Mark Scheme (Results)

January 2021

Pearson Edexcel IAL In Mechanics 1
Paper 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.

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.

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.

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)

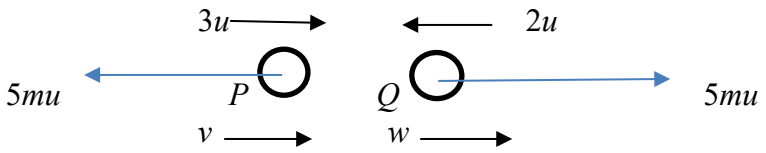
  HL Hooke's Law

  SHM Simple harmonic motion

  PCLM Principle of conservation of linear momentum

  RHS, LHS Right hand side, left hand side.

Question Number	Scheme	Marks
1(a)	$v^2 = 20^2 - 2g \times (-3)$	M1
	$v = 21$ or 21.4 (m s^{-1})	A1 (2)
1(b)	Complete method to find the total time: e.g. **either:** $-5 = 20t - \frac{1}{2}gt^2$ using one equation **or:** $0 = 20 - gt_1$ $(\Rightarrow t_1 = \frac{100}{49} = 2.040816..)$ $s_1 = (\frac{20+0}{2})t_1$ $(= \frac{1000}{49} = 20.40816...)$ (or $s_1 = 20t_1 - \frac{1}{2}gt_1^2$) using four equations $25.408.. = \frac{1}{2}gt_2^2$ $(\Rightarrow t_2 = 2.2771..)$ $t = t_1 + t_2 = 4.31795..$ and many other methods	M1
	There are two A marks for all the equations they use, -1 each error **N.B.** The second M mark should be treated as an A mark	A1 M(A)1
	$t = 4.3$ or 4.32 (s)	A1
		(6)
	Notes for question 1	
1(a)	M1 **Complete** method to find the speed, must be using 3 or -3 (Allow 9.81 for g or just g), condone sign errors	
	A1 Correct answer (Must have used 9.8 and be positive)	
1(b)	M1 **Complete** method to find the total time, condone sign errors	
	A1 M(A)1 There are now two A marks for the equation(s) that they use, -1 for each error. (Allow 9.81 for g or just g)	
	A1 Correct answer (Must have used 9.8)	
	N.B. No isw for this question **e.g. If they had the correct quadratic but went on to add the roots, this would lose the M mark.**	

Question Number	Scheme	Marks
2.		
2(a)	For P: $-5mu = 2m(v-3u)$	M1A1
	$v = \frac{1}{2}u$	A1 (3)
2(b)	For Q: $5mu = m(w-(-2u))$	M1A1
	$w = 3u$	A1 (3)
	OR: CLM: $2m\times 3u - m\times 2u = 2m\times\frac{1}{2}u + mw$ M1A1	
	$w = 3u$ A1	**(6)**
	Notes for question 2	
2(a)	M1 Dimensionally correct imp-momentum equation (M0 if g is included), with correct terms, condone sign errors, but must be a difference of momenta and must be using $2m$ to give an equation in v **only**.	
	A1 Correct equation	
	A1 cao (must be positive)	
2(b)	M1 Dimensionally correct imp-momentum equation (M0 if g is included), with correct terms, condone sign errors, but must be a difference of momenta and must be using m to give an equation in w **only**.	
	A1 Correct equation	
	A1 cao (must be positive)	
	OR: M1 Dimensionally correct CLM equation (Allow consistent extra g's or cancelled m's), with correct terms, condone sign errors, to give an equation in w **only**. **N.B.** They may find w first and use CLM to find v.	
	N.B. Mark parts (a) and (b) together if necessary.	

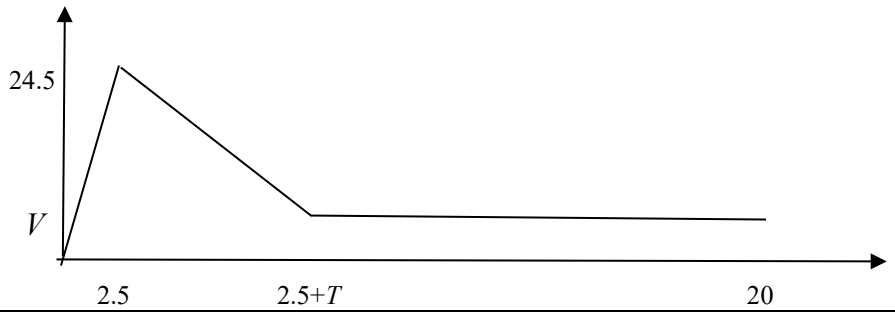
Question Number	Scheme	Marks
3.	$(\uparrow)\ R + 200\sin 15^o + T\sin 25^o = 20g$	M1A2
	$(\leftarrow)\ 200\cos 15^o - T\cos 25^o - F = 0$	M1A2
	$F = 0.3R$	B1
	Solving for T (192.31..)	**D**M1
	$T = 190$ or 192	A1
		(9)
	Notes for question 3	
	M1 Resolving vertically, correct no. of terms, condone sign errors and sin/cos confusion.	
	A2 Correct equation, -1 each error.	
	M1 Resolving horizontally, correct no. of terms, condone sign errors and sin/cos confusion.	
	A2 Correct equation, -1 each error.	
	B1 $F = 0.3R$ seen anywhere, e.g. on a diagram	
	DM1 Dependent on previous two M marks for solving for T	
	A1 cao (allow units)	
	N.B. For the first two M marks, forces and angles must be paired up correctly but allow slips.	

