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Mark Scheme (Results)

Summer 2016

Pearson Edexcel International A Level in Mechanics 1
(WME01/01)

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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.

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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. 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.

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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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Question Number	Scheme	Marks	Notes
1.	$76 = 4u + \frac{1}{2}a.4^2$ or $76 = \frac{1}{2}\left(u + \overline{u+4a}\right)\times 4$	M1	Use of $s = ut + \frac{1}{2}at^2$ for $t = 4, s = 76$ and $u \neq 0$ (use of $u = 0$ is M0)
	$(38 = 2u + 4a)$	A1	Correctly substituted equation
	$295 = 10u + \frac{1}{2}a.10^2$ or $295 = \frac{1}{2}\left(u + \overline{u+10a}\right)\times 10$ or $295 = \left(u+10a\right)\times 10 - \frac{1}{2}a\times 100$	M1	Use of $s = ut + \frac{1}{2}at^2$ for $t = 10, s = 295$ or $s = u't + \frac{1}{2}at^2$ for $t = 6, s = 219, u' \neq u$
	$(59 = 2u + 10a)$ or $219 = \left(19+2a\right)\times 6 + \frac{1}{2}a\times 6^2$ or $219 = \left(38-u\right)\times 6 + \frac{1}{2}a\times 6^2$ or $219 = \left(u+4a\right)\times 6 + \frac{1}{2}a\times 6^2$ or $219 = \frac{1}{2}\left(\overline{u+4a} + \overline{u+10}\right)\times 6$ or $219 = (u+10a)\times 6 - \frac{1}{2}a\times 36$	A1	Correctly substituted equation
		DM1	Solve simultaneous for *u* or for *a* This marks is not available if they have assumed a value for *u* or *a* in the preceding work - it is dependent on the first 2 M marks
	$u = 12$	A1	
	$a = 3.5$	A1	
		[7]	
1 Alt	$t = 2,\ v_2 = \frac{76}{4} = 19 \quad t = 7,\ v_7 = \frac{219}{6} = 36.5$	M1 A1	Find the speed at $t = 2, t = 7$ Both values correct Averages with no links to times is M0
	$36.5 = 19 + 5a \Rightarrow a = 3.5$	M1 A1	Use of $v = u + 5a$ with their *u*,*v* Correct *a*
	$19 = u + 2a$	DM1 A1	Complete method for finding *u* Correct equation in *u*
	$u = 19 - 7 = 12$	A1	

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Question Number	Scheme	Marks	Notes
2.(a)	$mu - 2kmu = -\frac{1}{2}mu + kmu$ OR $m\left(\frac{1}{2}u + u\right) = -km\left(-u - 2u\right)$	M1	Use of CLM OR Equal and opposite impulses Need all 4 terms dimensionally correct. Masses and speeds must be paired correctly Condone sign errors Condone factor of g throughout.
		A1	Unsimplified equation with at most one error
		A1	Correct unsimplified equation
	$k = \frac{1}{2}$	A1	From correct working only
		(4)	
2.(b)	For $P: I = \pm m(\frac{1}{2}u \pm -u)$ For Q: $I = \pm km(u \pm -2u)$	M1	Impulse on *P* or impulse on *Q*. Mass must be used with the correct speeds e.g. $km \times \frac{1}{2}u$ is M0 If working on *Q*, allow equation using their *k*. Terms must be dimensionally correct. Use of g is M0
	$\frac{3mu}{2}$	A1	Only From correct working only
		(2)	
		[6]	

