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Mark Scheme (Results)

Summer 2014 - Home

Pearson Edexcel GCE in 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.

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
1.	$\mathbf{F} = \lambda(\pm 8\mathbf{i} \pm 15\mathbf{j})$ $\lambda^2(8^2 + 15^2) = 8.5^2$ $\mathbf{F} = \frac{1}{2}(8\mathbf{i} + 15\mathbf{j})$ $\mathbf{AB} = (5\mathbf{i} + 4\mathbf{j})$ Work done = $\frac{1}{2}(8\mathbf{i} + 15\mathbf{j})$ = 50 (J)	M1 A1 M1 A1 A1 B1 M1 A1 **8**

Notes

First M1 for $\lambda(\pm 8\mathbf{i} \pm 15\mathbf{j})$
First A1 for correct expression
Second M1 for $\lambda^2(8^2 + 15^2) = 8.5^2$ from previous incorrect vector
Second A1 for $\lambda = \pm\frac{1}{2}$
Third A1 for correct **F**
B1 for correct **AB**
Third M1 for their **F.AB**
Fourth A1 for 50 (J). (-50 is A0)

Question Number	Scheme	Marks
2.	$\text{IF} = \mathrm{e}^{\int \mathrm{d}t} = \mathrm{e}^{t}$	M1 A1
	$\dfrac{\mathrm{d}}{\mathrm{d}t}(\mathbf{r}\mathrm{e}^{t}) = t\mathrm{e}^{t}\mathbf{i} + \mathbf{j}$	
	$\mathbf{r}\mathrm{e}^{t} = \int t\mathrm{e}^{t}\mathbf{i} + \mathbf{j}\ \mathrm{d}t$	M1
	$\mathbf{r}\mathrm{e}^{t} = (t\mathrm{e}^{t} - \mathrm{e}^{t})\mathbf{i} + t\mathbf{j} + \mathbf{C}$	M1 A2
	$t = 0, \mathbf{r} = \mathbf{i} + \mathbf{j} \Rightarrow \mathbf{C} = 2\mathbf{i} + \mathbf{j}$	M1
	$\mathbf{r}\mathrm{e}^{t} = (t\mathrm{e}^{t} - \mathrm{e}^{t})\mathbf{i} + t\mathbf{j} + 2\mathbf{i} + \mathbf{j}$	A1
	$\mathbf{r} = (t-1)\mathbf{i} + t\mathrm{e}^{-t}\mathbf{j} + (2\mathbf{i} + \mathbf{j})\mathrm{e}^{-t}$	
	$= (t - 1 + 2\mathrm{e}^{-t})\mathbf{i} + (t+1)\mathrm{e}^{-t}\mathbf{j}$	A1 **9**

Notes

First M1 for IF
First A1 for e^{t}
Second M1 see scheme
Third M1 for attempt to integrate (must include parts)
A2 for a correct integral
Fourth M1 for use of limits
A1 for a correct **C**
A1 for answer (any equivalent form)

Question Number	Scheme	Marks
3.	$(2\mathbf{i} + 3\mathbf{j} - \mathbf{k}) + (\mathbf{i} - 4\mathbf{j} - 2\mathbf{k}) + (-3\mathbf{i} + \mathbf{j} + 3\mathbf{k}) = \mathbf{0}$	M1 A1
	$(\mathbf{i} + \mathbf{j} - 2\mathbf{k}) \times (2\mathbf{i} + 3\mathbf{j} - \mathbf{k}) + (3\mathbf{i} - \mathbf{j} - \mathbf{k}) \times (\mathbf{i} - 4\mathbf{j} - 2\mathbf{k}) + (\mathbf{i} - 2\mathbf{j} + \mathbf{k}) \times (-3\mathbf{i} + \mathbf{j} + 3\mathbf{k})$	M1
	(allow $\sum \mathbf{F} \times \mathbf{r}$ **)**	
	$= (5\mathbf{i} - 3\mathbf{j} + \mathbf{k}) + (-2\mathbf{i} + 5\mathbf{j} - 11\mathbf{k}) + (-7\mathbf{i} - 6\mathbf{j} - 5\mathbf{k})$	A3
	$= (-4\mathbf{i} - 4\mathbf{j} - 15\mathbf{k})$	A1
	$\sqrt{(-4)^2 + (-4)^2 + (-15)^2}$	M1
	$\sqrt{257}$ Nm (2 SF or better)	A1
		9

Notes

First M1 for $\Sigma \mathbf{F}_i$
First A1 for $= \mathbf{0}$
Second M1 for $\Sigma\ \mathbf{r} \times \mathbf{F}$ or $\Sigma\ \mathbf{F} \times \mathbf{r}$
A3 -1 e.e.o.o. (-1 per cross product)
A1 $\pm(-4\mathbf{i} - 4\mathbf{j} - 15\mathbf{k})$
Third M1 for $|\mathbf{G}| = \sqrt{(-4)^2 + (-4)^2 + (-15)^2}$
A1 for $\sqrt{257}$ or 2sf or better.