Question Number	Scheme	Marks
4.	$M(D), \quad 900\times 5 = W(5-x)$ Other possible equations: $(\uparrow), 900 + R_D = W$ $\text{M}(A), Wx = 5R_D$ $\text{M}(B), (900\times 6)+(R_D\times 1) = W(6-x)$ $\text{M}(C), (900\times 1)+W(x-1) = 4R_D$ $\text{M}(G), 900x = R_D(5-x)$ **BUT** R_D then needs to be eliminated to produce an equation in W and x **only** in order to earn the M mark. **N.B.** M0 if they never put $R_C = 0$ Allow consistent use of Mg for W	M1A1
	$M(C), \quad 1500\times 5 = W(x-1)$ Other possible equations: $(\uparrow), 1500 + R_C = W$ $\text{M}(A), (1500\times 6)+(R_C\times 1) = Wx$ $\text{M}(B), W(6-x) = 5R_C$ $\text{M}(D), W(5-x)+(1500\times 1) = 4R_C$ $\text{M}(G), 1500(6-x) = R_C(x-1)$ **BUT** R_C then needs to be eliminated to produce an equation in W and x **only** in order to earn the M mark. **N.B.** M0 if they never put $R_D = 0$ Allow consistent use of Mg for W	M1A1
	Solving for x	**DM**1
	$x = 3.5$	A1
		(6)
	Notes for question 4	
	M1 For an equation in W and one unknown length. Correct no. of terms, dim correct but condone sign errors. An extra g on one side is an A error.	
	A1 Correct equation	
	M1 For an equation in W and the same unknown length. Correct no. of terms, dim correct but condone sign errors. An extra g on one side is an A error.	
	A1 Correct equation	
	DM1 Solving for x, dependent on the two previous M marks.	
	A1 cao with no wrong working seen.	

Question Number	Scheme	Marks
5(i)	**R = F + G**	
	$R^2 = 8^2 + 10^2 - 2\times 8\times 10\cos 120^o$ oe (244) **OR:** $R^2 = 8^2 + 10^2 + 2\times 8\times 10\cos 60^o$ **OR**: $R^2 = (8\sin 60)^2 + (10 + 8\cos 60^o)^2$ **OR**: $R^2 = (10\sin 60)^2 + (8 + 10\cos 60^o)^2$	M1A1
	$R = \sqrt{244}$=15.620499... N	A1
5(ii)	$\frac{\sin\alpha}{8} = \frac{\sin 120^o}{\sqrt{244}}$ (allow sin60º) **OR** $\frac{\sin\beta}{10} = \frac{\sin 120^o}{\sqrt{244}}$ (allow sin60º) **OR** $8^2 = (\sqrt{244})^2 + 10^2 - 2\times\sqrt{244}\times 10\cos\alpha$ **OR** $10^2 = (\sqrt{244})^2 + 8^2 - 2\times\sqrt{244}\times 8\cos\beta$ **OR** $\tan\alpha = \frac{8\sin 60}{10 + 8\cos 60^o}$ or $\sin\alpha = \frac{8\sin 60}{\sqrt{244}}$ or $\cos\alpha = \frac{10 + 8\cos 60^o}{\sqrt{244}}$ (or reciprocal of tan) **OR** $\tan\beta = \frac{10\sin 60}{8 + 10\cos 60^o}$ or $\sin\beta = \frac{10\sin 60}{\sqrt{244}}$ or $\cos\beta = \frac{8 + 10\cos 60^o}{\sqrt{244}}$ (or reciprocal of tan)	M1A1
	$\alpha = 26.(3..)^o$ **OR** $\beta = 33.67\ldots^o$ (accept 34)	A1
	Bearing is 206º (nearest degree)	A1
		(7)
	Notes for question 5	
5(i)	M1 for an equation in R **only** (M0 for $R^2 = 8^2 + 10^2 - 2\times 8\times 10\cos 60^o$ or if they clearly misquote the cosine rule) For the second alternative, condone sin/cos confusion and sign errors	
	A1 for a correct equation	
	A1 for $\sqrt{244}$ or 16 or better (N)	
5(ii)	M1 for an equation in a relevant angle **only**, using their R value. For the SOHCAHTOA alternatives, allow sin/cos confusion and sign errors	
	A1 for a correct equation	
	A1 for a relevant angle which is correct to the nearest degree	
	A1 cao	

