Mark Scheme (Pre Stand)

Summer 2019

Pearson Edexcel GCE In Mechanics 5
Paper 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.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- 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

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
1.	$\overrightarrow{AB} = (4\mathbf{i} + 4\mathbf{j})$	B1
	$(5\mathbf{i} + \mathbf{j} + p\mathbf{i} + q\mathbf{j}).(4\mathbf{i} + 4\mathbf{j}) = \frac{1}{2} \times 0.05 \times 40^2$	M1 A2ft
	$p + q = 4$	A1
	$3p + q = 0$	B1
	$p = -2,\ q = 6$	A1
		7
	Notes	
1.	First B1 for 4**i** + 4**j** First M1 for complete work-energy equation First A1 for work done ft on their AB Second A1 for KE (must see evidence of KE not just the use of 40) Second B1 for p/q equation seen or used anywhere A1 correct values for p and q	

Question Number	Scheme	Marks
2.	$R = e^{\int \frac{-3}{(t+1)}\,dt} = \frac{1}{(t+1)^3}$	M1 A1
	$\frac{\mathbf{r}}{(t+1)^3} = \int \frac{5}{(t+1)^3}\mathbf{j}\,dt$	M1
	$= \frac{-5}{2(t+1)^2}\mathbf{j} + \mathbf{C}$	M1 A1
	$\mathbf{r} = \frac{-5(t+1)}{2}\mathbf{j} + \mathbf{C}(t+1)^3$	
	$t = 0, \mathbf{r} = \mathbf{i} + 0.5\mathbf{j}$	
	$\mathbf{i} + 0.5\mathbf{j} = -2.5\mathbf{j} + \mathbf{C} \Rightarrow \mathbf{C} = \mathbf{i} + 3\mathbf{j}$	M1 A1
	$\mathbf{r} = \frac{-5(t+1)}{2}\mathbf{j} + (t+1)^3(\mathbf{i} + 3\mathbf{j})$	A1
	$= (t+1)^3\mathbf{i} + (3(t+1)^3 - \frac{5}{2}(t+1))\mathbf{j}$	**8**
	Notes	
2.	First M1 for using correct formula for integrating factor. First A1 for correct integrating factor Second M1 for multiplying both sides by IF and attempt to integrate Third M1 for integrating to get something of the form $\frac{a}{(t+1)^2}$ Second A1 integration correct Fourth M1 for use of limits to find **C** Third A1 correct value for **C** Fourth A1 correct final answer	

