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Pearson Edexcel

Mark Scheme (Final)

October 2019

Pearson Edexcel IAL Mathematics

(WME01/01) Mechanics 1

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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.

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PEARSON EDEXCEL IAL 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.

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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.

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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.

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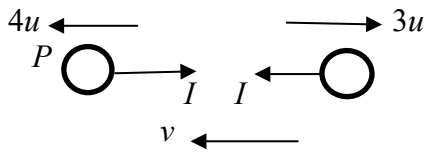
WME01 OCT 2019 POST QPEC
Mark Scheme

Question Number	Scheme	Marks
1.		
(a)	CLM: $3m\times 4u-2m\times 3u=3mv+2mv$	M1A1
	$v=6u/5$	A1 (3)
(b)	For Q: $\pm 2m(\frac{6u}{5}-(-3u))$	M1A1
	$\frac{42mu}{5}$	A1 (3)
Aliter	For P: $\pm 3m(\frac{6u}{5}-4u)$ **M1A1**	
	$\frac{42mu}{5}$ **A1**	**(6)**
	Notes for Qu 1	
1(a)	M1 for an equation with the correct no. of terms, dim correct (allow consistent missing m's or consistent extra g's) with one unknown, but allow sign errors	
	First A1 for a correct equation (allow -v)	
	Second A1 for $\frac{6u}{5}$ (must be positive)	
1(b)	M1 for impulse-momentum principle applied to Q ; condone sign errors but must be using $2m$ for mass and subtracting momenta (allow 'v' or their v in the equation for this M mark provided v is a velocity) M0 if it's dimensionally incorrect e.g if g is included	
	First A1 for a correct equation	
	Second A1 for $\frac{42mu}{5}$	
Aliter	M1 for impulse-momentum principle applied to P ; condone sign errors but must be using $3m$ for mass and subtracting momenta (allow v in the equation for this M mark) M0 if g is included	
	First A1 for a correct equation	
	Second A1 for $\frac{42mu}{5}$	

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Question Number	Scheme	Marks
2(a)	$40 = \frac{1}{2} g t_1^{\,2}$	M1
	$t_1 = \sqrt{\frac{80}{g}} (= \frac{20}{7} = 2.857..)$	A1
	$v_1 = \sqrt{2g \times 40}$ or $g \times \frac{20}{7}$ (= 28)	B1
	$t_2 = \frac{\frac{1}{2} \times \sqrt{2g \times 40}}{g}$ $(= \frac{10}{7})$ (1.42857..) **or** $\frac{\sqrt{2g \times 40}}{g}$ $(= \frac{20}{7})$ (2.857..)	M1
	Total time = 5.7 s or 5.71 s	A1 (5)
	N.B. Allow 5.72 then rounded to 5.7 or 5.71	
2(b)		
	$v_2 = 14$; $v_3 = 7$; $v_4 = 3.5$	M1
	$0 = 3.5^2 - 2gh$	M1A1
	$h = 0.625$ or 0.63 (m) or 5/8 (m)	A1 cso (4)
		(9)
	Notes for qu 2	
2(a)	First M1 for a complete method to obtain an equation in t_1 only	
	First A1 for a correct unsimplified t_1 (correct to at least 2SF as a decimal)	
	B1 for a correct unsimplified v_1 value, allow a negative answer	
	Second M1 for $\frac{\frac{1}{2} v_1}{g}$ or $\frac{v_1}{g}$ with their v_1 value substituted (correct to at least 2SF as a decimal if no working)	
	Second A1 for either 5.7 or 5.71 (A0 for $\frac{40}{7}$)	
2(b)	First M1 for $v_4 = (\frac{1}{2})^3 v_1$ oe N.B. their v_1.	
	Second M1 for a complete method to obtain an equation in *h* only e.g. $0 = (v_4)^2 - 2gh$	
	First A1 for a correct equation	
	Second A1 for 0.63 or 0.625 cso (A0 for 40.625)	
	N.B. If they go as far as $v_3 (= 7)$ or $v_5 (= 1.75)$ then use $0 = (v_3)^2 - 2gh$ or $0 = (v_5)^2 - 2gh$, can score max M0M1A0A0	

