Pearson

Mark Scheme (Results)

Oct 2017

Pearson Edexcel IAL in Mechanics 2 (WME02/01)

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- 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. 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. Marks for each question are scored by clicking in the marking grids that appear below each student response on ePEN. The maximum mark allocation for each question/part question(item) is set out in the marking grid and you should allocate a score of '0' or '1' for each mark, or "trait", as shown:

	0	1
aM		●
aA	●	
bM1		●
bA1	●	
bB	●	
bM2		●
bA2		●

9. Be careful when scoring a response that is either all correct or all incorrect. It is very easy to click down the '0' column when it was meant to be '1' and all correct.

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.	$\mathbf{I} = 0.2(5\mathbf{i}+8\mathbf{j}) - 0.2(10\mathbf{i}-17\mathbf{j})$	M1	Use of $\mathbf{I} = \pm m(\mathbf{v}-\mathbf{u})$. Must be using the change in velocity.
	$\mathbf{I} = -\mathbf{i}+5\mathbf{j}$	A1	Allow $\pm$. Seen or implied.
	$\lvert\mathbf{I}\rvert = \sqrt{1+25} = ...$	M1	Use of Pythagoras to find $\lvert\mathbf{I}\rvert$ or $\lvert\mathbf{v}-\mathbf{u}\rvert$
	$... = \sqrt{26}$ (N s)	A1	5.099... 5.1 or better
		[4]	

Question Number	Scheme	Marks	Notes
2(a)	$T = \dfrac{30000}{24}$	M1	Use of $P = Fv$
	$(= 1250 \text{ N})$	A1	Seen or implied
	$1250 - 650 = 1200a$	M1	Equation of motion. All terms required & must be dimensionally correct. Allow for their 1250. Condone sign errors
	$a = \dfrac{600}{1200} = 0.5 \text{ m s}^{-2}$	A1	
		(4)	
(b)	$T' - 650 - 1200g \sin\alpha = 0$	M1	No acceleration. Condone sign errors and sin/cos confusion.
	$T' = 650 + 1200g \times \dfrac{1}{12} \quad (= 1630)$	A1	Correct unsimplified substituted expression for the driving force.
	Rate of working $= \left(650 + 1200g \times \dfrac{1}{12}\right) \times 24 \text{ W}$	dM1	Their driving force $\times 24$ Dependent on the previous M1
	$(= 39.12) = 39 \quad (\text{kW})$	A1	Or 39.1 (kW) Max 3 s.f. The Q asks for kW
		(4)	
		[8]	

Question Number	Scheme	Marks	Notes
3(a)	$N = 4g\cos 40° \ (= 30.028...)$		
	$F = 0.5 \times 4g\cos 40°$	M1	Use of $F = \mu N$ where N is a resolved component of $4g$. Condone sin/cos confusion
	Work done $= 12 \times 0.5 \times 4g\cos 40°$	M1	Their $F \times 12$
	$(= 180.17...) = 180$ J	A1	Max 3 s.f.
		(3)	
(b)	Work done + Final KE = Initial KE + GPE	M1	Must be using W.E. Need all terms. Condone sign errors. Terms must be dimensionally correct. Condone sin/cos confusion
	Their WD $+ \frac{1}{2} \times 4 \times 24^2$ $= \frac{1}{2} \times 4u^2 + 4g \times 12\sin 40°$ follow their WD	A1ft	At most one error Incorrect sign(s) is one error. $(4g \times 12\sin 40 = 302.367.....)$
		A1ft	Correct unsimplified (for their WD)
	$u(= 22.691...) = 23$ or 22.7 m s^{-1}	A1	Max 3 s.f.
		(4)	
		[7]	

