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Mark Scheme (Results)

January 2019

Pearson Edexcel International Advanced Level In Mechanics M1 (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.
- 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.

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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: 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)
   - d… or dep – dependent
   - indep – independent
   - dp decimal places
   - sf significant figures
   - $*$ The answer is printed on the paper or ag- answer given
   - $\llcorner$ or d… The second mark is dependent on gaining the first mark

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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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Question Number	Scheme	Marks
1(i)	$6mu - 3mu = -2m.\frac{3u}{2} + 3mv$	M1 A1
	$v = 2u$	A1
(ii)	$I = \pm 2m(\frac{3u}{2} - -3u)$	M1 A1
	Magnitude $= 9mu$	A1
	OR: $I = \pm 3m(2u - -u)$	M1 A1
	Magnitude $= 9mu$	A1 **6**
	Notes	
1(i)	M1 for CLM with correct no. of terms to give an equation in one unknown. Allow consistent extra *g*'s and/or cancelled *m*'s. Condone sign errors (They may obtain this equation by finding the impulse on each and eliminating the impulse – apply the *same* criteria, including condone sign errors)	
	First A1 for a correct unsimplified equation. Allow: $6mu - 3mu = -2m.\frac{3u}{2} - 3mv$	
	Second A1 for $2u$ (must be positive) (**N.B.** If all terms in the CLM are given the same sign, this leads to $2u$ M1A0A0)	
(ii)	M1 for dimensionally correct Impulse-momentum equation with consistent use of $2m$ or $3m$ (i.e. M0 if *g* included or *m* omitted.) **N.B**. Mark the actual equation not the formula (some candidates use $I = m(v+u)$ when the direction has been reversed)	
	First A1 for a correct unsimplified equation	
	Second A1 for $9mu$ (must be positive)	

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Question Number	Scheme	Marks
2(a)	$\tan\theta = \frac{6}{7}$	M1
	$\theta = 40.60°...$	A1
	Bearing is $360° - 40.60° = 319°$ nearest degree	A1 (3)
(b)	$\mathbf{r}_A = (20\mathbf{i} - 17\mathbf{j}) + 4(-6\mathbf{i} + 7\mathbf{j}) = (-4\mathbf{i} + 11\mathbf{j})$	M1 A1
	$\mathbf{r}_B = (-8\mathbf{i} + 9\mathbf{j}) + 4(p\mathbf{i} + 2p\mathbf{j}) = (-8 + 4p)\mathbf{i} + (9 + 8p)\mathbf{j}$	A1
	$\mathbf{r}_A - \mathbf{r}_B = (4 - 4p)\mathbf{i} + (2 - 8p)\mathbf{j}$	**DM**1
	$-8 + 4p - -4 = 9 + 8p - 11$	M1 A1
	$p = -0.5$	A1
	$\mathbf{v}_B = (-0.5\mathbf{i} - \mathbf{j})$	M1
	$\lvert\mathbf{v}_B\rvert = \sqrt{(-0.5)^2 + (-1)^2}$	M1
	$= \frac{\sqrt{5}}{2} = 1.1 \text{ ms}^{-1}$ or better	A1 (10)
		13
	Notes	
2(a)	M1 for any trig ratio using 6 and 7: $\tan\theta = \pm\frac{6}{7}$ or $\pm\frac{7}{6}$: $\sin\theta$ or $\cos\theta = \pm\frac{6}{\sqrt{6^2+7^2}}$ or $\pm\frac{7}{\sqrt{6^2+7^2}}$	
	A1 for a correct angle from their *correct* equation e.g. 49°, 41°, 139°, 131°,….	
	A1 for 319° cao	
2(b)	First M1 for attempt at use of $\mathbf{r}_4 = \mathbf{r}_0 + 4\mathbf{v}$ for either *A* or *B*	
	First A1 for $(-4\mathbf{i} + 11\mathbf{j})$ **i**'s and **j**'s must be collected at some stage	
	Second A1 for $(-8 + 4p)\mathbf{i} + (9 + 8p)\mathbf{j}$ **i**'s and **j**'s must be collected at some stage	
	Second **DM**1, dependent on first M1, for finding the difference between their two $\mathbf{r}_4$ vectors (must be an attempt to subtract both **i** and **j** components)	
	Third M1 for equating the **i** cpt and **j** cpt of their difference (M0 if no difference) to give an equation in *p only*. oe e.g. $\frac{(4-4p)}{(2-8p)} = \frac{(-)1}{(-)1}$	
	Third A1 for a correct equation in *p* only	
	Fourth A1 for a correct value of *p*	
	Fourth M1 for using their *p* value to obtain a velocity vector for *B*	
	Fifth M1 for finding the magnitude of their $\mathbf{v}_B$ (**N.B.** This M mark is available, even if their $\mathbf{v}_B$ does not have the correct form)	
	Fifth A1 for $\frac{\sqrt{5}}{2}$ oe or 1.1 or better	