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Question Number	Scheme	Marks	Notes
3.(a)	$7^2 = 2 \text{ x } 9.8h$	M1	Use of $v^2 = u^2 + 2as$ with $u = 0, v = 7$ or alternative complete method to find *h*.
	$h = 2.5$	A1	Condone $h = -2.5$ in the working but the final answer must be positive.
		(2)	
3.(b)	$9 \text{ x } 7 = 10.5\, u$	M1	Use CLM to find the speed of the blocks after the impact. Condone additional factor of g throughout.
	$u = 6$	A1	
	$0^2 = 6^2 - 2a \text{ x } 0.12$	M1	Use of $v^2 = u^2 + 2as$ with $u = 6, v = 0$ Allow for their *u* and $v = 0$ Allow for $u = 7, v = 0$ Accept alternative *suvat* method to form an equation in *a*. Condone use of 12 for 0.12
		A1	Correctly substituted equation in *a* with $u = 6, s = 0.12$ $(\text{implied by } a = 150)$
	$(\downarrow)\ 10.5g - R = 10.5 \text{ x } (-a)$	M1	Use of $F = ma$ with their $a \neq \pm g$. Must have all 3 terms and 10.5 Condone sign error(s)
	$(\downarrow)\ 10.5g - R = 10.5 \text{ x } (-150)$	A1	Unsimplified equation with *a* substituted and at most one error (their *a* with the wrong sign is 1 error)
		A1	Correct unsimplified equation with *a* substituted
	$R = 1680$ or 1700	A1	
		(8)	
	Alternative for the last 6 marks:		
	$\frac{1}{2} \times 10.5 \times 6^2 + 10.5 \times 9.8 \times 0.12 = R \times 0.12$	M2	Energy equation (needs all three terms)
		A3	-1 each error A1A1A0 for 1 error, A1A0A0 for 2 errors
	$R = 1680$ or 1700	A1	
		[10]	

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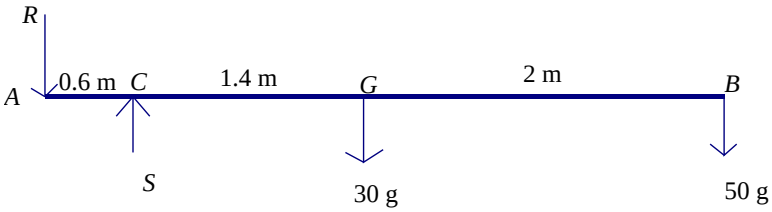
Question Number	Scheme	Marks	Notes
4.(a)			
	$M(A)$ (30g x 2) + (50g x 4) = 0.6 S	M1	Moments equation. Requires all terms and dimensionally correct. Condone sign errors. Allow M1 if g missing
	$M(C)\ \ (0.6\times R)=(1.4\times 30\text{g})+(3.4\times 50\text{g})$ $M(G)\ \ (2\times R)=(1.4\times S)+(2\times 50\text{g})$ $M(B)\ \ (4\times R)+(2\times 30g)=(3.4\times S)$	A1	Correct unsimplified equation
	$(\uparrow)\ R+30g+50g=S$ $(R+784=S)$	M1	Resolve vertically. Requires all 4 terms. Condone sign errors
		A1	Correct equation (with R or their R)
	NB: The second M1A1 can also be earned for a second moments equation		
	$R = 3460$ or 3500 or $\frac{1060g}{3}$ (N) Not 353.3g	A1	One force correct
	$S = 4250$ or 4200 or $\frac{1300g}{3}$ (N) Not 433.3g	A1	Both forces correct If both forces are given as decimal multiples of g mark this as an accuracy penalty A0A1
		(6)	
4.(b)	$M(C)$ (30g x 1.4) + (Mg x 3.4) = 0.6 x 5000	M1	Use $R = 5000$ and complete method to form an equation in M or weight. Needs all terms present and dimensionally correct. Condone sign errors. Accept inequality. Use of R and S from (a) is M0
		A1	Correct equation in M (not weight) $(\text{implied by } M = 77.68)$
	$M = 77$ kg	A1	77.7 is A0 even is the penalty for over-specified answers has already been applied
		(3)	
4.(c)	The weight of the diver acts at a point.	B1	Accept "the mass of the diver is at a point".
		(1)	
		[10]	

