Pearson Edexcel

# Mark Scheme (Results)

## Summer 2022

Pearson Edexcel International Advanced Level In Mechanics 1 (WME01) Paper 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 √ 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.

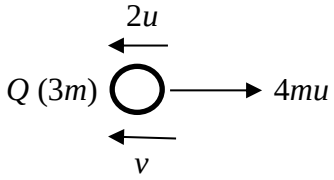
- In all cases, if the candidate clearly labels their working under a particular part of a question i.e. (a) or (b) or (c),……then that working can only score marks for that part of the question.

- 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 |

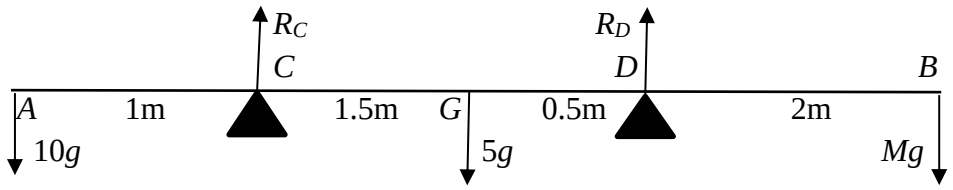
| Question Number | Scheme | Marks |
|---|---|---|
| **1.** |  | |
| **1(a)** | $-4mu = 3m(v-2u)$ **or** $4mu = 3m(-v+2u)$ **or** $-4mu = 3m(-v-2u)$ **or** $4mu = 3m(v+2u)$ | M1A1 |
| | speed is $\frac{2}{3}u$, $0.67u$ or better | A1 |
| | | (3) |
| **1(b)** | Same as its original direction or direction is unchanged or just 'unchanged' or 'same direction' or 'it is the same'.Allow 'opposite to *P*'s original direction' or 'towards *P*'<br>Apply isw if they add 'east' or 'to the left' etc<br>( 'motion of *Q* is unchanged'is B0) | DB1 |
| | | (1) |
| | | **(4)** |
| | **Notes for question 1** | |
| **1(a)** | M1 impulse-momentum equation, dimensionally correct, correct no. of terms, condone sign errors but must be attempting a difference of momenta. Allow if they use *m* instead of 3*m*. | |
| | A1 Correct equation ($v$ may be replaced by $-v$) | |
| | A1 cao (must be positive) | |
| **1(b)** | DB1 Dependent on obtaining either $\frac{2}{3}u$ or $-\frac{2}{3}u$ for $v$ in (a). | |
| | | |

| Question Number | Scheme | Marks |
|---|---|---|
| **2(a)** | $220 = (28\times 10) - \frac{1}{2}a\times 10^2$ | M1 A1 |
| | Other possible equations, any 2 of which could be used to obtain an equation in $a$ **only**:<br>$28 = u + 10a$<br>$220 = \frac{(u+28)}{2}\times 10$<br>$220 = 10u + \frac{1}{2}a\times 10^2$<br>$28^2 = u^2 + 2a\times 220$ | |
| | $a$ = 1.2 ( m s$^{-2}$ ) | A1 |
| | | (3) |
| **2(b)** | Any ONE of these:<br>$28 = u_4 + 1.2\times 6 \Rightarrow u_4 = 20.8$<br>$28 = u_5 + 1.2\times 5 \Rightarrow u_5 = 22$<br>$s_4 = 16\times 4 + \frac{1}{2}\times 1.2\times 4^2 = 73.6$<br>$s_5 = 16\times 5 + \frac{1}{2}\times 1.2\times 5^2 = 95$<br>Allow distances from $Q$<br>e.g. $s_6 = 28\times 6 - \frac{1}{2}\times 1.2\times 6^2 = 146.4$<br>$s_5 = 28\times 5 - \frac{1}{2}\times 1.2\times 5^2 = 125$ | M1A1**ft** |
| | | |
| | e.g. $s = 20.8\times 1 + \frac{1}{2}\times 1.2\times 1^2$ **OR** $s = 22\times 1 - \frac{1}{2}\times 1.2\times 1^2$<br>**OR** $s = 95 - 73.6$ **OR** $22^2 = 20.8^2 + 2\times 1.2s$ **OR** $s = 146.4 - 125$ | M1 |
| | 21.4 (m) Allow 21 (m). | A1 (4) |
| | | **(7)** |
| | **Notes for question 2** | |
| | **N.B.** Use of an incorrect *suvat* formula is M0. | |
| **2(a)** | M1 Complete method to find an equation in $a$ **only** (note that $u$ = 16)<br>**N.B.** Allow $220 = (28\times 10) + \frac{1}{2}a\times 10^2$ ( $s = ut + \frac{1}{2}at^2$ for 'reverse' motion) leading to $a$ = -1.2 M1A0A0<br>but if they then change $a$ to 1.2, then it becomes M1A1A1 retrospectively)<br>M0 if they assume $u$ = 0 | |
| | A1 Correct equation | |

