



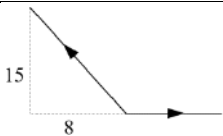
# Mark Scheme (Results)

Summer 2023

Pearson Edexcel International Advanced Level  
In Mechanics M1 (WME01)

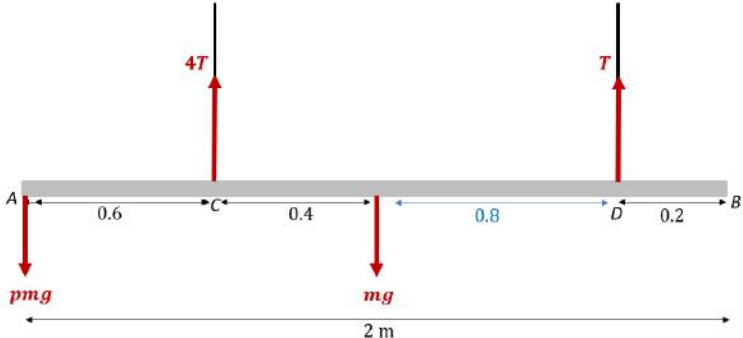
Paper 01

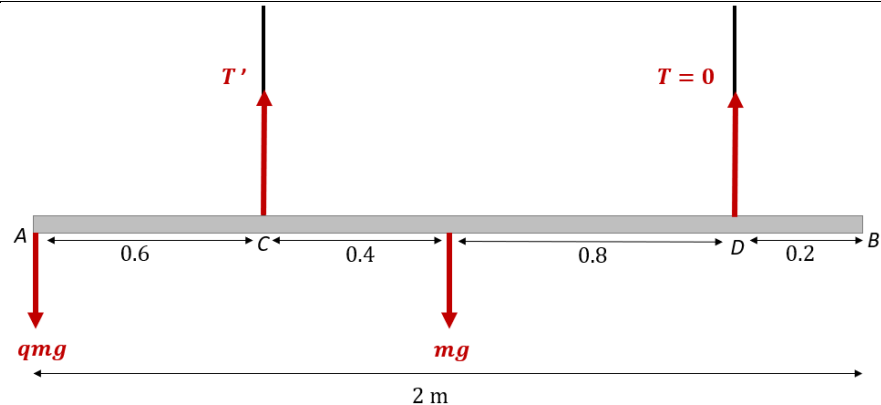
| Question Number | Scheme                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Marks    |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 1(a)            | <div style="text-align: center;"> <math>\xrightarrow{\quad} 2u</math>      <math>3u \xleftarrow{\quad}</math><br/> <math>A (4 \text{ kg})</math>      <math>B (2 \text{ kg})</math><br/> <math>\xrightarrow{\quad} v</math>      <math>\xrightarrow{\quad} 2u</math> </div> <p>CLM: <math>(4 \times 2u) + (-3u \times 2) = 4v + (2 \times 2u)</math></p> <p style="text-align: center;"><b>OR</b></p> <p>Equating impulses: <math>2(2u - 3u) = 4(-v - 2u)</math></p> | M1<br>A1 |
|                 | $\frac{1}{2}u (\text{m s}^{-1})$                                                                                                                                                                                                                                                                                                                                                                                                                                     | A1       |
|                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | (3)      |
| 1(b)            | The direction of motion is reversed.                                                                                                                                                                                                                                                                                                                                                                                                                                 | B1       |
|                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | (1)      |
| 1(c)            | <p>For B: <math>I = \pm 2(2u - 3u)</math></p> <p style="text-align: center;"><b>OR</b></p> <p>For A: <math>I = \pm 4\left(\frac{u}{2} - 2u\right)</math></p>                                                                                                                                                                                                                                                                                                         | M1<br>A1 |
|                 | $I = 10u \text{ N s or } 10u \text{ kgms}^{-1}$                                                                                                                                                                                                                                                                                                                                                                                                                      | A1       |
|                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | (3)      |
|                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | (7)      |
| <b>Notes</b>    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |          |
| (a)             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |          |
| M1              | Dimensionally correct CLM equation or equating of impulses equation. Allow consistent extra g's. Ignore sign errors. May be +v or -v                                                                                                                                                                                                                                                                                                                                 |          |
| A1              | Correct unsimplified equation                                                                                                                                                                                                                                                                                                                                                                                                                                        |          |
| A1              | Cao. Must be <b>positive</b> .                                                                                                                                                                                                                                                                                                                                                                                                                                       |          |
| (b)             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |          |
| B1              | Accept <i>opposite direction</i> . Do not accept <i>changed</i> or <i>to the left</i> or <i>backwards</i> , away from B<br><br>N.B. This mark is <b>dependent</b> on <b>correctly</b> obtaining $\frac{1}{2}u$ or $-\frac{1}{2}u$ in (a)                                                                                                                                                                                                                             |          |
| (c)             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |          |
| M1              | Dimensionally correct impulse-momentum equation using A or B. Condone sign errors with appropriate velocities. M0 if g is included                                                                                                                                                                                                                                                                                                                                   |          |
| A1              | Correct unsimplified equation                                                                                                                                                                                                                                                                                                                                                                                                                                        |          |
| A1              | Cao <b>with</b> units. Accept kg m/s                                                                                                                                                                                                                                                                                                                                                                                                                                 |          |