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Question Number	Scheme	Marks	Notes
5.(a)	$(2\mathbf{i}-3\mathbf{j})+(p\mathbf{i}+q\mathbf{j})=(p+2)\mathbf{i}+(q-3)\mathbf{j}$	M1	Resultant force = $\mathbf{F}_1+\mathbf{F}_2$ in the form $a\mathbf{i}+b\mathbf{j}$
	$\frac{p+2}{q-3}=\frac{1}{2}$ or $\left.\begin{matrix}p+2=n\\q-3=2n\end{matrix}\right\}$ for $n\neq 1$	M1	Use parallel vector to form a scalar equation in p and q.
		A1	Correct equation (accept any equivalent form)
	$4+2p=-3+q$	DM1	Dependent on no errors seen in comparing the vectors. Rearrange to obtain given answer. At least one stage of working between the fraction and the given answer
	$2p-q+7=0$	A1	**Given Answer**
		(5)	
5.(b)	$q=11\Rightarrow p=2$	B1	
	$\mathbf{R}=4\mathbf{i}+8\mathbf{j}$	M1	$(2+p)\mathbf{i}+8\mathbf{j}$ for their p
	$4\mathbf{i}+8\mathbf{j}=2\mathbf{a}$ $(\mathbf{a}=2\mathbf{i}+4\mathbf{j})$	M1	Use of $\mathbf{F}=m\mathbf{a}$
	$\lvert\mathbf{a}\rvert=\sqrt{2^2+4^2}$	DM1	Correct method for $\lvert\mathbf{a}\rvert$ Dependent on the preceding M1
	$=\sqrt{20}$ = 4.5 or 4.47 or better (m s^{-2})	A1	$2\sqrt{5}$
		(5)	
	Alternative for the last two M marks:		
	$\lvert\mathbf{F}\rvert=\sqrt{16+64}\left(=\sqrt{80}\right)$ M1		Correct method for $\lvert\mathbf{F}\rvert$
	$\sqrt{80}=2\times\lvert\mathbf{a}\rvert$ DM1		Use of $\lvert\mathbf{F}\rvert=m\lvert\mathbf{a}\rvert$ Dependent on the preceding M1
		[10]	

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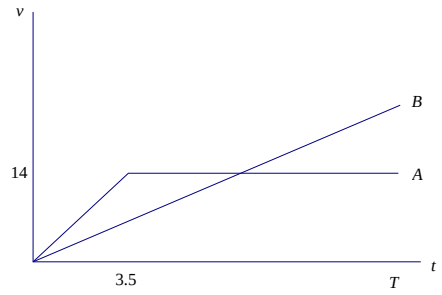
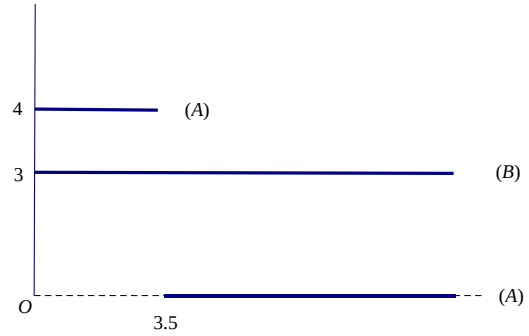
Question Number	Scheme	Marks	Notes
6.(a)	$v = u + at \Rightarrow 14 = 3.5a$	M1	Use of *suvat* to form an equation in a
	$a = 4$	A1(2)	
6.(b)		B1	Graph for A or B
		B1	Second graph correct and both graphs extending beyond the point of intersection
		B1	Values 3.5, 14, T shown on axes, with T not at the point of intersection. Accept labels with delineators.
		(3)	NB 2 separate diagrams scores max B1B0B1
6.(c)	$\frac{1}{2}T.3T$, $\frac{(T+T-3.5)}{2}.14$	M1	Find distance for A or B in terms of T only. Correct area formulae: must see $\frac{1}{2}$ in area formula and be adding in trapezium
		A1	One distance correct
		A1	Both distances correct
	$\frac{1}{2}T.3T = \frac{(T+T-3.5)}{2}.14$ $\frac{1}{2}T.3T = \frac{1}{2}\times 4\times 3.5^2 + 14(T-3.5)$	M1	Equate distances and simplify to a 3 term quadratic in T in the form $aT^2 + bT + c = 0$
	$3T^2 - 28T + 49 = 0$	A1	Correct quadratic
	$(3T-7)(T-7) = 0$	M1	Solve 3 term quadratic for T
	$T = \frac{7}{3}$ or 7	A1	Correct solution(s) - can be implied if only ever see $T = 7$ from correct work.
	but $T > 3.5$, $T = 7$	A1 (8)	
6.(d)	73.5 m	B1 (1)	From correct work only. B0 if extra answers.
6.(e)		B1	(*A*) Condone missing 4
		B1	(*B*) Condone graph going beyond $T = 7$ Must go beyond 3.5. Condone no 3.
		B1 (3)	(*A*) Condone graph going beyond $T = 7$ Must go beyond 3.5. B0 if see a solid vertical line. Sometimes very difficult to see. If you think it is there, give the mark.
		[17]	Condone separate diagrams.

