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Pearson Edexcel

# Mark Scheme (Results)

## January 2022

### Pearson Edexcel International A 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.
- 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
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 ^ 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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| Question Number | Scheme | Marks |
|---|---|---|
| **1(a)** | $F = 5\cos 30^\circ$ oe (Resolving perp to string or from triangle of forces or Lami's Theorem: $\frac{F}{\sin 120^\circ} = \frac{5}{\sin 90^\circ}$)<br><br>**OR** $\frac{F\sin 30^\circ}{\sin 60^\circ}\cos 60^\circ + F\cos 30^\circ = 5$ | M1 A1 |
| | $F = \frac{5\sqrt{3}}{2}$ 4.3 or better | A1 |
| | **N.B.** $F\sin 30^\circ = T\sin 60^\circ$ | (3) |
| **1(b)** | $T = 5\sin 30^\circ$ oe (Resolving along string or from triangle of forces or Lami's Theorem: $\frac{T}{\sin 150^\circ} = \frac{5}{\sin 90^\circ}$)<br><br>**OR** $T\cos 60^\circ + \frac{T\sin 60^\circ}{\sin 30^\circ}\cos 30^\circ = 5$ | M1 A1 |
| | $T = \frac{5}{2}$ (N) | A1 |
| | **N.B.** $F\sin 30^\circ = T\sin 60^\circ$ | (3) |
| | | **(6)** |
| | | |
| | **Notes for question 1** | |
| **1(a)** | M1 Complete method to obtain equation in $F$ only - correct no. of terms, condone sign errors and sin/cos confusion<br>(If they resolve horizontally and vertically, they will need to eliminate $T$ to obtain this M mark, with the usual rules applying to each equation they use)<br>**N.B.** If they do (b) first and find an incorrect value for $T$ and then use that value in (a), using an equation that would earn M1, with usual rules, to find $F$, give M1A0A0 in (a).<br>M0 if using wrong angles e.g. 45° | |
| | A1 Correct equation | |
| | A1 cao (4.3301..) | |
| **1(b)** | M1 Complete method to obtain equation in $T$ only - correct no. of terms, condone sign errors and sin/cos confusion<br>(If they resolve horizontally and vertically, they will need to eliminate $F$ to obtain this M mark, with the usual rules applying to each equation they use)<br>**N.B.** If they find an incorrect value for $F$ in (a) and then use that value in (b), using an equation that would earn M1, with usual rules, to find $T$, give M1A0A0 in (b).<br>M0 if using wrong angles e.g. 45° | |
| | A1 Correct equation | |
| | A1 cao | |
| | | |

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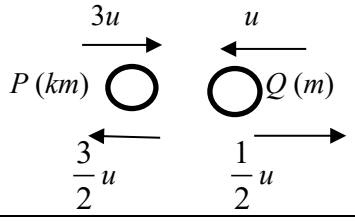
| Question Number | Scheme | Marks |
|---|---|---|
| **2(a)** |   | |
| | CLM: $km\times 3u - mu = -km\times\frac{3}{2}u + m\times\frac{1}{2}u$ | M1 A1 A1 |
| | $k = \frac{1}{3}$ | A1 |
| | | (4) |
| **2(b)** | $I = m\left(\frac{1}{2}u - -u\right)$ **OR** $I = \frac{1}{3}m\left(\frac{3}{2}u - -3u\right)$ | M1 A1 |
| | $I = \frac{3}{2}mu$ must be positive | A1 |
| | | (3) |
| | | **(7)** |
| | | |
| | **Notes for question 2** | |
| **2(a)** | M1 Correct no. of terms, dim correct, condone sign errors but structure must be correct – allow consistently cancelled *m*'s or extra *g*'s | |
| | A1 Correct equation with one error | |
| | A1 Correct equation | |
| | A1 Allow 0.33 or better | |
| **2(b)** | M1 Condone sign errors but must have masses and speeds paired correctly and must be attempting a difference of momenta.<br>Allow M1 if *k* is not substituted.<br>M0 if *g* included | |
| | A1 Allow $\pm m\left(\frac{1}{2}u - -u\right)$ **OR** $\pm\frac{1}{3}m\left(\frac{3}{2}u - -3u\right)$ (no ft on *k*) | |
| | A1 cao Allow them to change a negative expression into a positve one | |
| | | |
| | **N.B.** If they do (b) first, and obtain an impulse of magnitude *I*, then they do (a) : $I = km(\frac{3u}{2} - -3u)$ , apply CLM scheme to their equation. | |
| | | |