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Question Number	Scheme	Marks
3.	Trailer: $2060 - 300 - 400g\sin\alpha = 400a$	M1A2
	Car: $D - 420 - 800g\sin\alpha - 2060 = 800a$	M1A2
Aliter	System: $D - 420 - 800g\sin\alpha - 300 - 400g\sin\alpha = 400a + 800a$ **M1A2**	
	$D = 6000$	A1
	Notes for qu 3	**(7)**
	Use the mass in the *ma* term of an equation to determine to which part of the system the equation applies.	
	First M1 for equation of motion for the trailer, correct no. of terms, with weight resolved, condone sign errors	
	First A2 for a correct equation (including T used for 2060), -1 each error	
	Second M1 for equation of motion for the car, correct no. of terms, with weight resolved, condone sign errors	
	Second A2 for a correct equation (including T used for 2060), -1 each error	
Aliter	**Replace either of the above with an equation of motion for the whole system**	
	M1 for equation of motion for the whole system, correct no. of terms, with both weights resolved, condone sign errors	
	A2 for a correct equation, -1 each error	
	N.B. If g is consistently omitted, this leads to $D = 6000$. This scores max M1A1A0M1A1A0A0	

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Question Number	Scheme	Marks
4(a)	$R = kmg\cos\theta + mg\sin\theta$ (perpendicular to the plane)	M1A2
	$F = kmg\sin\theta - mg\cos\theta$ (parallel to the plane)	M1A2
	$F = \mu R$ seen or implied	B1
	Eliminate F and R and **explicitly cancel *m*** to give an equation in k, θ and μ **only** (allow inconsistent or no g's)	M1
	Use of $\tan\theta = \dfrac{\sin\theta}{\cos\theta}$ to obtain an expression for μ in terms of k and $\tan\theta$ only (all g's must have been cancelled) , dependent on previous three M marks. **Need to see division by $\cos\theta$ <u>top and bottom</u> oe for this mark**.	**DM**1
	$\mu = \dfrac{k\tan\theta - 1}{k + \tan\theta}$ GIVEN ANSWER (Must be **exactly** the same)	A1 (10)
Aliter	**N.B. Horizontal and/or vertical resolutions are possible**	
	$mg + F\cos\theta = R\sin\theta$ (horizontal) **M1A2**	
	$R\cos\theta + F\sin\theta = kmg$ (vertical) **M1A2**	
4(b)	$\dfrac{\tan\theta - 1}{1 + \tan\theta} > 0$ **OR** $mg\sin\theta - mg\cos\theta > 0$	M1
	$\tan\theta > 1 \Rightarrow \theta > 45^o$ GIVEN ANSWER	A1 (2)
		(12)
	Notes for qu 4	
4(a)	First M1 for resolving perp to the plane, dimensionally correct, with correct no. of terms, *kmg* and *mg* both resolved, condone sign errors	
	First A2 for a correct equation, -1 each error (allow *X* for *mg* anywhere) Consistent omission of *g*, treat as **one** error	
	Second M1 for resolving parallel to the plane, dimensionally correct, with correct no. of terms, *kmg* and *mg* both resolved, condone sign errors	
	First A2 for a correct equation, -1 each error (allow *X* for *mg* anywhere) Consistent omission of *g*, treat as **one** error	
	$F = \mu R$ seen or implied, even on a diagram	
	Third M1 (independent) for eliminating F and R and cancelling m's	
	Fourth DM1, dependent on previous three M marks	
	Fifth A1 for correctly obtaining the GIVEN ANSWER	
4(b)	M1 for either using $k = 1$ and the given answer > 0 or = 0 or using $F > 0$ or $F = 0$ Allow M1A0 for using $k = 1$ and $\theta = 45^o$ to show $\mu = 0$ M0 if first thing seen is $\tan\theta - 1 > 0$	
	A1 for correctly obtaining the GIVEN ANSWER and must have used an inequality throughout. Need to see $\tan\theta - 1 > 0$ oe.	

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Question Number	Scheme	Marks
5(a)	$M(C),\ Mg\times1.5=12g\times1.75$	M1A1
	$M=14$	A1 (3)
5(b)	A moments equation, with usual rules i.e. dim correct, correct no. of terms, condone sign errors	M1A1
	$(\uparrow),\ T_A+2T_A=12g+15g$ or another Moments equation	M1A1
	Possible moments equations: $M(A),\ 2T_A\times3.5=12g\times1.75+15gx$ $M(B),\ (2T_A\times1.5)+(T_A\times5)=12g\times3.25+15g(5-x)$ $M(C),\ T_A\times3.5=12g\times1.75+15g(3.5-x)$ $M(D),\ 2T_A\times1.75=T_A\times1.75+15g(x-1.75)$ $M(G),\ T_Ax=2T_A(3.5-x)+12g(x-1.75)$ **N.B.** These equations could be in terms of T_C and/or in terms of their own unknown length (e.g. y) where y is clearly defined in terms of x.	
	$x=2.8$	A1 (5)
		(8)
	Notes on qu 5	
5(a)	M1 for a complete method to obtain an equation <u>in M only</u>. **N.B.** they may use 2 equations in T_C and M and then eliminate T_C to give an equation <u>in M only</u>. Possible equations: $(\uparrow),\ T_C=12g+Mg$ M(A), $12g\times1.75+5Mg=3.5T_C$ M(B), $12g\times3.25=1.5T_C$ M(G), $T_C\times1.75=3.25Mg$ **N.B.** M0 if they never use $T_A=0$	
	First A1 for a correct equation <u>in M only</u>	
	Second A1 for $M=14$	
	N.B. If g's are <u>consistently</u> omitted in <u>all</u> equations used in 5(a), full marks can be scored.	
5(b)	First M1 for a moments equation with the usual rules, in x and at most 2 further unknowns	
	First A1 for a correct equation in x and one other unknown	
	Second M1 for a vertical resolution in 2 unknowns or a second moments equation in x and at most 2 further unknowns	
	Second A1 for a correct resolution in one unknown or for a correct moments equation in x and the same one other unknown	
	Third A1 for $x=2.8$ **N.B.** If g's are <u>consistently</u> omitted in <u>both</u> equations in 5(b), full marks can be scored.	