| Question Number | Scheme                                                                                                                                                                                                                                                                           | Marks       |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| 2(a)            | $\mathbf{F}_3 + (3c\mathbf{i} + 4c\mathbf{j}) + (-14\mathbf{i} + 7\mathbf{j}) = \mathbf{0}$ oe                                                                                                                                                                                   | M1          |
|                 | $\mathbf{F}_3 = (14 - 3c)\mathbf{i} + (-7 - 4c)\mathbf{j}$                                                                                                                                                                                                                       | A1          |
|                 |                                                                                                                                                                                                                                                                                  | (2)         |
| 2(b)            | Resultant force<br>$\mathbf{F}_1 + \mathbf{F}_2 = (6 - 14)\mathbf{i} + (8 + 7)\mathbf{j}$<br>$(= -8\mathbf{i} + 15\mathbf{j})$                                                                                                                                                   | M1          |
|                 |  <p>Find any relevant angle for <b>their (even if they've subtracted) resultant</b> (need not be acute nor positive)</p>                                                                        | M1          |
|                 | any of $\tan^{-1}\left(\pm\frac{8}{15}\right), \tan^{-1}\left(\pm\frac{15}{8}\right), \sin^{-1}\left(\pm\frac{8}{17}\right), \cos^{-1}\left(\pm\frac{8}{17}\right), \dots$                                                                                                       | A1ft        |
|                 | 120° or better (118.0724...) <b>OR</b> 240° or better (241.9276..<br>In radians 2.1 or better (2.0607..) <b>OR</b> 4.2 or better (4.2224...)                                                                                                                                     | A1          |
|                 |                                                                                                                                                                                                                                                                                  | (4)         |
| 2(c)            | Use of Pythagoras on their resultant : $\sqrt{(-8)^2 + 15^2}$<br><b>or</b> their acceleration: $\sqrt{\left(\frac{-8}{m}\right)^2 + \left(\frac{15}{m}\right)^2}$                                                                                                                | M1          |
|                 | Use of $ \text{their } \mathbf{R}  = 8.5m$ <b>or</b> their Resultant = $ma$                                                                                                                                                                                                      | M1          |
|                 | A correct equation in $m$ only eg $17 = m \times 8.5$                                                                                                                                                                                                                            | A1ft        |
|                 | $m = 2$                                                                                                                                                                                                                                                                          | A1          |
|                 | <b>N. B.</b><br>$\sqrt{\left(\frac{-8}{8.5}\right)^2 + \left(\frac{15}{8.5}\right)^2} \quad \text{M1}$ $-8\mathbf{i} + 15\mathbf{j} = 8.5m \quad \text{M1}$ $\sqrt{\left(\frac{-8}{8.5}\right)^2 + \left(\frac{15}{8.5}\right)^2} = m \quad \text{A1ft}$ $2 = m \quad \text{A1}$ |             |
|                 |                                                                                                                                                                                                                                                                                  | (4)         |
|                 |                                                                                                                                                                                                                                                                                  | <b>(10)</b> |

| Notes |                                                                                                                                                   |
|-------|---------------------------------------------------------------------------------------------------------------------------------------------------|
|       | Accept column vectors throughout apart from answer for (a)                                                                                        |
| (a)   |                                                                                                                                                   |
| M1    | Uses the vector <b>sum</b> of all 3 forces being equal to zero oe<br>N.B. $\mathbf{F}_3 = \mathbf{F}_1 + \mathbf{F}_2$ is M0                      |
| A1    | cao Must be in terms of $c$ , $\mathbf{i}$ and $\mathbf{j}$ but allow uncollected $\mathbf{i}$ 's and $\mathbf{j}$ 's and apply isw if necessary. |
| (b)   |                                                                                                                                                   |
| M1    | Finds the resultant using $\mathbf{F}_1 + \mathbf{F}_2$ or $-\mathbf{F}_3$                                                                        |
| M1    | Uses trig to find a relevant angle <b>for their resultant</b>                                                                                     |
| A1ft  | Any <b>correct</b> relevant angle (does not need to be acute), ft on their resultant                                                              |
| A1    | Cso.                                                                                                                                              |
| (c)   |                                                                                                                                                   |
| M1    | Use of Pythagoras to find the magnitude of their resultant force <b>or</b> their acceleration                                                     |
| M1    | Allow their $\mathbf{R} = 8.5\ m$                                                                                                                 |
| A1ft  | A correct scalar equation in $m$ only eg $17 = m \times 8.5$ , ft on their resultant                                                              |
| A1    | cso                                                                                                                                               |