| | | |
|---|---|---|
| | A1 cao | |
| **2(b)** | M1 Complete method to find the speed at $t = 4$ or 5<br>**OR** a distance at $t = 4$ or 5<br>M0 if they assume $u = 0$ | |
| | A1**ft** A correct speed or distance, follow through on their $a$ and $u$ but only if $u$ has been **used** to find $a$ in part (a). | |
| | M1 Complete method to find the required distance | |
| | A1 cao | |

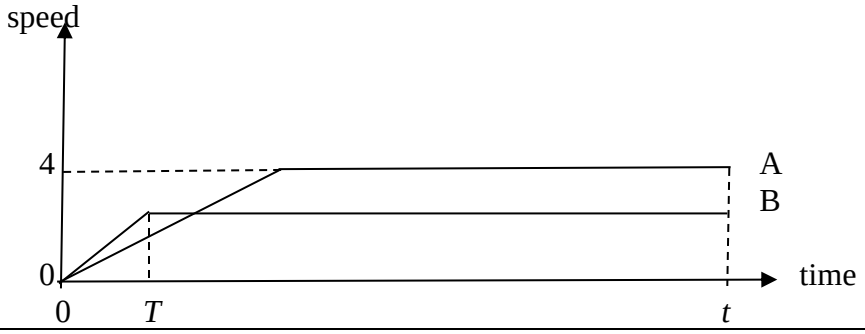
| Question Number | Scheme | Marks |
|---|---|---|
| **3(a)** | $7400 - 200 - 6000 = 6000a$<br>$7400 - 200 - R = 8000a$ Any two of these three equations<br>$6000 - R = 2000a$<br><br>**N.B.** 6000 (N) must be used as the tension to earn an M mark. | M1A1<br>M1A1 |
| | $R = 5600$ | DM1A1 |
| | **N.B.** If they consistently use tonnes in their equations treat as a MR i.e. max M1A0M1A0M1A1<br>Wrong figs. for mass, e.g. 6000000 etc or just *m*, can score M mark in that equation. | |
| | | (6) |
| **3(b)** | Same acceleration for the tractor and the block | B1 |
| | | (1) |
| | | **(7)** |
| | **Notes for question 3** | |
| | **N.B.** Enter marks on ePen in the order in which the equations appear. | |
| **3(a)** | M1 Correct no. of terms, condone sign errors<br>(use mass to determine which equation is being attempted) | |
| | A1 Correct equation | |
| | M1 Correct no. of terms, condone sign errors | |
| | A1 Correct equation | |
| | DM1 Solve for *R*, dependent on both M marks | |
| | A1 cao | |
| **3(b)** | B1 Any equivalent statement e.g 'both have the same acceleration' but not just 'same acceleration'. Need to say 'both' or mention the tractor and the block. Allow 'they have the same acceleration'.<br>Allow 'same acceleration throughout the system' and 'both particles have the same acceleration'.<br>**N.B.** B0 if extra wrong answers are included. | |