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| Question Number | Scheme | Marks |
|---|---|---|
| **3(a)** | M($D$), $mg \times 1.2 = 30g \times 0.8$ | M1 A1 |
| | Other possible equations:<br>$(\uparrow)\ R = mg + 30g$<br>M($A$) $2.5mg + 30g \times 4.5 = 3.7R$<br>M($G$) $30g \times 2 = 1.2R$<br>M($C$) $mg \times 2 = 0.8R$<br>M($B$) $2.5mg + 30g \times 0.5 = 1.3R$ | |
| | $m$ = 20 (kg) | A1 |
| | **N.B.** Allow an inequality if they state $m$ = 20 (kg) at the end | (3) |
| **3(b)** | M($D$), $Xg \times 3.7 + 20g \times 1.2 = 30g \times 1.3$<br>**N.B.** Allow inequality $\geq$…the correct way round for M1A1ft | M1A1**ft** |
| | Other possible equations:<br>$(\uparrow)\ S = mg + 30g + Xg$<br>M($A$) $2.5mg + 30g \times 5 = 3.7S$<br>M($G$) $30g \times 2.5 = 1.2S + Xg \times 2.5$<br>M($B$) $2.5mg + Xg \times 5 = 1.3S$<br>where $m$ is their answer from (a). | |
| | $X = \frac{150}{37}$ , 4.1 or better (4.05405…) | A1 |
| | | (3) |
| **3(c)** | The mass of the block is concentrated at a point. oe | B1 |
| | **N.B.** Must mention either mass or weight and 'acting at a point' or 'concentrated at a point'. | (1) |
| | | **(7)** |
| | **Notes for question 3** | |
| **3(a)** | M1 Complete method to give an equation in $m$ only.<br>Allow M1 if they use weight instead of $mg$<br>**N.B.** If they don't use M($D$), e.g. ($\uparrow$) and M($A$), they will need to eliminate the reaction at $D$ to obtain the M mark.<br>Each equation used must have the correct no. of terms and be dimensionally correct.<br>M0 if they don't have the reaction acting at $D$. | |
| | A1 Correct equation | |
| | A1 cao | |
| **3(b)** | M1 Complete method to give an equation in $X$ only.<br>Allow M1 if they use weight instead of $Xg$<br>**N.B.** If they don't use M($D$), e.g. ($\uparrow$) and M($A$), they will need to eliminate the reaction at $D$ to obtain the M mark.<br>Each equation used must have the correct no. of terms and be dimensionally correct.<br>M0 if they don't have the reaction acting at $D$. | |
| | A1**ft** Correct equation. Follow through on their 20 | |
| | A1 cao | |
| **3(c)** | B1 Any equivalent statement. | |