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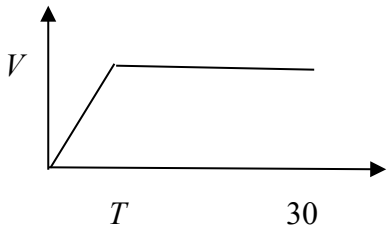
Question Number	Scheme	Marks
6(a)		B1 shape B1 V, T, 30 (2)
6(b)	$V = 0.8T$ or $V = \frac{400}{60-T}$ oe	B1 (1)
6(c)	$\frac{(30+30-T)V}{2} = 200$ (trapezium) or $V = \frac{400}{60-T}$	M1A1
	$\frac{(30+30-T)0.8T}{2} = 200$ or $0.8T = \frac{400}{60-T}$	M1
	$T^2 - 60T + 500 = 0$	A1 (4)
6(d)	$(T-10)(T-50) = 0$	M1
	$T = 10$ or 50	A1
	$T = 10$ since $T < 30$	A1 (3)
6(e)	Any two of:	B1 B1
	do not have an instantaneous change from acceleration to constant speed do not have constant velocity do not have constant acceleration reaction time at start stop watch error at end -1 for each incorrect extra	
	.	(2)
		(12)
	Notes for qu 6	
6(a)	First B1 for shape; B0 if there is a solid vertical line at the end but allow a dotted line.	
	Second B1 for V, T and 30 correctly placed. Allow appropriate delineators.	
6(b)	B1 for $V = 0.8T$ or $V = \frac{400}{60-T}$ oe but V must be in terms of T.	
6(c)	First M1 for, an equation in V and T only, with a clear attempt to use area = 200, with the correct structure (3 alternatives) (M0 if a single *suvat* equation is used or ½ is missing	
	OR: $\frac{1}{2}TV + V(30-T) = 200$ (triangle + rectangle) **OR**: $30V - \frac{1}{2}TV = 200$ (rectangle – triangle)	
	First A1 for a correct equation	

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Question Number	Scheme	Marks
	Second independent M1 for substituting for V in terms of T, using their answer for (b) or using $V = 0.8T$ in the alternative, but must be using or have used 200, to earn this mark to give an equation in T only.	
	Second A1 for $T^2 - 60T + 500 = 0$	
6(d)	M1 for a clear attempt to solve their quadratic (must be a 3 term quadratic), with working N.B. This mark can be implied by two correct values for T	
	First A1 for two correct answers 10 or 50	
	Second A1 for 10 with correct justification	
6(e)	+1 for each correct answer (max of 2), -1 for each incorrect **extra** answer after two answer.	
	Incorrect answers:	
	Air resistance, friction at the ground, height or size of athlete	