Question Number	Scheme	Marks	Notes
4(a)	M(A) or alternative complete method to an equation in T only	M1	Must have all terms. Terms must be dimensionally correct. Condone sign errors and sin/cos confusion.
	$T \times 2a = mg \times 3a \sin 60° + mg \times 6a \sin 60°$	A1	Unsimplified equation with at most one error
		A1	Correct unsimplified equation
	$T = 9mg\dfrac{\sqrt{3}}{4}$	A1 (4)	With trig. substituted. $3.90mg$ or better
(b)	$\mathrm{R}(\rightarrow) \quad R = T\cos 60°$	M1	Resolve horizontally. Condone sin/cos confusion
	$\left(= 9mg\dfrac{\sqrt{3}}{4} \times \dfrac{1}{2}\right)$	A1ft	Follow their T. Allow with $\cos 60°$
	$R = \dfrac{9\sqrt{3}}{8}mg$	A1ft (3)	$1.95mg$ or better. Follow their (a).
Alt 4(b)	$2mg\cos 60° = R\cos 30° - F\cos 60°$ $T - F\cos 30 = 2mg\cos 30° + R\cos 60°$	(M1)	Resolve parallel and perpendicular to the rod and eliminate F
	$\dfrac{5mg\sqrt{3}}{4} - \dfrac{R}{2} = -\sqrt{3}mg + \dfrac{3R}{2}$	(A1ft)	Equation in R only. Follow their T
	$R = \dfrac{9\sqrt{3}}{8}mg$	(A1ft)	With trig. substituted. Follow their (a)
(c)	$\mathrm{R}(\uparrow) \quad T\cos 30° - F = mg + mg$	M1	Resolve vertically. Need all terms. Condone sign errors and sin/cos confusion. Allow for $\pm F$
		A1	Unsimplified equation with at most one error. Allow for $\pm F$
	$F = 9mg\dfrac{\sqrt{3}}{4} \times \dfrac{\sqrt{3}}{2} - 2mg\left(= \dfrac{11}{8}mg\right)$	A1	Correct unsimplified expression for F, with trig. substituted. Allow for $\pm F$. Seen or implied.
	$\mu = \dfrac{F}{R} = \dfrac{\frac{11}{8}mg}{\frac{9\sqrt{3}}{8}mg}$	dM1	Use of $F = \mu R$ Dependent on the two previous M marks
	$= \dfrac{11}{9\sqrt{3}} \quad (= 0.71 \text{ or } 0.706 \text{ or better})$	A1 (5)	(g cancels)
(c) alt 1st 3 marks	$2mg\cos 60° = R\cos 30° - F\cos 60°$	(M1)	Resolve parallel to the rod. Need all terms. Condone sign errors and sin/cos confusion. Allow for $\pm F$
	$mg = \dfrac{27}{16}mg - \dfrac{1}{2}F$	(A1)	Unsimplified equation with at most one error. Allow for $\pm F$. sin/cos confusion is one error
	$F = \dfrac{11}{8}mg$	(A1)	Correct unsimplified expression for F. Allow for $\pm F$. Seen or implied.
		[12]	

Question Number	Scheme	Marks	Notes
5(a)	Mass ratio $\pi a^2 \qquad 4a^2\sqrt{3} \qquad a^2\left(4\sqrt{3}-\pi\right)$	B1	
	Dist from D $\frac{3a}{2} \qquad \frac{2a}{3}\sqrt{3} \qquad \bar{x}$	B1	
	$4\sqrt{3}\times\frac{2a}{3}\sqrt{3}-\pi\frac{3a}{2}=\left(4\sqrt{3}-\pi\right)\bar{x}$	M1	Moments about BC. Condone sign errors. Accept in vector form.
		A1ft	Correct unsimplified equation. Follow their clear statements of areas and mass ratios.
	$\bar{x}=\frac{4\sqrt{3}\times\frac{2a}{3}\sqrt{3}-\pi\frac{3a}{2}}{\left(4\sqrt{3}-\pi\right)}=\frac{(16-3\pi)a}{2\left(4\sqrt{3}-\pi\right)}$	A1	$\left(0.86822...a=\right)0.87a$ or better
		(5)	
(b)	$\tan\theta=\frac{2a}{\bar{x}}$	M1	Trig ratio of a relevant angle
	$\theta=\tan^{-1}\left(\frac{2a}{\bar{x}}\right)$ or $\theta=90°-\tan^{-1}\left(\frac{\bar{x}}{2a}\right)$	A1ft	Follow their $\bar{x}$
	$\theta=67°$	A1	Final answer. Q asks for acute angle and the nearest degree. Do not ISW
			SR: Final answer $23°$ scores M1A0A0
		(3)	
		[8]	