Question Number	Scheme	Marks
4. (a)	$(m+\delta m)(v+\delta v)+(-\delta m)(v+k)=mv$ $mv+v\delta m+m\delta v-v\delta m-k\delta m=mv$ $m\delta v-k\delta m=0$ $\frac{\mathrm{d}v}{\mathrm{d}m}-\frac{k}{m}=0$	M1 A2 **DM**1 A1 (5)
(b)	$\int \mathrm{d}v=k\int\frac{\mathrm{d}m}{m}$ $v=k\ \ln m+C$ $v=U, m=M \Rightarrow C=U-k\ln M$ $v=k\ \ln m+U-k\ln M$ $v=U+k\ln\left(\frac{m}{M}\right)$ $v=0\Rightarrow m=M\mathrm{e}^{-\frac{U}{k}}$	M1 A1 M1 A1 M1 A1 (6)
(c)	$m=M\mathrm{e}^{-\alpha t^2}\Rightarrow v=U-k\alpha t^2$ $s=Ut-\frac{1}{3}k\alpha t^3(+D)$ At $t=T$, $s=UT-\frac{1}{3}k\alpha T^3$ At $t=T, v=0\Rightarrow k\alpha T^2=U$ $s=UT-\frac{1}{3}UT=\frac{2}{3}UT$	M1 M1 A1 M1 M1 A1 (6)
		17

Notes	
4.(a)	First M1 for momentum equation (correct number of terms, excluding any $\delta m \delta v$ terms) A2 for a correct equation -1 e.e. Second M1, dependent on first M1, for simplifying and dividing by $m\delta m$ and taking limits Third A1 for PRINTED ANSWER
4.(b)	First M1 for separating and integrating First A1 correct expression (without C) Second M1 for using limits Second A1 for a correct v (seen or implied) Third M1 for putting $v = 0$ and solving for m Third A1 for correct answer
4(c).	First M1 for obtaining $v = U - k\alpha t^2$ (method) Second M1 for integrating wrt time First A1 for a correct expression for s (without D) Third M1 for using $v = 0$ at $t = T$ to obtain $U = k\alpha T^2$ (method) Fourth M1 for obtaining s in terms of U and T Second A1 for correct answer

Question Number	Scheme	Marks
5.(a)	$I_L = \frac{1}{3}ma^2 + m(\frac{1}{3}a)^2$ $= \frac{4}{9}ma^2$	M1 A1
(b)		A1 (3)
(c)	$\frac{1}{2}\frac{4}{9}ma^2\dot{\theta}^2 = mg\frac{1}{3}a(1-\cos\theta)$ $\dot{\theta} = \sqrt{\frac{3g(1-\cos\theta)}{2a}}$	M1 A1 A1 A1 (4)
	$mg\frac{1}{3}a\sin\theta = \frac{4}{9}ma^2\ddot{\theta}$ $\frac{3g\sin\theta}{4a} = \ddot{\theta}$	M1 A1 A1 (3)
(d)	$mg\cos\theta - X = m\frac{1}{3}a\dot{\theta}^2; X = 0$ $\dot{\theta}^2 = \frac{3g(1-\cos\theta)}{2a}$ eliminating $\cos\theta$ and solving, $\dot{\theta} = \sqrt{\frac{g}{a}}$	M1 A1 A1 **DM**1 A1 (5) **15**

Notes

5.(a) M1 for use of parallel axes rule
First A1 for correct expression
Second A1 for answer

5.(b) M1 for energy equation
First A1 for KE terms
Second A1 for PE terms
Third A1 for answer

5.(c) M1 for moments about axis (or differentiate energy equation)
First A1 for a correct equation
Second A1 for answer

5.(d) First M1 for resolving along the rod
First A1 for forces incl. $X = 0$
Second A1 for mass x accln
Second M1, dependent on first M1, for eliminating $\cos\theta$ and solving for $\dot{\theta}$
Third A1 for correct answer

Question Number	Scheme	Marks
6.(a)	$\delta m = 2\pi x \delta x \dfrac{m}{\pi a^2} = \dfrac{2mx\delta x}{a^2}$	M1 A1
	$\delta I = \dfrac{2mx^3\delta x}{a^2}$	A1
	$I = \dfrac{2m}{a^2}\int_0^a x^3 \,\mathrm{d}x$	M1
(b)	$= \frac{1}{2}ma^2$ PRINTED	A1 (5)
	$\frac{1}{2}\dfrac{4M}{3}(2a)^2 - \frac{1}{2}\dfrac{M}{3}a^2$	M1 A1
	$= \frac{5}{2}Ma^2$	
	$2I = \frac{5}{2}Ma^2$ (perp axes rule)	M1
	$I = \frac{5}{4}Ma^2$ PRINTED	A1 (4)
(c)	$\left(\frac{5}{4}Ma^2 + M(\frac{3a}{2})^2\right)\omega = Mu(\frac{3a}{2})$	M1 A1 A1
	$\omega = \frac{3u}{7a}$	A1
	KE loss $= \frac{1}{2}Mu^2 - \frac{1}{2}\left(\frac{5}{4}Ma^2 + M(\frac{3a}{2})^2\right)(\frac{3u}{7a})^2$	M1 **A2 ft**
	$= \dfrac{5Mu^2}{28}$	A1 (8)
		17

Notes	
6.(a)	First M1 for area element First A1 for a correct δm Second A1 for a correct δI Second M1 for using mass per unit area and integrating with correct limits Third A1 for the **PRINTED ANSWER**
6.(b)	M1 for use of difference of MI (difference in the masses must be *M*) A1 for correct expression without mass per unit area M1 for use of MI about diameter (in formula book) A1 for the **PRINTED ANSWER** **N.B.** The two M marks may be earned in either order
6.(c)	First M1 for conservation of angular momentum equation First A1 for LHS on scheme Second A1 for RHS on scheme Third A1 for a correct ω (or possibly *v*) Second M1 for a difference in KE (must have found an ω) (omission of MI of particle is missing term so M0) Fourth and fifth A2 **ft** on their ω Sixth A1 for a correct positive answer

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