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Question Number	Scheme	Marks
3(a)	$560 - mg = 1.4m$	M1 A1 (2)
(b)	$2800 - Mg - 560 = 1.4M$	M1 A1 (2)
(c) (i)	$560 = 11.2m$ $m = 50$	**DM**1 A1
(ii)	$2240 = 11.2M$ $M = 200$	A1 A1 (3) **7**
	Notes	
(a)	M1 for equation of motion for the person only, with usual rules, condone sign errors, and with at least one value (560 or 1.4) substituted. *Credit given for this equation only if it appears in (a).*	
	A1 for a correct equation	
(b)	M1 for equation of motion for the lift only, with usual rules, condone sign errors, and with at least one value (2800, 560 or 1.4) substituted. *Credit given for this equation only if it appears in (b).*	
	A1 for a correct equation	
(c)	**Hence**: DM1, dependent on appropriate previous M mark, for solving one of their equations, wherever it appears, for either m or M **Otherwise**: DM1, dependent on appropriate previous M mark, for solving one of their equations and/or the whole system equation, wherever they appear, for either m or M **N.B.** There are no marks available for the whole system equation	
	First A1 for $m = 50$	
	Second A1 for $M = 200$	

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Question Number	Scheme	Marks
4(a)	$M(R),\ 40g(x-3)+2.5g\times 2=30g\times 0.5$ $x=3.25$ m from P	M1 A2 A1 (4)
(b)	Mass of the box is concentrated at the point Q oe	B1 (1)
(c)	$M(R),\ 3Mg\ +\ 30g\times 0.5=2.5g\times 2+40g\times 2$ $M=\frac{70}{3}$, 23 or better	M1 A2 A1 (4) **9**
	Notes	
4(a)	M1 for moments about *R* to give an equation in *x* (or another unknown distance) *only* (i.e. M0 if reaction at *P* is non-zero) Correct no. of terms, dimensionally correct	
	A2 for a correct equation in *x only* (allow consistent omission of *g*) -1 each error	
	Alternative: Instead of $M(R)$, they may write down 2 equations and eliminate the normal reaction at *R*, N_R, to obtain an equation in a distance *only* : Possible equations: $(\uparrow)N_R=40g+30g+2.5g$ $M(P),40gx+30g\times 2.5+2.5g\times 5=3N_R$ $M(Q),40g(5-x)+30g\times 2.5=2N_R$ $M(G),40g(2.5-x)+0.5N_R=2.5g\times 2.5$ Equations must have correct no. of terms and be dimensionally correct but M0 if reaction at *P* is non-zero	
	Third A1 for $\frac{13}{4}$ m oe Allow 3.3 m	
(b)	B1 for *mass* or *weigh*t of box acts at Q but B0 if extra wrong answers	
(c)	M1 for moments about *R* to give an equation in *M only* (i.e. M0 if reaction at *P* is non-zero) Correct no. of terms, dimensionally correct	
	A2 for a correct equation in *M only* (allow consistent omission of *g*) -1 each error	
	Alternative: Instead of $M(R)$, they may write down 2 equations and eliminate the normal reaction at *R*, S_R , to obtain an equation in *M only* : Possible equations: $(\uparrow)S_R=40g+30g+2.5g+Mg$ $M(P),42.5g\times 5+30g\times 2.5=3S_R$ $M(Q),Mg\times 5+30g\times 2.5=2S_R$ $M(G),Mg\times 2.5+0.5S_R=42.5g\times 2.5$ Equations must have correct no. of terms and be dimensionally correct but M0 if reaction at *P* is non-zero	
	Third A1 for $\frac{70}{3}$ oe or 23 or better Accept 24	