Question Number	Scheme	Marks	Notes
6(a)		M1	Integrate a to obtain v
	$v = t^2 - 3t \ (+c)$	A1	Condone missing C
	$t = 3,\ v = 2 \Rightarrow c = 2$	M1	Substitute to find C
	$v = t^2 - 3t + 2$	A1	
		(4)	
(b)	$0 = (t-2)(t-1)$	M1	Set their $v = 0$ and solve for t
	$t = 1,\ 2$	A1	
	$s = \int_1^2 (t^2 - 3t + 2)\,\mathrm{d}t$	M1	Integrate v to obtain s
	$= \left[\frac{1}{3}t^3 - \frac{3}{2}t^2 + 2t\right]_1^2$	A1ft	Condone if limits not seen. Follow their v.
	$= -\frac{1}{6}$ m	dM1	Use their t values as limits. Dependent on the preceding M1.
	Dist $= \frac{1}{6}$ (m)	A1	0.17, 0.167 or better
		(6)	
		[10]	

Question Number	Scheme	Marks	Notes
7(a)	$\frac{1}{2}m\times v^2-\frac{1}{2}m\times 15^2=47.5mg$	M1	The Q tells them to use energy. Need all 3 terms. Condone sign errors Must be dimensionally correct.
		A1	Unsimplified equation with at most one error
		A1	Correct unsimplified equation
	$v=34$ m s^{-1}	A1	
		(4)	
(b)	$u=15\times\frac{3}{5}$ m s^{-1}, $a=-9.8$ m s^{-1}, $v=0$		
	$0=9^2-2\times 9.8s$	M1	Complete method using *suvat* to reach an equation in s.
	$s=4.1326...$	A1	
	ht above beach $=51.63...=52$ (m)	A1ft	Or 51.6(m). Their s + 47.5. Max 3 s.f.
		(3)	
(c)	least speed $=15\times\frac{4}{5}=12$ m s^{-1}	B1	
		(1)	
(d)	$u=-15\times\frac{3}{5}$ m s^{-1}, $a=9.8$ m s^{-1}, $s=47.5$		
	$47.5=-9t+\frac{1}{2}\times 9.8t^2$	M1	Complete method using *suvat* to reach an equation in t.
	$\left(4.9t^2-9t-47.5=0\right)$	A1	Correct equation (any form)
	$t=\frac{9\pm\sqrt{9^2+4\times 4.9\times 47.5}}{9.8}$	dM1	Solve for t. Dependent on preceding M
	$t=4.16448...$	A1	Only. –ve value must be rejected if seen.
	Horiz dist $=15\times\frac{4}{5}\times 4.16448...\left(=49.9738...\text{m}\right)$	M1	Complete method using *suvat* and their t to find distance. Independent
	$=50$ or 50.0 (m)	A1	Max 3 s.f.
		(6)	
		[14]	
	Alternative for first 4 marks in **(d)**		
	Complete method to find vertical component of the speed on impact with the ground	M1	Or use their $\sqrt{(a)^2-(c)^2}$ provided $(c)\neq 0$
	$v=\sqrt{1012}\left(=31.8....\right)$	A1	
	$\sqrt{1012}=-9+gt$	M1	Use *suvat* to find t. Condone sign error(s)
	$t=4.16448...$	A1	

Question Number	Scheme	Marks	Notes
8(a)	$2mu = -2mv_B + 3mv_A$	M1	CLM. Need all 3 terms. Dimensionally correct.
		A1	Correct unsimplified
	$eu = v_A + v_B$	M1	Impact law. Used the right way round. Condone sign error
		A1	Correct with signs consistent with CLM equation
(i)	Solve for v_A or v_B	dM1	for finding either. Dependent on both preceding M marks
	$v_A = \frac{2u}{5}(1+e)$	A1	
(ii)	$v_B = \frac{u}{5}(3e-2)$	A1	They need modulus signs if they have $2-3e$
		(7)	
(b)	Dir of motion of B reversed $\Rightarrow v_B > 0 \quad e > \frac{2}{3}$	B1	
	Impact between A and the wall:		
	$\frac{1}{7} \times \frac{2u}{5}(1+e) = V_A$	B1 ft	Follow their v_A
	For a second impact between A and B, $V_A > v_B$: $\quad \frac{1}{7} \times \frac{2u}{5}(1+e) > \frac{u}{5}(3e-2)$	M1	Inequality must be the right way round.
	$(2+2e > 21e-14)$		
	$19e < 16 \qquad e < \frac{16}{19}$	A1	
	$\therefore \frac{2}{3} < e < \frac{16}{19}$ **Given Answer**	A1	With sufficient correct working to justify given answer.
		(5)	
		[12]	