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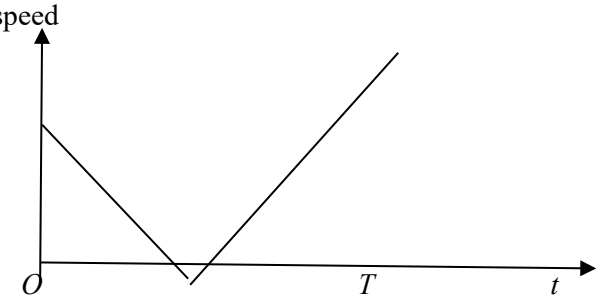
| Question Number | Scheme | Marks |
|---|---|---|
| **4(a)** | $0^2 = u^2 - 2\times g\times 19.6$ | M1 A1 |
| | $-24.5 = uT - \frac{1}{2}gT^2$ | M1 A1 |
| | Produce an equation in *T only* and solve for *T* | DM1 |
| | $T = 5$ | A1 |
| | | (6) |
| **4(b)** | speed<br><br> | B1 Shape<br><br>DB1 Second line longer than the first, approx. equal angles and *T* or their answer for *T* marked |
| | | (2) |
| | | **(8)** |
| | | |
| | **Notes for question 4** | |
| **4(a)** | M1 Attempt at a relevant *suvat* equation which uses $s = 19.6$ (or $-19.6$), with correct no. of terms but condone sign errors. | |
| | A1 A correct equation (*g* does not need to be substituted) | |
| | M1 Attempt at another relevant *suvat* equation which uses 24.5 or 44.1 e.g. finding time from *B* to the ground, with correct no. of terms but condone sign errors, | |
| | A1 A correct equation (neither *u* nor *g* need to be substituted) | |
| | DM1 dependent on both M marks , for finding an equation in *T* only and solving for *T* i.e. for a complete method to find *T*<br><br>**N.B**. This mark cannot be awarded if their equation has NO solutions. | |
| | A1 $T = 5$ **N.B.** If $g = 9.8$ has not been used, A0 | |
| **4(b)** | B1 A V-shape (*and nothing else*) starting on the speed axis, with point on the *t*-axis | |
| | **DB**1 Dependent on the first B1, for approximately equal angles between the 2 lines and the *t*-axis, second line longer than the first, *T* or their *T* marked correctly.<br>B0 if clearly unequal angles.<br>**N.B**. If graph reflected, B0 DB0. | |