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Question Number	Scheme	Marks
5.	$PM = 3.5 - 2\tan 45^o = 1.5$ OR $PB = \sqrt{3.5^2 + (\frac{2}{\sin 45})^2 - 2\times 3.5\times(\frac{2}{\sin 45})\cos 45^o} = 2.5$	M1
	$\tan\alpha = \frac{1.5}{2}; \cos\alpha = \frac{4}{5}; \sin\alpha = \frac{3}{5}$	A1
	OR $\alpha = 37^o$ *or* $(90^o - \alpha) = 53^o$ (at least 2SF)	
	$T_P\cos\alpha + T_Q\cos 45^o = 6g$	M1 A2 -1 ee
	$T_P\sin\alpha = T_Q\cos 45^o$	M1 A1
	$T_P = \frac{30g}{7} = 42$ N; $T_Q = 36$ or 35.6 N	**DM1** A1; A1
		10
	Notes	
	First M1 for finding the length of *PM* or *PB*	
	First A1 for a correct trig ratio for α or $(90^o - \alpha)$ or a correct value for α or $(90^o - \alpha)$ Do not penalise accuracy here if their final answers for the tensions are correct.	
	N.B. If they assume the tensions are the same , no further marks available If they think α = 30 or 60 or....., they could get all 5 resolving marks as a value of α is not required **but if α = 45, only M marks available.** However, if α and 45 are interchanged in the resolving equations - no marks available for resolving	
	Second M1 for resolving vertically with usual rules	
	Second/Third A1's for a correct equation, (α does not need to be substituted) -1 each error	
	Third M1 for resolving horizontally with usual rules	
	Fourth A1 for a correct equation (α does not need to be substituted but if it is , follow through on their value)	
	Fourth DM1, dependent on all **THREE** previous M marks, for solving for either tension	
	Fifth A1 for T_P Allow 42.0 Units not needed	
	Sixth A1 for T_Q Units not needed	
	Alternative, using Triangle of Forces/Lami's Theorem, for middle 5 marks.	
	$\frac{T_P}{\sin 45^o} = \frac{6g}{\sin(45^o + \alpha)}$ OR $\frac{T_Q}{\sin(180^o - \alpha)} = \frac{6g}{\sin(45^o + \alpha)}$	M1 A2 -1 ee
	$\frac{T_Q}{\sin(180^o - \alpha)} = \frac{6g}{\sin(45^o + \alpha)}$ OR $\frac{T_P}{\sin 45^o} = \frac{6g}{\sin(45^o + \alpha)}$ OR $\frac{T_P}{\sin 45^o} = \frac{T_Q}{\sin(180^o - \alpha)}$	M1 A1
	N.B. Treat omission of *g* as one error	

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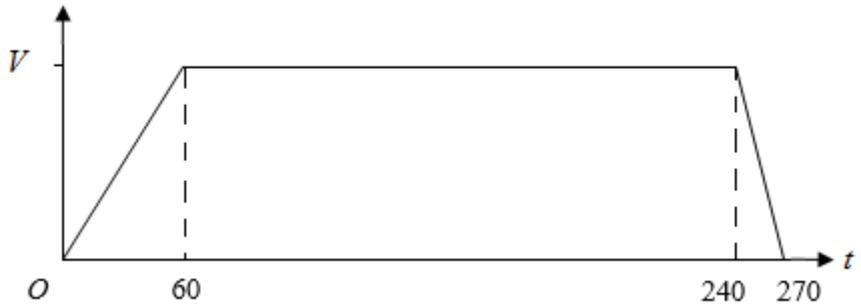
Question Number	Scheme	Marks
6(a)		B1 Shape B1 Figs. and V (2)
(b)	$4500 = \frac{(270+180)}{2}V$ OR $4500 = \frac{1}{2}60V + 180V + \frac{1}{2}30V$ $V = 20$	M1 A1 A1 (3)
(c)	$\frac{(T+T-60)}{2}\times 20 = 2250$ OR $\frac{1}{2}60.20 + (T-60).20 = 2250$ $T = 142.5$ s	M1 A2 **ft** A1 (4)
(d)	$T_1 = \frac{1}{4}\times 60$ $= 15$ $T_2 = 270 - \left(\frac{1}{4}\times 30\right)$ OR $240 + \left(\frac{3}{4}\times 30\right)$ $= 262.5$	M1 A1 M1 A1 A1 (5) **14**
	Notes	
6(a)	First B1 for a trapezium (not to scale) starting and finishing on the t-axis but B0 if solid vertical lines included	
	Second B1 for 3 figs. (60, 270 and use of 30 with a delineator or 240) and V. 270 can be implied by 3 correct delineators	
6(b)	M1 for a complete method to produce an equation, in V only, with the correct structure i.e. one trapezium or two triangles + rectangle or triangle + trapezium or trapezium + triangle or rectangle – two triangles = 4500 (allow 4.5 for the M mark) (M0 if a single *suvat* equation is used)	
	First A1 for a correct unsimplified equation	
	Second A1 for $V = 20$	
6(c)	M1 for a complete method to produce an equation, in *ONE* variable e.g. t where $t = (T - 60)$, with the correct structure i.e. one trapezium or triangle + rectangle or rectangle – triangle = 2250 (allow 2.25 for the M mark) (M0 if a single *suvat* equation is used)	
	First and second A1's for a correct unsimplified equation **ft on their 20** -1 each error	
	Third A1 for 142.5 (s) cao Accept 143.	
6(d)	First M1 for a complete method to give an equation in T_1 *only*	