| Question Number             | Scheme                                                                                                                                                                                                                                                                                                                                                               | Marks    |
|-----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 3(a)                        | $1.5 = 0 + \frac{1}{2} g t^2$                                                                                                                                                                                                                                                                                                                                        | M1<br>A1 |
|                             | $t = 0.55 \text{ or } 0.553(\text{s})$                                                                                                                                                                                                                                                                                                                               | A1       |
|                             |                                                                                                                                                                                                                                                                                                                                                                      | (3)      |
| 3(b)                        | $1.5 = 0 + \frac{1}{2} a (0.6)^2$                                                                                                                                                                                                                                                                                                                                    | M1<br>A1 |
|                             | $0.2g - R = 0.2a$                                                                                                                                                                                                                                                                                                                                                    | M1<br>A1 |
|                             | $R = 0.293, 0.29$                                                                                                                                                                                                                                                                                                                                                    | A1       |
|                             |                                                                                                                                                                                                                                                                                                                                                                      | (5)      |
|                             |                                                                                                                                                                                                                                                                                                                                                                      | (8)      |
| <b>Notes for Question 3</b> |                                                                                                                                                                                                                                                                                                                                                                      |          |
| (a)                         |                                                                                                                                                                                                                                                                                                                                                                      |          |
| M1                          | Complete method to find the time taken using $a = g$                                                                                                                                                                                                                                                                                                                 |          |
| A1                          | Correct unsimplified equation in $t$ only                                                                                                                                                                                                                                                                                                                            |          |
| A1                          | Cao                                                                                                                                                                                                                                                                                                                                                                  |          |
| (b)                         |                                                                                                                                                                                                                                                                                                                                                                      |          |
| M1                          | Complete method to form an equation in $a$ only, $a \neq g$ , using $t = 0.6$                                                                                                                                                                                                                                                                                        |          |
| A1                          | Correct unsimplified equation in $a$ only                                                                                                                                                                                                                                                                                                                            |          |
| M1                          | Use $F = ma$ to form an equation of motion with correct terms, condone sign errors, $a \neq g$                                                                                                                                                                                                                                                                       |          |
| A1                          | Correct unsimplified equation                                                                                                                                                                                                                                                                                                                                        |          |
| A1                          | Cao                                                                                                                                                                                                                                                                                                                                                                  |          |
|                             | <p><b>N.B.</b> Allow <b>consistent</b> use of <math>(-a)</math> instead of <math>a</math> and penalise in the second equation if inconsistent.</p> <p><b>N.B.</b> Penalise use of <math>g = 9.81</math> once for the whole question.<br/>Also penalise once for the whole question, answers as fractions, penalise the first one, if both answers are fractions.</p> |          |