Question Number	Scheme	Marks
3(a)	$\mathbf{F}_1 = (-6\mathbf{i}+8\mathbf{j}+24\mathbf{k})$ N $\quad \mathbf{F}_2 = (2\mathbf{i}-4\mathbf{j}-4\mathbf{k})$ N $\quad \mathbf{F}_3 = (4\mathbf{i}-4\mathbf{j}-20\mathbf{k})$ N $\mathbf{F}_1 + \mathbf{F}_2 + \mathbf{F}_3 = \mathbf{0}$ $\sum \mathbf{r} \times \mathbf{F} = (4\mathbf{i}-6\mathbf{j}-8\mathbf{k}) \times (-6\mathbf{i}+8\mathbf{j}+24\mathbf{k}) + (\mathbf{i}-2\mathbf{j}+4\mathbf{k}) \times (2\mathbf{i}-4\mathbf{j}-4\mathbf{k})$ $+ (2\mathbf{i}-4\mathbf{j}+2\mathbf{k}) \times (4\mathbf{i}-4\mathbf{j}-20\mathbf{k})$ $= (-80\mathbf{i}-48\mathbf{j}-4\mathbf{k}) + (24\mathbf{i}+12\mathbf{j}) + (88\mathbf{i}+48\mathbf{j}+8\mathbf{k})$ $= (32\mathbf{i}+12\mathbf{j}+4\mathbf{k})$ ($\neq \mathbf{0}$, therefore a couple) $\lvert\mathbf{G}\rvert = \sqrt{32^2+12^2+4^2} = 4\sqrt{74}$ (N m) oe	B2 M1 M1 A1 A1 M1 A1 (8)
(b)	$\mathbf{F}_4 = (\mathbf{i}-2\mathbf{j}-2\mathbf{k})$ $\mathbf{G} + (x\mathbf{i}+y\mathbf{j}+z\mathbf{k}) \times (\mathbf{i}-2\mathbf{j}-2\mathbf{k}) = (\mathbf{i}+\mathbf{j}-2\mathbf{k}) \times (\mathbf{i}-2\mathbf{j}-2\mathbf{k})$ $(32\mathbf{i}+12\mathbf{j}+4\mathbf{k}) + (-2y+2z)\mathbf{i} + (z+2x)\mathbf{j} + (-2x-y)\mathbf{k} = (-6\mathbf{i}-3\mathbf{k})$ $(-2y+2z)\mathbf{i} + (z+2x)\mathbf{j} + (-2x-y)\mathbf{k} = (-38\mathbf{i}-12\mathbf{j}-7\mathbf{k})$ $-2y+2z=-38; \quad z+2x=-12; \quad -2x-y=-7$ One solution e.g. $x=0, y=7, z=-12$ $\mathbf{r} = (7\mathbf{j}-12\mathbf{k}) + t(\mathbf{i}-2\mathbf{j}-2\mathbf{k})$	B1 M1 A1 ft A1 ft A1 (5) **13**
	Notes	
3(a)	First and second B1 for finding correct forces, -1 for each incorrect force FirstM1 for showing that sum of forces is **0** Second M1 attempt to find $\sum \mathbf{r} \times \mathbf{F}$ Allow consistent use of $\sum \mathbf{F} \times \mathbf{r}$ First A1 for 3 correct products Second A1 for correct sum Third M1 for finding the magnitude of their **G** Third A1 for correct answer, exact or to at least 3 s.f.	
(b)	B1 for correct $\mathbf{F}_4$ seen or used First M1 Use of **G** + moment of $\mathbf{F}_4$ = resultant moment First A1 for correct vector products, ft on their **G** Second A1 for correct simultaneous equations ft on their **G** Third A1 for correct line equation (needs **r** = …)	

Question Number	Scheme	Marks
4.	$mv = (m + \delta m)(v + \delta v) + (-\delta m)(v - U)$	M1 A1
	$\mathrm{d}v = -\dfrac{U}{m}\mathrm{d}m$	A1
	$\int_0^{U\ln\frac{6}{5}} \mathrm{d}v = -U\int_{\frac{3M}{2}}^{m} \dfrac{\mathrm{d}m}{m}$	M1 A1 (limits)
	$U\ln\dfrac{6}{5} = U\left[\ln m\right]_m^{\frac{3M}{2}}$	A1
	$m = \dfrac{5M}{4}$	
	$\dfrac{1}{2}$ of the fuel remains.	A1 **7**
	Notes	
4.	First M1 for use of Impulse-Momentum principle, dimensionally correct, with correct number of terms, usual rules First A1 for correct equation Second A1 for correct simplification to this form or equivalent Second M1 for separating the variables and attempting to integrate both sides Third A1 for correct limits or equivalent Fourth A1 for correct integration on both sides Fifth A1 for correct answer	

Question Number	Scheme	Marks
5.	$I_A = \frac{4}{3}2m(2a)^2 = \frac{32ma^2}{3}$ CAM about A: $mu2a = I_A\omega - mv2a$ NIL: $0.5u = 2a\omega + v$ $\omega = \frac{9u}{44a}$	B1 M1 A2 M1 A1 **DM**1 A1 **8**
	Notes	
	B1 for correct I_A First M1 for conservation of angular momentum with usual rules First and second A1 for correct equation, -1 for each wrong term Second M1 for use of NLR Third A1 for correct equation Third DM1 for solving for ω, dependent on both of previous M marks Fourth A1 for correct answer	

