t\mathbf{F}_2$ First A1 for $s = 1$ or $t = 1$ Second A1 for $\mathbf{i} + \mathbf{j} + \mathbf{k}$ Second M1 for changing equation to $\mathbf{r} = \mathbf{a} + \lambda\mathbf{b}$ Third A1 for any correct equation.	
4(c)	First M1 $\mathbf{F}_1 + \mathbf{F}_2 + \mathbf{F}_4 = (3\mathbf{i} + \mathbf{j} + \mathbf{k})$ First A1 for $\mathbf{F}_4 = (2\mathbf{i} + 2\mathbf{j} + \mathbf{k})$ Second M1 for $(\mathbf{r}_1 \text{ x } \mathbf{F}_1) + (\mathbf{r}_2 \text{ x } \mathbf{F}_2) + (\mathbf{i} - 2\mathbf{j} + 3\mathbf{k})$ x (their $\mathbf{F}_4$) $= (\mathbf{i} + \mathbf{j} + \mathbf{k})$ x $(3\mathbf{i} +$ j Second A1**ft** and Third A1**ft** for correct equation with products evaluated (-1 ee) Fourth A1 for $\mathbf{G} = (-7\mathbf{i} + 4\mathbf{j} + 6\mathbf{k})$ Third M1 for $\lvert\mathbf{G}\rvert = \sqrt{(-7)^2 + 4^2 + 6^2}$ Fifth A1 for √101 oe (2 or more SF)	

Question Number	Scheme	Marks
5.	Taking strips parallel to *BC*:	
	$l_x = \frac{2ax}{h}$	M1 A1
	$\delta m = \frac{2ax}{h}.\frac{M\delta x}{ah} = \frac{2Mx\delta x}{h^2}$	M1 A1
	$\delta I = \frac{1}{3}\delta m(\frac{ax}{h})^2 + \delta m.x^2$	M1 A1A1
	$= \frac{2M}{3h^4}(a^2+3h^2)x^3\delta x$	A1
	$I = \frac{2M}{3h^4}(a^2+3h^2)\int_0^h x^3 \mathrm{d}x$	DM1
	$= \frac{2M}{3h^4}(a^2+3h^2)\left[\frac{x^4}{4}\right]_0^h$	
	$= \frac{M}{6}(a^2+3h^2)$ **	A1
		(10)
		[10]
Notes for Question 5		
	First M1 for attempt to find length of strip in terms of *x, h* and *a*, using similar triangles or equivalent (must be dim correct) First A1 for a correct expression Second M1 for attempt to find mass of strip in terms of *x, h, M* and δx (must be dim correct) (this mark is not available if ρ is not found) Second A1 for a correct expression. Third M1 for use of parallel axes rule on strip Third A1 for $\frac{1}{12}\delta m l_x^2$ term Fourth A1 for $\delta m x^2$ term Fifth A1 for a correct expression in *a*, *x, h, M* and δx Fourth M1 dependent on Third M1, for integrating their δI (which must have a δx) Sixth A1 for PRINTED ANSWER N.B. Third M1 They may use perpendicular axes on *whole* triangle, with same working. (N.B. if ρ is used but never eliminated, can score max M1A1M0A0M1A1A1A0M1A0)	

Question Number	Scheme	Marks
6.	$4mg - T_1 = 4mf$	M1 A1
	$T_2 - mg = mf$	M1 A1
	$(T_1 - T_2)a - 2mga = \frac{1}{2}2ma^2.\frac{f}{a}$	M1 A3
	$4mg - mg - 2mg = 6mf \Rightarrow f = \frac{g}{6}$	DM1
	ang accln = $\frac{g}{6a}$	A1
		(10)
		[10]
Notes for Question 6		
	First M1 for equation of motion for 4*m* First A1 for correct equation using either *f* or α Second M1 for equation of motion for *m* Second A1 for correct equation using either *f* or α Third M1 for equation of motion for pulley A3 for a correct equation using either *f* or α Fourth M1, dependent on previous three M's, for producing an equation in α and g only. Sixth A1 for answer S.C. M4A5 'whole system' equation: $(4mg - mg - 2mg)a = (4ma^2 + ma^2 + ma^2)\alpha$	

Question Number	Scheme	Marks
7.		
(a)	$I_A = \frac{1}{2}mr^2 + mr^2 = \frac{3mr^2}{2}$	M1 A1
	$\rightarrow \qquad X = mr\dot{\theta}^2 = 0$	M1 A1A1
	$\downarrow \qquad mg - Y = mr\ddot{\theta}$	M1 A1
	$M(A) \qquad mgr = \frac{3mr^2}{2}\ddot{\theta}$	M1 A1
	$Y = \frac{1}{3}mg$	DM1 A1
		(11)
(b)	$\frac{1}{2}\frac{3mr^2}{2}\omega^2 = mgr$	M1 A1
	$I.2r = \frac{3mr^2}{2}\omega$	M1 A1
	$I = \frac{m}{2}\sqrt{3gr}$	DM1 A1
		(6)
		[17]
Notes for Question 7		
7(a)	First M1 for use of parallel axes rule First A1 for correct expression Second M1 for resolving horizontally (usual rules) Second A1 for a correct equation Third A1 for 0 Third M1 for resolving vertically (usual rules) Fourth A1 for a correct equation Fourth M1 for moments about A (usual rules) Fifth A1 for a correct equation Fifth M1, dependent on previous two M marks, for solving for Y. A1 for answer	
7(b)	First M1 for energy equation First A1 for a correct equation Second M1 for angular impulse-momentum equation Second A1 for a correct equation Third M1, dependent on previous M's, for solving for I Third A1 for the answer	

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