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	First A1 for 15 (independent of V so allow even if their V is wrong)	
	Second M1 for a complete method to give an equation in T_2 *only*	
	Second A1 for a correct equation	
	Third A1 for 262.5 (independent of V so allow even if their V is wrong) **Accept 263**	
	N.B. Accept $T_1 = 262.5$ and $T_2 = 15$	

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Question Number	Scheme	Marks
7(a)	For B, $S = 3mg\cos\alpha$ For B, $3mg\sin\alpha - T - F_1 = 3ma$ For A, $R = mg$ For A, $T - F_2 = ma$ $F_1 = \frac{1}{3}S$; $F_2 = \frac{1}{5}R$ Solving for T $T = \dfrac{3mg}{5}$ or $5.88m$	M1 A1 M1 A2 B1 M1 A1 M1 **DM**1 A1 (11)
(b)	Constant tension throughout the string.	B1 (1)
(c)	$R = 2T\cos\dfrac{(180^o - \alpha)}{2}$ $(= 2T\sin\dfrac{1}{2}\alpha)$ $(2T\cos 63.4^o)$ $= 2\times\dfrac{3mg}{5}\times\dfrac{\sqrt{5}}{5}$ $= \dfrac{6mg\sqrt{5}}{25}$ $(5.3m$ or $5.26m)$ **OR:** $R = \sqrt{(T - T\cos\alpha)^2 + (T\sin\alpha)^2}$ or $R = \sqrt{(T^2 + T^2 - 2T^2\cos\alpha}$ Substitute their expression for T (MUST be in terms of m) and a correct value of α $= \dfrac{6mg\sqrt{5}}{25}$ $(5.3m$ or $5.26m)$	M1 A1 DM1 A1 (4) **16** M1A1 DM1 A1
	Notes	
	N.B. Use of sin(4/5) or similar, treat as an A error but allow recovery	
7(a)	First M1 for resolving perp to the plane , with usual rules	
	First A1 for a correct equation	
	Second M1 for equation of motion parallel to the inclined plane, with usual rules	
	Second and Third A1's for a correct equation -1 each error	
	B1 cao	
	Third M1 for equation of motion horizontally, with usual rules	
	Fourth A1 for a correct equation	
	Fourth M1 for using '$F = \mu R$' correctly twice	
	Fifth DM1, dependent on all M marks, for solving for T in terms of *m only*	
	Fifth A1 cao	
	N.B. Either equation of motion can be replaced by the whole system equation: $3mg\sin\alpha - F_1 - F_2 = 4ma$ (M1A2 or M1A1 as appropriate)	
(b)	Penalise extra wrong answers	
(c)	First M1 for attempt at correct expression for R in terms of T and α with usual rules i.e. condone cos/sin confusion but must be using the correct angle (can be in terms of α)	

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	Special Case: Allow max M1A1DM0A0 if *m* is lost from their *T* but expression for *R* is otherwise correct.	
	First A1 for a correct expression for R in terms of T and α	
	Second DM1 for substituting in their expression for T and a correct value for α but must be in terms of m	
	Second A1 for a correct answer (any equivalent surd form)	

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