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| Question Number | Scheme | Marks |
|---|---|---|
| **5.** | Resolve perp to the plane: $R = mg\cos\alpha$ | M1A1 |
| | Resolve parallel to the plane: | M1 |
| | $mg\sin\alpha + F = 2P$ | A1 |
| | $mg\sin\alpha - F = P$ | A1 |
| | Use of $F = \mu R$ | M1 |
| | Substitute correctly for trig, eliminate *P* and *F* and solve for $\mu$ | M1 |
| | $\mu = 0.25$ | A1 |
| | **N.B.** If they consistently omit *g* and obtain the correct answer, max marks are: M1A0M1A0A0M1M1A1 | (8) |
| | | **(8)** |
| | **Notes for question 5** | |
| | M1 First resolution, correct no. of terms, condone sign errors and sin/cos confusion<br>**N.B.** If they use cos (4/5) etc, treat as an A error but allow recovery. | |
| | A1 Correct equation | |
| | M1 Second (or third) resolution, correct no. of terms, condone sign errors and sin/cos confusion<br>**N.B.** M0 if they don't substitute for *X*, but full marks is possible if they use *X* and 2*X* oe.<br>If they use sin (3/5) etc, treat as an A error but allow recovery. | |
| | A1 Correct equation (A0 if they use different *R*'s or *F*'s) | |
| | A1 Correct equation (A0 if they use different *R*'s or *F*'s) | |
| | M1 Use of $F = \mu R$ | |
| | M1 Substitute for trig, eliminate *P* and *F* and solve for $\mu$ | |
| | A1 cao | |
| | | |
| | Other possible equations: | |
| | $(\rightarrow) 2P\cos\alpha = R\sin\alpha + F\cos\alpha \quad (1)$ | |
| | $(\rightarrow) \quad P\cos\alpha = R\sin\alpha - F\cos\alpha \quad (2)$ | |
| | $(\uparrow) mg - 2P\sin\alpha = R\cos\alpha - F\sin\alpha \quad (3)$ | |
| | $(\uparrow) mg - P\sin\alpha = R\cos\alpha + F\sin\alpha \quad (4)$ | |
| | | |
| | **SC:** (Only needs 2 equations) | |
| | Equation (1): M1A1 | |
| | Equation (2): M1A1 | |
| | (1) + (2): $3P\cos\alpha = 2R\sin\alpha$ | |
| | $(1)-(2)$: $P\cos\alpha = 2F\cos\alpha$ | |
| | Divide $\frac{1}{3} = \frac{F}{R}\cot\alpha$. A1 | |
| | Use of $F = \mu R$ M1 | |
| | Substitute for trig and solve for $\mu$ M1 | |
| | $\mu = 0.25$ A1 | |
| | | |
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| Question Number | Scheme | Marks |
|---|---|---|
| **6(a)** | $(p\mathbf{i} + q\mathbf{j}) + (2q\mathbf{i} + p\mathbf{j}) = 2(\mathbf{i} - \mathbf{j})$ (allow 2g) | M1 |
| | Equating coefficients of **i** or **j** | M1 |
| | $p + 2q = 2$ | A1 |
| | $q + p = -2$ | A1 |
| | $p = -6$; $q = 4$ | A1 |
| | | (5) |
| **6(b)** | $\tan\alpha = \pm 1$ ; e.g. 45° or $\frac{\pi}{4}$ | M1 |
| | Angle is $135°$ or $225°$ or $\frac{3\pi}{4}$ or $\frac{5\pi}{4}$ | A1 |
| | | (2) |
| **6(c)** | $\mathbf{v} = (3\mathbf{i} - 4\mathbf{j}) + T(\mathbf{i} - \mathbf{j})$ | M1 |
| | $\frac{3+T}{-4-T} = \frac{11}{-13}$ | M1A1 |
| | Solve for $T$ | **DM**1 |
| | $T = 2.5$ | A1 |
| | | (5) |
| | | **(12)** |
| | **Notes for question 6** | |
| **6(a)** | M1 Use of $\mathbf{F} = m\mathbf{a}$ with $m = 2$. Correct no. of terms and must be attempting to add the two forces. | |
| | M1 Must have an equation in $p$ and $q$ *only* (no vectors)<br>This mark is available if $m$ has been omitted.<br>M0 if they use a ratio i.e. $\frac{p+2q}{2} = \frac{q+p}{-2}$ but never equate coefficients. | |
| | A1 A correct equation in any form | |
| | A1 Two correct equations in any form | |
| | A1 cao | |
| **6(b)** | M1 (Use of trig.) to find a relevant angle | |
| | A1 cao accept radians or degrees | |
| **6(c)** | M1 Use of $\mathbf{v} = \mathbf{u} + \mathbf{a}T$ to obtain a velocity vector. | |
| | M1 Use of ratios using *their* **v (**must be a **velocity)** to produce an equation in $T$ (allow $t$) only<br>Condone sign error but must be the correct way up. | |
| | A1 Correct equation | |
| | **DM**1 Dependent on previous M mark for solving for $T$ | |
| | A1 cao | |
| | | |
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| Question Number | Scheme | Marks |
|---|---|---|
| **7(a)** | $T = ma$ (allow -$a$) | B1 |
| | | (1) |
| **7(b)** | $4mg\sin\alpha - T - F = 4ma$ **OR** $4mg\sin\alpha - F = 5ma$ (allow -$a$) (allow -$a$) | M1A1 |
| | $F = \frac{1}{4}R$ | B1 |
| | $R = 4mg\cos\alpha$ | M1A1 |
| | Solve for $T$ in terms of $mg$ only | **D**M1 |
| | $T = \frac{8mg}{25}$ oe | A1 |
| | | (7) |
| **7©** | $2T\sin\frac{1}{2}\alpha$ oe e.g. $\sqrt{T^2 + T^2 - 2T^2\cos\alpha}$ using cos rule<br>Or $\frac{T\sin\alpha}{\sin(90^o - \frac{1}{2}\alpha)}$ using sine rule<br>Or $\sqrt{(T - T\cos\alpha)^2 + (T\sin\alpha)^2}$ using components and Pythag. | M1 A1 |
| | Substitute for $T$ and trig | M1 |
| | $\frac{8mg\sqrt{10}}{125}$ oe, $2m$ or $2.0m$ or $1.98m$ or $0.2mg$ or better | A1 |
| | | (4) |
| **7(d)** | e.g. Tension will be the same <u>*throughout*</u> *a* ***section*** of the string. | B1 (1) |
| | | **(13)** |
| | **Notes for question 7** | |
| **7(a)** | B1 cao The equation must appear in (a) to earn the B1. | |
| **7(b)** | M1 Equation of motion for $P$ parallel to the plane, correct no. of terms, condone sign errors and sin/cos confusion | |
| | A1 Correct equation | |
| | B1 $F = \frac{1}{4}R$ seen – could just be on the diagram | |
| | M1 Resolve perpendicular to the plane for $P$, correct no. of terms, condone sign errors and sin/cos confusion | |
| | A1 Correct equation | |
| | **DM**1 Dependent on both M marks, for solving for $T$ – must be in terms of $mg$ *only* (must be of form $kmg$ ) | |
| | A1 cao | |
| **7©** | M1 If using resolving, condone cos/sin confusion and sign errors but must have correct angle | |
| | A1 Any correct unsimplified expression in terms of $T$ and $\alpha$ | |
| | M1 For substituting in their $T$ (must be of form $kmg$) and *correct* values for their trig | |
| | A1 cao | |
| **7(d)** | B1<br>B0 for 'tension is the same throughout the string'<br>B0 if incorrect extras | |
| | | |