| Question Number      | Scheme                                                                                                                                                                                                                                                                                                                                                                                                                                              | Marks |
|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| 4(a)                 | $T$ and $4T$ correctly placed                                                                                                                                                                                                                                                                                                                                                                                                                       | B1    |
|                      | Vertical resolution<br>$T + 4T = pmg + mg$                                                                                                                                                                                                                                                                                                                                                                                                          | M1 A1 |
|                      | OR<br>a moments equation, see below.                                                                                                                                                                                                                                                                                                                                                                                                                |       |
|                      | $M(A): (4T \times 0.6) + (T \times 1.8) = (mg \times 1)$<br><br>Other moments equations:<br>$M(C): (pmg \times 0.6) + (T \times 1.2) = (mg \times 0.4)$<br>$M(G): (pmg \times 1) + (T \times 0.8) = (4T \times 0.4)$<br>$M(D): (pmg \times 1.8) + (mg \times 0.8) = (4T \times 1.2)$<br>$M(B): (4T \times 1.4) + (T \times 0.2) = (pmg \times 2) + (mg \times 1)$ | M1 A1 |
|                      | Eliminate $T$<br>$5\left(\frac{5mg}{21}\right) = pmg + mg$                                                                                                                                                                                                                                                                                                                                                                                          | M1    |
|                      | $p = \frac{4}{21}$ (exact ratio of 2 positive integers)                                                                                                                                                                                                                                                                                                                                                                                             | A1    |
|                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                     | (7)   |
| 4(b)                 | Tension at $D$ is zero, seen or implied.                                                                                                                                                                                                                                                                                                                                                                                                            | B1    |
|                      | $M(C): (qmg \times 0.6) = (mg \times 0.4)$                                                                                                                                                                                                                                                                                                                                                                                                          | M1 A1 |
|                      | $q = \frac{2}{3}$ (exact ratio of 2 positive integers), accept 0.666..... or $0.\dot{6}$                                                                                                                                                                                                                                                                                                                                                            | A1    |
|                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                     | (4)   |
| 4(c)                 | The centre of mass (or gravity) of the beam is in the middle; the mass (weight) of the beam acts at the middle, mass at centre, centre of mass at the centre. Penalise incorrect extras.                                                                                                                                                                                                                                                            | B1    |
|                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                     | (1)   |
| (12)                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                     |       |
| Notes for Question 4 |                                                                                                                                                                                                                                                                                                                                                                                                                                                     |       |
| (a)                  | N.B. Full marks can be scored if <u>consistent</u> omission of $g$ 's in a <b>complete solution</b> , but otherwise penalise omission of $g$ 's                                                                                                                                                                                                                                                                                                     |       |
| B1                   | Correct relationship between the tensions and placed correctly, seen or implied.                                                                                                                                                                                                                                                                                                                                                                    |       |
| M1                   | Vertical resolution. Condone forces at $C$ and $D$ the wrong way round or written as $T_C$ and $T_D$ .<br>This equation may be replaced with a moments equation.                                                                                                                                                                                                                                                                                    |       |

|                |                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>A1</b>      | Correct unsimplified equation ( <u>even if <math>T</math> and <math>4T</math> are the wrong way round on their diagram</u> )                                                                                                                                                                                                                                                                                                             |
| <b>M1</b>      | Moments equation. Correct forces multiplied by a length. Condone consistent forces at $C$ and $D$ the wrong way round or written as $T_C$ and $T_D$                                                                                                                                                                                                                                                                                      |
| <b>A1</b>      | Correct unsimplified equation, <b>in a variable consistent with their first equation.</b>                                                                                                                                                                                                                                                                                                                                                |
| <b>M1</b>      | Eliminate $T$ to give an equation in $p$ only allow extra $m$ 's or $g$ 's or both                                                                                                                                                                                                                                                                                                                                                       |
| <b>A1</b>      | Cao. Must be exact.                                                                                                                                                                                                                                                                                                                                                                                                                      |
|                | <b>N.B.</b> If they write down more than two equations, award the marks for those equations which they use to solve the problem.                                                                                                                                                                                                                                                                                                         |
| <b>(b)</b>     |                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>B1</b>      | Recognise tension at $D$ is 0, seen or implied                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>M1</b>      | Complete method to obtain an equation $q$ only.<br>e.g. Moments about $C$ equation.                                                                                                                                                                                                                                                                                                                                                      |
| <b>A1</b>      | Correct unsimplified equation in $q$ only.                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>A1</b>      | Cao. Must be exact.                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>ALT (b)</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>M1</b>      | Two other equations could be used and solved to find $q$ .<br>M0 if tension at $D$ is never zero.                                                                                                                                                                                                                                                                                                                                        |
| <b>A1</b>      | Correct unsimplified equation in $q$ only.                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>A1</b>      | Cao. Must be exact.                                                                                                                                                                                                                                                                                                                                                                                                                      |
|                |  <p>Alternative equations:</p> <p>vert: <math>T' = qmg + mg</math></p> <p>M(A): <math>(T' \times 0.6) = (mg \times 1)</math></p> <p>M(G): <math>(qmg \times 1) = (T' \times 0.4)</math></p> <p>M(D): <math>(qmg \times 1.8) + (mg \times 0.8) = (T' \times 1.2)</math></p> <p>M(B): <math>(qmg \times 2) + (mg \times 1) = (T' \times 1.4)</math></p> |
| <b>(c)</b>     |                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>B1</b>      | Any appropriate comment                                                                                                                                                                                                                                                                                                                                                                                                                  |