Question Number	Scheme	Marks
6(a)	$(11\mathbf{i}+11\mathbf{j})+t(3\mathbf{i}-\mathbf{j})$	M1A1 (2)
6(b)	When $t = 6$, $\mathbf{r}_A = (29\mathbf{i}+5\mathbf{j})$	M1
	$\mathbf{r}_B = (7\mathbf{i}+16\mathbf{j})+t(4\mathbf{i}-2\mathbf{j}) = (29\mathbf{i}+5\mathbf{j})$	M1
	Solve **both** $4t+7=29$ and $16-2t=5$ **explicitly** to give $t = 5.5$ for **both equations** (Division by vectors is DM0)	**D**M1 A1* (4)
6(c)	$\overrightarrow{AB} = (7\mathbf{i}+16\mathbf{j})+t(4\mathbf{i}-2\mathbf{j})-\{(11\mathbf{i}+11\mathbf{j})+t(3\mathbf{i}-\mathbf{j})\}$	M1
	$\overrightarrow{AB} = [(t-4)\mathbf{i}+(5-t)\mathbf{j}]$ m GIVEN ANSWER	A1* (2)
6(d)	$AB^2 = (t-4)^2+(5-t)^2$ oe seen or implied by a numerical calculation	M1
	$= 2(t-4.5)^2+0.5$	A1
	Complete method using the above to find the minimum	M1
	Minimum $AB = \sqrt{0.5} = 0.71$ m (or better)	A1
	OR $AB^2 = (t-4)^2+(5-t)^2$ oe seen or implied by a numerical calculation M1	
	$4t-18$ **or** $2(t-4)-2(5-t)$ A1 **N.B**. Either of these could be implied by seeing $t = 4.5$	
	Complete method using the above to find the minimum M1	
	Minimum $AB = \sqrt{0.5} = 0.71$ m (or better) A1	(4)
	OR $AB^2 = (t-4)^2+(5-t)^2$ oe seen or implied by a numerical calculation M1	
	$2t^2-18t+(41-d^2)=0$ $(d = AB)$ A1	
	Complete method using $b^2-4ac=0$: $(-18)^2-4\times2(41-d^2)=0$ to find minimum M1	
	Minimum $AB = \sqrt{0.5} = 0.71$ m (or better) A1	
	Accept column vectors throughout except in (c)	**(12)**
	Notes for question 6	
6(a)	M1 for an attempt at $\mathbf{r}_A$ with a correct structure	
	A1 cao	
6(b)	M1 for putting $t = 6$ into their $\mathbf{r}_A$ to find $\mathbf{r}_P$	
	M1 for equating their $\mathbf{r}_B$ at time t (with correct structure) to their $\mathbf{r}_P$	
	DM1 Solve their vector equation for **both** components, dependent on both previous M marks. Need to see 5.5 occurring **twice**. **N.B**. One ratio equation is not sufficient for this mark	

Question Number	Scheme	Marks
	A1* cao	
6(c)	M1 for finding their $\mathbf{r}_B$ – their $\mathbf{r}_A$ or their $\mathbf{r}_A$ – their $\mathbf{r}_B$ M0 if they start with $\mathbf{r}_A = \mathbf{r}_B$	
	A1* for correctly establishing *exactly* (i.e. not a column vector) the given expression (allow omission of m), writing out **in full** the difference between the vectors before simplifying correctly to the given answer.	
6(d)	M1 for a correct expression for either AB or AB^2 seen or implied.	
	A1 for a correct quadratic in completed square form	
	M1 for a complete method using the completed square form to find the minimum value of AB.	
	A1 cao	
	OR:	
	M1 for a correct expression for either AB or AB^2 seen or implied	
	A1 for a correct derivative (**N.B.** can be implied by $t = 4.5$)	
	M1 for a complete method using the derivative to find the minimum value of AB.	
	A1 cao	
	OR:	
	M1 for a correct expression for either AB or AB^2 seen or implied	
	A1 for a correct equation	
	M1 for a complete method using the discriminant = 0 to find the minimum value of AB.	
	A1 cao	