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| Question Number | Scheme | Marks |
|---|---|---|
| **8(a)** | $\mathbf{r} = (13\mathbf{i} + 5\mathbf{j}) + t(3\mathbf{i} - 10\mathbf{j})$ | M1 A1 |
| | | (2) |
| **8(b)** | $\mathbf{s} = (3\mathbf{i} - 5\mathbf{j}) + t(15\mathbf{i} + 14\mathbf{j})$ | M1 A1 |
| | $\overrightarrow{AB} = \mathbf{s} - \mathbf{r}$ | M1 |
| | = | |
| | $\overrightarrow{AB} = (12t - 10)\mathbf{i} + (24t - 10)\mathbf{j}$ km * | A1 * |
| | | (4) |
| **8(c)** | $AB^2 = (12t - 10)^2 + (24t - 10)^2$ ( $720t^2 - 720t + 200$ ) | M1 |
| | Differentiate and equate to 0 **OR** Complete square **OR** **use** $t = \dfrac{-b}{2a}$ | M1 |
| | $1440t - 720 = 0$ oe $\qquad 720(t - \frac{1}{2})^2 + 20$ | A1 |
| | Solve for $t$ $\qquad$ Use $(t - \frac{1}{2})^2 \geq 0$ $\qquad t = \dfrac{720}{2 \times 720}$ | DM1 |
| | Substitute their value of $t$ into their $AB$ expression | M1 |
| | $\sqrt{20}$ oe (km) 4.5 or better | A1 |
| | | |
| | **OR for last 5 marks:** | |
| | Complete method | M1 |
| | $720t^2 - 720t + 200 = D^2$ i.e. $720t^2 - 720t + 200 - D^2 = 0$ | A1 |
| | (For real $t$, $720^2 \geq 4 \times 720(200 - D^2)$ | DM1 |
| | Solve for $D$, ( $D \geq \sqrt{20}$ ) | M1 |
| | $\sqrt{20}$ oe (km) 4.5 or better | A1 |
| | | (6) |
| **8(d)** | Use $\overrightarrow{AB} = -4\mathbf{i} + 2\mathbf{j}$ at $t = \frac{1}{2}$ to obtain a relevant angle e.g. 26.56°..<br>Allow e.g. $\tan\alpha$ = ½ or $\tan^{-1}\dfrac{1}{2}$ | M1 |
| | Bearing is 297° or better | A1 |
| | | (2) |
| | | **(14)** |
| | **Notes for question 8** | |
| | Accept column vectors through out apart from the answer for (b) | |
| **8(a)** | M1 Expression with correct structure | |
| | A1 cao | |
| **8(b)** | M1 Expression with correct structure | |
| | A1 cao | |
| | M1 Allow difference in either order | |
| | A1* Correct given expression correctly obtained<br>**N.B.** $\overrightarrow{AB} = (-10 + 12t)\mathbf{i} + (-10 + 24t)\mathbf{j}$ is A0 | |
| **8(c)** | M1 Correct expression (with or without square root) | |
| | M1 Attempt to differentiate ( at least one power decreasing by 1) or to complete the square | |
| | A1 Correct equation or expression | |
| | DM1 Dependent on previous M for finding the critical value for $t$<br>**OR** For the completing the square method, for 'ignoring' the $(t - \frac{1}{2})^2$ term. | |

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| Question Number | Scheme | Marks |
|---|---|---|
| | M1 Substitute their $t$ (it may not be clear where it has come from but it *must be non-zero*) into their $AB$ expression (must have square root) | |
| | A1 cao | |
| **8(d)** | M1 Using their $t$ value to obtain $\overrightarrow{AB}$ and a relevant angle | |
| | A1 cao | |

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