| Question Number | Scheme | Marks |
|---|---|---|
| **4(a)** | $(\uparrow)\ R = 5g - 14\sin 30^o$ | M1 A1 |
| | $R$ = 42 (N) | A1 |
| | (Max Friction =) $\frac{3}{7} \times 42 = 18$ (N) (18 only, with no working can score this M mark) | M1 |
| | Horiz cpt of $P$ = $14\cos 30^o = 12.124\ldots$ and 12 < 18 (their **max** friction) They must be comparing with a **maximum** friction i.e. the word '**maximum**' oe must have been clearly stated somewhere.<br><br>**N.B.** M0 if they state or imply that the friction **acting** on the block is 18 N. | M1 |
| | Friction = 12 or better (N) and block doesn't move | A1 |
| | | (6) |
| **4(b)** | $(\uparrow) P\sin 30^o + S = 5g$ | M1A1 |
| | $(\rightarrow) P\cos 30^o = \frac{3}{7}S$ (Allow M1A0 if they use the max friction from (a) or $\frac{3}{7} \times$ wrong value for $S$ ) (allow M1A0 for $P\cos 30^o = F$ ) | M1A1 |
| | Solve for $P$ | DM1 |
| | $P$ = 19 or 19.4 (N) | A1 |
| | | (6) |
| | | **(12)** |
| | **Notes for question 4** | |
| **4(a)** | M1 Correct no. of terms, condone sin/cos confusion and sign errors | |
| | A1 Correct equation **in *R* only**. | |
| | A1 Correct value (seen or implied) | |
| | M1 Use of $F = \frac{3}{7}R$ with their $R$ substituted. | |
| | M1 Condone sin/cos confusion | |
| | A1 cao and any equivalent correct statement and justification | |
| **4(b)** | M1 Correct no. of terms, condone sin/cos confusion and sign errors | |
| | A1 Correct equation | |
| | M1 Correct no. of terms, condone sin/cos confusion and sign errors | |
| | A1 Correct equation | |
| | DM1 Dependent on both M marks; must be solving two equations in $P$ and one other unknown | |
| | A1 cao | |

| Question Number | Scheme | Marks |
|---|---|---|
| **5.** |  | |
| **5(a)** | M($D$), $2\times R_C + 2Mg = 0.5\times 5g + 3\times 10g$ | M1 A1 |
| | $R_C = 16.25g - Mg$ oe or $R_C = 159 - 9.8M$ or $160 - 9.8M$ | A1 |
| | | (3) |
| | Other possible equations that could be used in (a), to obtain an equation in $R_C$ and $M$ **only,** or in (b), to obtain an equation in $R_D$ and $M$ **only**<br><br>($\uparrow$), $R_C + R_D = 10g + 5g + Mg$<br>M($A$), $R_C + 3R_D = 5g\times 2.5 + 5Mg$<br>M($B$), $4R_C + 2R_D = 5g\times 2.5 + 5\times 10g$<br>M($G$), $1.5R_C + 2.5Mg = 0.5R_D + 2.5\times 10g$ | |
| **5(b)** | M($C$), $2\times R_D + 1\times 10g = 1.5\times 5g + 4\times Mg$ | M1A1 |
| | $R_D = 2Mg - 1.25g$ oe or $R_D = 19.6M - 12.3$ or $20M - 12$ | A1 |
| | | (3) |
| **5(c)** | Use of when $R_C \geq 0$ or $R_D \geq 0$ Allow equality or > 0<br>**N.B**. They may take moments about $D$ or $C$ again, with respectively $R_C = 0$ or $R_D = 0$ | M1 |
| | $M \leq 16.25$ **OR** $M \geq 0.625$ Allow equality<br>**N.B.** Allow 2SF or better. | A1ft |
| | $0.625 \leq M \leq 16.25$<br>**N.B.** Allow 2SF or better.<br>If either critical value appears, without working or from working done in parts (a) and/or (b), they can score M1A1ft and also potentially, the final A1. | A1 |
| | | (3) |
| | | **(9)** |
| | **Notes for question 5** | |
| | **N.B. Only penalise over accuracy, after use of $g$ = 9.8, ONCE in this question.** | |
| **5(a)** | M1 Complete method to give an equation in $R_C$ and $M$ **only**, correct number of terms, condone sign errors, dim correct<br>M0 if they assume that the reactions are equal. | |
| | A1 Correct equation(s) | |
| | A1 Correct expression ($g$'s must be collected) | |
| **5(b)** | M1 Complete method to give an equation in $R_D$ and $M$ **only**, correct number of terms, condone sign errors, dim correct | |

| | | |
|---|---|---|
| | M0 if they assume that the reactions are equal. | |
| | A1 Correct equation(s) | |
| | A1 Correct expression ($g$'s must be collected) | |
| | | |
| | | |
| **5(c)** | M1 Use of either of their reactions to find one critical value | |
| | A1ft Critical value of $R_C$ **OR** Critical value of $R_D$<br>but must be POSITIVE. | |
| | A1 cao Allow $0.625\text{kg} \leq M\text{kg} \leq 16.25\text{kg}$ | |