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Question Number	Scheme	Marks
7.(i)	$P^2 = 8^2 + 6^2 - 2\times 8\times 6\cos 60^{\circ}$	M1A1
	$P = \sqrt{52} = 7.2$ (N) or better	A1
(ii)	$\frac{\sin\alpha}{6} = \frac{\sin 60^{\circ}}{\sqrt{52}}$ or $\frac{\sin\beta}{8} = \frac{\sin 60^{\circ}}{\sqrt{52}}$ $6^2 = 8^2 + P^2 - 2\times 8\times P\cos\alpha$ or $8^2 = 6^2 + P^2 - 2\times 6\times P\cos\beta$	M1A1 **ft**
	$\alpha = 46.(1..)^{\circ}$ $\beta = 73.(897..)$ or $106.(103..)$	A1
	Bearing is 74° to nearest degree	A1 cso
		(7)
	Alternative using column vectors	
(i)	$P^2 = (8\cos 30^0)^2 + (6 - 8\sin 30^0)^2$	M1A1
	$P = \sqrt{52} = 7.2$ (N) or better	A1
(ii)	$\tan\beta = \frac{8\cos 30^0}{6 - 8\sin 30^0}$ or $\sin\beta = \frac{8\cos 30^0}{\sqrt{52}}$ or $\cos\beta = \frac{6 - 8\sin 30^0}{\sqrt{52}}$ or equivalents for $(90^0 - \beta)$	M1A1 **ft**
	$\beta = 73.(897..)^{o}$ or $(90^0 - \beta) = 16.103\ldots$	A1
	Bearing is 74° to nearest degree	A1
	N.B. If 4 is consistently used instead of 8, max marks are:	
	(i) M1A0A0 (ii) M1A1ftA0A0 i.e. 3/7	
	Notes for qu 7	
7(i)	First M1 for use of the cosine rule (with P, 6, 8 and 60° or their α or (120° – their α).	
	First A1 for a correct equation	
	Second A1 for a correct magnitude	
(ii)	Second M1 for a complete method to find a relevant angle – must be using their P, 60° (or 120°) and either 6 or 8 if using the sine rule or their P, 6, and 8 if using the cosine rule.	
	Third A1 ft for a correct equation, ft on their P	
	Fourth A1 for at least one correct angle, accurate to nearest degree	
	Fifth A1 cso for a correct bearing to nearest degree	
	Alternative using column vectors	
(i)	First M1 for use of Pythagoras with correct structure allowing for sin/cos confusion and sign errors	
	First A1 for a correct equation	
	Second A1 for a correct magnitude	
(ii)	Second M1 for a complete method to find a relevant angle – must be using their P components with correct structure allowing for cos/sin confusion and sign errors	

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Question Number	Scheme	Marks
	Third A1 ft for a correct equation, ft on their P components	
	Fourth A1 for at least one correct angle, accurate to nearest degree	
	Fifth A1 cso for a correct bearing to nearest degree	

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Question Number	Scheme	Marks
8(a)	$\mathbf{v}_B = (40\cos 60)\mathbf{i} + (-40\sin 60)\mathbf{j}$	M1A1
	$= 20\mathbf{i} - 20\sqrt{3}\mathbf{j}$	A1 (3)
8(b)	$\mathbf{r} = 60\mathbf{i} + t(-20\mathbf{i})$	M1 A1
	$\mathbf{s} = t(20\mathbf{i} - 20\sqrt{3}\mathbf{j})$	B1**ft** (3)
8(c)	$\overrightarrow{AB} = \mathbf{s} - \mathbf{r} = t(20\mathbf{i} - 20\sqrt{3}\mathbf{j}) - [60\mathbf{i} + t(-20\mathbf{i})]$	M1
	$\sqrt{(40t-60)^2 + (-20t\sqrt{3})^2} = 60$ **OR** $(40t-60)^2 + (-20t\sqrt{3})^2 = 60^2$	M1 A2**ft**
	$2800t^2 - 4800t = 0$	M1 A1
	$t = \frac{12}{7}$	A1
	13 43 OR 1 43 pm (nearest minute)	A1 **cso** (8)
		(14)
	Notes for qu 8	
	For (a) and (b) allow working in column vector form	
8(a)	M1 for 40 resolved in both components but allow sin/cos confusion and sign errors	
	First A1 for two correct unsimplified components	
	Second A1 for a correct vector, allow 2SF or better for the **j** component **N.B.** Need to see a complete velocity vector not just $p =$, $q =$	
8(b)	M1 for $\mathbf{r} = 60\mathbf{i} \pm 20t\mathbf{i}$	
	A1 for $\mathbf{r} = 60\mathbf{i} + t(-20\mathbf{i})$	
	B1 ft on their answer for (a)	
8(c)	M1 for finding either $\mathbf{s} - \mathbf{r}$ or $\mathbf{r} - \mathbf{s}$. Allow missing brackets if they recover.	
	Second M1 for obtaining an equation in t only by using the magnitude of their $\mathbf{s} - \mathbf{r}$ or $\mathbf{r} - \mathbf{s}$ and equating it to 60 (allow the square on both sides). Must be a clear attempt to use Pythagoras	
	First and Second A1 **ft** for a correct equation, **ft** on their $\mathbf{s} - \mathbf{r}$ or $\mathbf{r} - \mathbf{s}$	
	Third M1 for a simplified quadratic equation = 0 with at least a t^2 and a t term	
	Third A1 for a correct equation from correct working (**N.B**. Coefficient of t^2 must be in range $[2797, 2825]$)	
	Fourth A1 for a correct value of t (allow AWRT 1.7) from correct working	
	Fifth A1 for a correct time to the nearest minute **cso**	
	SC: If using $+20\sqrt{3}$ oe for the coefficient of j in part (a) , can score for (c) **max M1M1A2 M1A1A1A0**	

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