Question Number	Scheme	Marks
7(a)	$v = 2.5\times 9.8 = 24.5\ (\text{m s}^{-1})$ Allow $2.5g$	B1 (1)
7(b)		B1 shape B1 figures (2)
7(c)	$73.75 = \dfrac{(24.5+(24.5-3.9T))T}{2}$ **OR** $73.75 = 24.5T - \dfrac{1}{2}\times 3.9T^2$ **OR** $73.75 = (24.5-3.9T))T + \dfrac{1}{2}\times 3.9T\times T$ **OR** $V^2 = 24.5^2 + 2\times(-3.9)\times 73.75$ and then $5 = 24.5 - 3.9T$ $T = 5$ **N.B.** The second M mark should be treated as an A mark	M1 A1A1M1 A1 (5)
7(d)	Height = Total area under graph	
	$= \left(\dfrac{1}{2}\times 24.5\times 2.5\right) + 73.75 + (20-2.5-5)\times(24.5-3.9\times 5)$	M1A2
	=167 (m) nearest metre.	A1 (4)
		(12)
	Notes for question 7	
7(a)	B1 cao	
7(b)	B1 Correct shape of graph with the second line less steep than the first Graph may be reflected in the *t*-axis. B0 if solid vertical line at $t = 20$	
	B1 All five values correctly placed (allow omission of 0 and appropriate delineators)	
7(c)	M1 for a complete method to obtain an equation, with a correct structure, in T only.	
	A1A1M1(A1) For a correct equation or equations, -1 each error.	
	A1 cao (must be a single answer i.e the other root (7.56) must be clearly rejected.	
7(d)	M1 for a complete method, using the total area under the graph oe, with a correct structure (i.e. triangle + trapezium + rectangle oe), to obtain an expression for the height of H above the ground.	
	A2 For a correct equation, -1 each error.	
	A1 cao	

Question Number	Scheme	Marks
8(a)	$R = 2g\cos\alpha$ (Could be earned in (b) if used there)	M1A1
	$T - 2g\sin a - F = 2a$	M1A1
	$4g - T = 4a$	M1A1
	OR $4g - 2g\sin a - F = 6a$ (whole system) M1A1	
	$F = 0.25R$ seen anywhere e.g on a diagram or in (b)	B1
	Solve for T	M1
	$T = 2.4g = \frac{12g}{5} = 24$ or 23.5 (N)	A1 (9)
8(b)	$2.4g - 2g\sin a - 0.4g = 2a$ OR $4g - 2.4g = 4a$	M1
	$a = 0.4g$	A1
	$v^2 = \frac{4gh}{5}$	M1
	$-\frac{6g}{5} - \frac{2g}{5} = 2a'$ (a' is new acceleration of A up the slope) Allow +ve terms on LHS	B1
	$0 = \frac{4gh}{5} - \frac{8g}{5}s$	M1
	$s = \frac{1}{2}h$	A1
	$d > 1.5h$	A1 (7)
8(c)	Weight of string; extensibility of the string; friction at pulley	B1 (1)
	N.B. Simply restating what's in the question is B0.	**(17)**
	Notes for question 8	
8(a)	M1 Resolving perpendicular to the plane, correct no. of terms, condone sign errors and sin/cos confusion	
	A1 Correct equation	
	M1 Equation of motion parallel to the plane, correct no. of terms, condone sign errors and sin/cos confusion	
	A1 Correct equation	
	M1 Equation of motion vertically, correct no. of terms, condone sign errors.	
	A1 Correct equation	
	N.B. Either equation of motion may be replaced by a whole system equation with usual rules.	
	B1 $F = 0.25R$ seen anywhere e.g. on diagram	
	M1 Solve for T (Must have *two* equations of *motion* with a in each)	
	A1 cao	
8(b)	M1 Eliminate T from their equations of motion to give an equation in a **only**. (**N.B**. May be done in (a) but must be used in (b))	

Question Number	Scheme	Marks
	(Must have *two* equations of *motion* with a in each)	
	A1 $a = 0.4g$ oe (**N.B.** May be found in (a) but must be used in (b))	
	M1 Complete method to give an equation in v and h only using their a, which must have been found. (M0 if $0.4g$ or g used)	
	B1 Correct equation of motion, with forces in numerical form or in terms of g, for A after B hits the ground in a' only	
	M1 for an equation in s and h only, using their a' (M0 if no a' found)	
	A1 For a correct expression for s in terms of h.	
	A1 cao	
8(c)	B1 Any correct answer. B0 if any incorrect extras included.	