| Question Number | Scheme | Marks |
|---|---|---|
| **6.** | $(5\mathbf{i}-8\mathbf{j})=(-\mathbf{i}+4\mathbf{j})+3\mathbf{a}$ | M1A1 |
| | $\mathbf{v}=(-\mathbf{i}+4\mathbf{j})+2.5(2\mathbf{i}-4\mathbf{j})$ | M1 |
| | $\mathbf{v}=(4\mathbf{i}-6\mathbf{j})$ | A1 |
| | Speed = $\sqrt{4^2+(-6)^2}=\sqrt{52}=7.2$ $(\text{m s}^{-1})$ or better | M1A1 |
| | | **(6)** |
| | **OR:** $(4-3.5)\left[\mathbf{v}-(-\mathbf{i}+4\mathbf{j})\right]=(3.5-1)\left[(5\mathbf{i}-8\mathbf{j})-\mathbf{v}\right]$ oe | M2A1 |
| | $\mathbf{v}=(4\mathbf{i}-6\mathbf{j})$ | A1 |
| | Speed = $\sqrt{4^2+(-6)^2}=\sqrt{52}=7.2$ $(\text{m s}^{-1})$ or better | M1A1 |
| | | **(6)** |
| | **Notes for question 6** | |
| | M1 For use of $\mathbf{v}=\mathbf{u}+\mathbf{a}t$, with $t$ = 3 oe, to give an *equation* in **a** only<br>Allow **u** and **v** reversed | |
| | A1 Correct unsimplified equation in **a** only | |
| | M1 For an equation in **v** only using their **a** and $t$ = 2.5 oe (e.g. they may find **u** (= $(-3\mathbf{i}+8\mathbf{j})$), the velocity at $t$ = 0, then use $t$ = 3.5)<br>M0 if they assume **u** = **0** | |
| | A1 $(4\mathbf{i}-6\mathbf{j})$ | |
| | M1 Use of Pythagoras, including square root, to find magnitude of their **v** | |
| | A1 cao | |
| | | |
| | **OR**: Ratio method | |
| | M2 for an equation in **v** only, with the correct structure | |
| | A1 Correct unsimplified ratio equation<br>A1 $(4\mathbf{i}-6\mathbf{j})$ | |
| | M1 Use of Pythagoras, including square root, to find magnitude of their **v** | |
| | A1 cao | |

| Question Number | Scheme | Marks |
|---|---|---|
| **7(a)** |  | B1 for A<br>B1 for B<br>B1 4 & *T*<br>Allow their numerical value of *T*<br>(3) |
| **7(b)** | $\frac{4}{0.8} = 5$ (s) | B1 |
| | $100 = \frac{(t + t - 5)}{2} \times 4$ **OR** $100 = \frac{1}{2} \times 5 \times 4 + 4(t - 5)$ | M1A1ft |
| | $t = 27.5$ (s) | A1 |
| | | (4) |
| **7(c)** | $100 = \frac{(27.5 + 27.5 - T)}{2} \times T$ **OR** $100 = \frac{1}{2} \times T \times T + T(27.5 - T)$ | M1A1ft |
| | $T^2 - 55T + 200 = 0$ oe | A1 |
| | $T = 3.915047\ldots$ accept 3.9 or better | A1 |
| | | (4) |
| **7(d)** | $4 - 3.915..$ | M1 |
| | 0.085 or better $(\text{m s}^{-1})$ | A1**ft** |
| | | (2) |
| | | **(13)** |
| | **Notes for question 7** | |
| **7(a)** | B1 Correct shape for A's graph. | |
| | B1 Correct shape for B's graph with steeper gradient initially and must cross A's graph. Both graphs must end at the same time.<br>B0 once if solid vertical line at the end | |
| | B1 4 and *T* correctly marked. Allow appropriate delineators.<br>**N.B.** If graphs are on separate axes can score max B1B0B1<br>If no labels, give BOD. If incorrect labels, max B1B0B1 | |
| **7(b)** | B1 5 (s) seen – could be on graph | |
| | M1 Attempt at equation in *t only*, with correct structure<br>i.e. trapezium or (rectangle + triangle) or (rectangle – triangle) oe including $\frac{1}{2}$ where appropriate, based on total area (OR distance using 2 or more *suvat* formulae) being 100<br>M0 for a *single suvat* equation for the *whole* motion.<br>**N.B.** If they clearly use *T* (for *t*) in their equation and **in their answer**, it's M0 but give BOD where possible. | |
| | A1ft Correct equation in *t* only, ft on their 5 | |
| | A1 cao | |
| **7(c)** | M1 Attempt at equation in *T only*, with correct structure,<br>i.e. trapezium or (rectangle + triangle) or (rectangle – triangle) oe based on total area (OR distance using 2 or more *suvat* formulae) being 100<br>M0 for a *single suvat* equation for the *whole* motion. | |