Question Number	Scheme	Marks
6(a)	$I_A = \frac{1}{2}ma^2 + ma^2 = \frac{3}{2}ma^2$	B1
	$\frac{1}{2}I_A(\frac{4g}{a} - \omega^2) = mga(1-\cos\beta)$	M1 A2
	$\omega = \sqrt{\frac{56g}{15a}}$	A1 (5)
(b)	$-mga\sin\beta = I_A\ddot{\theta}$	M1 A1
	$\ddot{\theta} = -\frac{2g}{5a}$	A1
	$Y - mg\cos\beta = ma\omega^2$	M1 A1
	$Y = \frac{68mg}{15}$	A1
	$X - mg\sin\beta = ma\ddot{\theta}$	M1 A1
	$X = \frac{mg}{5}$	A1
	$R = \sqrt{(\frac{mg}{5})^2 + (\frac{68mg}{15})^2}$	M1
	$= \frac{mg}{15}\sqrt{4633}$ oe	A1 (11)
		16
	Notes	
6(a)	B1 for correct I_A M1 for conservation of energy equation with usual rules First and second A1 for correct equation, A1 each side Third A1 for correct answer	
(b)	First M1 for equation of rotational motion about axis with usual rules (or differentiation of energy equation at a general position – see below) A1 for correct equation Second A1 for correct value of $\ddot{\theta}$ Second M1 for equation of motion inwards, usual rules Third A1 for correct equation Fourth A1 for correct value of Y Third M1 for correct tangential equation, usual rules Fifth A1 for correct equation Sixth A1 for correct value of X Fourth M1 for finding the magnitude, using their X and Y, in terms of m and g only Seventh A1 for correct answer	
Or	$mga - mga\cos\theta = 3mga - \frac{3}{4}ma^2\dot{\theta}^2$ Differentiate with respect to t $mga\sin\theta\dot{\theta} = -\frac{3}{4}ma^2 \times 2\dot{\theta}\ddot{\theta}$ $\quad \ddot{\theta} = -\frac{2g}{3a}\sin\theta$	

Question Number	Scheme	Marks
7a)	$r = \dfrac{M}{\rho(b^2 - a^2)}$	B1
	$I_O = \dfrac{1}{2}\rho b^2 r b^2 - \dfrac{1}{2}\rho a^2 r a^2$	M1 A1
	$= \dfrac{1}{2}\rho \dfrac{M}{\rho(b^2 - a^2)}(b^4 - a^4)$	**DM**1
	$= \dfrac{1}{2}M(b^2 + a^2)$ Given answer.	A1 (5)
(b)	$I_T = \dfrac{1}{2}.\dfrac{1}{2}M(b^2 + a^2) + Mb^2$	M1 M1 A1
	$= \dfrac{1}{4}M(5b^2 + a^2)$	
	$-Mgb\sin\theta = I_T\ddot{\theta}$	M1 A1
	$\ddot{\theta} = -\dfrac{4gb\sin\theta}{(5b^2 + a^2)} \simeq -\dfrac{4gb\theta}{(5b^2 + a^2)}$ SHM	M1
	Period $= 2\pi\sqrt{\dfrac{(5b^2 + a^2)}{4gb}} = \pi\sqrt{\dfrac{(5b^2 + a^2)}{gb}}$ Given answer	M1 A1 (8)
(c)	$\dfrac{1}{2}a = a\cos\sqrt{\dfrac{4gb}{(5b^2 + a^2)}}\ t$	M1 A1
	$t = \dfrac{\pi}{6}\sqrt{\dfrac{(5b^2 + a^2)}{gb}}$	A1 (3)
		16
	Notes	
7(a)	B1 for correct expression for ρ seen or used First M1 for subtraction of moments of inertia of discs First A1 for correct expression Second DM1 for elimination of ρ Second A1 for correct GIVEN ANSWER	
7(b)	First M1 for use of perpendicular axes theorem Second M1 for use of parallel axes theorem First A1 for correct expression for I_T Third M1 for equation of rotational motion, usual rules Second A1 for correct equation Fourth M1 for using small angle approx. and putting into appropriate form (with – sign) Fifth M1 for SHM and use of correct formula for period Third A1 for correct GIVEN ANSWER	
7c)	M1for use of correct formula (including cos) First A1 for correct equation Second A1 for correct answer	

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