See next page

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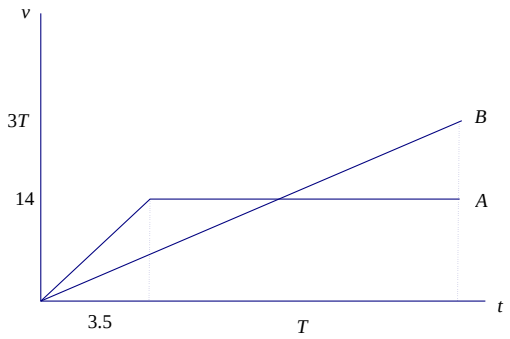
	Alternative for (c) for candidates with a sketch like this:  	B1 B1 B0	Treat as a special case. B1B1B0 on the graph and then max 5/8 for (c) if they do not solve for the *T* in the question.
	$\frac{1}{2}\times 3\times (T+3.5)^2 = \frac{1}{2}\times 4\times 3.5^2 + 14T$	M1	Use diagram to find area
		A1	One distance correct
		A1	Both distances correct
	$12T^2 - 28T - 49 = 0$	M1	Simplify to a 3 term quadratic in *T*
		A1	Correct quadratic
	$(2T-7)(6T+7)=0$	M1	Complete method to solve for the *T* in the question
	$T = \frac{7}{2}$ or $\frac{-7}{6}$	A1	Correct solution(s) - can be implied if only ever see $\text{Total} = 7$
	$\text{Total time} = 7$	A1 (8)	

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Question Number	Scheme	Marks	Notes
7.(a)	$F = 0.25R$	B1	
	$\sin\alpha = \frac{3}{5}$ or $\cos\alpha = \frac{4}{5}$ $\sin\beta = \frac{4}{5}$ or $\cos\beta = \frac{3}{5}$	B1	Use of correct trig ratios for α or β
	$R = 4g\cos\alpha$ (31.36)	M1	Normal reaction on *P* Condone trig confusion (using α)
		A1	Correct equation
	$T + F = 4g\sin\alpha$	M1	Equation of motion for *P*. Requires all 3 terms. Condone consistent trig confusion Condone an acceleration not equated to 0 : $T + F - 4g\sin\alpha = 4a$
	$(T + 7.84 = 23.52)$ $(T = 15.68)$	A1	Correct equation
	$T = mg\sin\beta$	M1	Equation of motion for *Q* Condone trig confusion Condone an acceleration not equated to 0: $T - mg\sin\beta = -ma$
	$(T = 7.84m)$	A1	Correct equation
	Solve for *m*	DM1	Dependent on the 3 preceding M marks Not available if their equations used $a \neq 0$
	$m = 2$	A1	
	NB Condone a whole system equation $4g\sin\alpha - F = mg\sin\beta$ followed by $m = 2$ for 6/6 M2 for an equation with all 3 terms. Condon trig confusion. Condone an acceleration $\neq 0$ A2 (-1 each error) for a correct equation:		
		(10)	
7.(b)	$F = \sqrt{T^2 + T^2}$ or $2T\cos 45°$ or $\frac{T}{\cos 45}$	M1	Complete method for finding *F* in terms of *T* Accept $\sqrt{(R_h)^2 + (R_v)^2}$
		A1	Correct expression in *T*
		DM1	Substitute their *T* into a correct expression Dependent on the previous M mark
	$F = \sqrt{2}\frac{8g}{5} = 22$ or 22.2 (N)	A1	Watch out - resolving vertically is not a correct method and gives 21.9 N.
		(4)	
7.(c)	Along the angle bisector at the pulley	B1 (1)	Or equivalent - accept angle + arrow shown on diagram. ($8.1°$ to downward vertical) Do not accept a bearing
		[15]	

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