| | | |
|---|---|---|
| | A1ft Correct equation in $T$ only, ft on their 27.5 | |
| | A1 Correct 3 term quadratic | |
| | A1 cao | |
| **7(d)** | M1 for $4-T$ . (Allow $T-4$) | |
| | A1 **ft** follow through on their $T$ value provided it's < 4.<br>Must be correct to at least **2 SF**. | |

| Question Number | Scheme | Marks |
|---|---|---|
| | **Allow column vectors throughout except for the answer to (b).** | |
| **8(a)** | Use trig to get an equation in a relevant angle e.g tan $\alpha$ = 1 or uses isosceles triangle.<br>M0 if not using the velocity of $Q$ | M1 |
| | $135^o$ | A1 |
| | | (2) |
| **8(b)** | $\mathbf{p} = t(15\mathbf{i})$ | M1 A1 |
| | $\mathbf{q} = 200\mathbf{j} + t(20\mathbf{i} - 20\mathbf{j})$ oe | A1 |
| | $\overrightarrow{PQ} = \mathbf{q} - \mathbf{p} = 200\mathbf{j} + t(20\mathbf{i} - 20\mathbf{j}) - t(15\mathbf{i})$ (M0 if they put **p** = **q**)<br>Need to see at least this line of working. | M1 |
| | $\overrightarrow{PQ} = 5t\mathbf{i} + (200 - 20t)\mathbf{j}$ (m) * | A1* |
| | | (5) |
| **8(c)** | $\overrightarrow{PQ} = 50\mathbf{i}$ at $t$ = 10<br>(Allow M1 if they find **p** = 150**i** and **q** = 200**i** at $t$ = 10)<br>**N.B.** This mark could be implied by a correct diagram | M1 |
| | $270^o$ | A1 |
| | | (2) |
| **8(d)** | $5t = 200 - 20t$ | M1 |
| | $t = 8$ | A1 |
| | $\overrightarrow{PQ} = (5\times 8)\mathbf{i} + (200 - 20\times 8)\mathbf{j}$ | M1 |
| | $PQ = \sqrt{40^2 + 40^2} = 40\sqrt{2}$ (m), 57 or better | M1A1 |
| | | (5) |
| **8(e)** | $(5t)^2 + (200 - 20t)^2 = 200^2$ | M1 |
| | $425t^2 - 8000t = 0$ | A1 |
| | $t$ = 0 or $\frac{320}{17}$=18.82… Accept 19 or better Apply isw | A1 |
| | | (3) |
| | | **(17)** |
| | **Notes for question 8** | |
| **8(a)** | M1 e.g. use of cos or sin or the cosine rule | |
| | A1 cao | |
| **8(b)** | M1 Correct structure for either | |
| | A1 oe | |
| | A1 oe | |
| | M1 Allow **p** – **q** | |
| | A1* Correct given answer correctly obtained, allow omission of m. | |
| **8(c)** | M1 Clear attempt to find $\overrightarrow{PQ}$ at $t$ = 10 or **p** and **q** at $t$ = 10 | |
| | A1 cao | |
| **8(d)** | M1 Equating components to give an equation in $t$ only, with no vectors | |
| | A1 cao | |
| | M1 Substituting their $t$ value into their $\overrightarrow{PQ}$ | |
| | M1 Finding the magnitude, with square root | |

| | | |
|---|---|---|
| | A1 cao | |
| **8(e)** | M1 Use of Pythagoras – allow with square root – to obtain an equation in *t*. | |
| | A1 Correct unsimplified 2 term quadratic in *t*. | |
| | A1 For both answers | |
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with its registered office at 80 Strand, London, WC2R 0RL, United Kingdom