| Question number | Scheme                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Marks                                      |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|
| 5(a)            | For car: $\left(\frac{T+T-30}{2}\right)V$                                                                                                                                                                                                                                                                                                                                                                                                                                                              | M1                                         |
|                 | $V(T-15)$ (metres) * Allow $(T-15)V$                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | A1*                                        |
|                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | (2)                                        |
| 5(b)            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | B1 shape<br><br>B1 Horiz labels (10,50,60) |
|                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | (2)                                        |
| 5(c)            | $\frac{\text{speed}}{40} = \frac{V}{30}$                                                                                                                                                                                                                                                                                                                                                                                                                                                               | M1                                         |
|                 | $(\text{speed}) = \frac{4V}{3} \text{ (m s}^{-1}\text{)*}$                                                                                                                                                                                                                                                                                                                                                                                                                                             | A1*                                        |
|                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | (2)                                        |
| 5(d)            | For motorbike<br><b>OR:</b> $\frac{1}{2}\left(\frac{4V}{3} \times 40\right) + \left(\frac{4V}{3} \times 10\right) + \frac{1}{2}\left(\frac{4V}{3} + V\right)(T-60)$<br><b>OR:</b><br>$\frac{1}{2}\left(\frac{4V}{3} \times 40\right) + \left(\frac{4V}{3} \times 10\right) + \frac{1}{2}\left(\frac{4V}{3} - V\right)(T-60) + V(T-60)$<br><br><b>OR:</b> $\frac{1}{2} \times \frac{4V}{3} \times (10+50) + \frac{1}{2}\left(\frac{4V}{3} + V\right)(T-60)$<br><br>(Simplified: $\frac{7VT}{6} - 30V$ ) | M1<br><br><br>A1 A1                        |
|                 | Equate their motorbike distance to $V(T-15)$<br>to give an equation in $T$ only                                                                                                                                                                                                                                                                                                                                                                                                                        | M1                                         |
|                 | $T = 90$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | A1                                         |
|                 | <b>ALT:</b> Find area of upper trapezium <b>and</b> parallelogram (differences in areas)                                                                                                                                                                                                                                                                                                                                                                                                               | M1                                         |
|                 | $\frac{1}{2}\left(\frac{V}{3}\right)(T-40+10)$                                                                                                                                                                                                                                                                                                                                                                                                                                                         | A1                                         |
|                 | <b>and</b> $10V$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | A1                                         |
|                 | Equate to give an equation in $T$ only ( $V$ cancels)                                                                                                                                                                                                                                                                                                                                                                                                                                                  | M1                                         |
|                 | $T = 90$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | A1                                         |
|                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | (5)                                        |
|                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | (11)                                       |

| Notes for Question 5 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>(a)</b>           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>M1</b>            | <p>Uses total area under graph to find an expression for the distance in terms of <math>V</math> and <math>T</math> only<br/> May use:</p> <p>Trapezium: <math>\left(\frac{T + T - 30}{2}\right)V</math></p> <p>triangle + rectangle : <math>\frac{1}{2}(30V) + V(T - 30)</math></p> <p>a triangle subtracted from a rectangle: <math>VT - \frac{1}{2}(30 \times V)</math></p> <p><b>OR</b> use of <i>suvat</i>: <math>\frac{1}{2}(30V) + V(T - 30)</math></p> |
| <b>A1*</b>           | Given answer correctly obtained (allow omission of 'metres'.                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>(b)</b>           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|                      | <b>N.B.</b> If graph is not done on either of the given graphs on the question paper, they score B0B0 .                                                                                                                                                                                                                                                                                                                                                        |
| <b>B1</b>            | Correct shape with acceleration lines parallel and meeting at $(T, V)$<br>B0 if continuous vertical line at $t = T$                                                                                                                                                                                                                                                                                                                                            |
| <b>B1</b>            | Correct horizontal labels. Accept appropriately labelled delineators.<br><b>N.B.</b> This mark is independent of the first B1.                                                                                                                                                                                                                                                                                                                                 |
| <b>(c)</b>           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>M1</b>            | Correct method using gradients or <i>suvat</i> to obtain an equation in $V$ only                                                                                                                                                                                                                                                                                                                                                                               |
| <b>A1*</b>           | Given answer correctly obtained                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>(d)</b>           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>M1</b>            | <p>For motorbike: find an expression for the <b>TOTAL</b> area under the graph (or use <i>suvat</i>) to find the total distance travelled in terms of <math>V</math> and <math>T</math> only.</p> <p><b>N.B.</b> <math>\frac{1}{2}\left(\frac{4V}{3} \times 40\right) + \left(\frac{4V}{3} \times 10\right) + \frac{1}{2}\left(\frac{4V}{3} - V\right)(T - 60)</math> is M0 as it omits a part of the area.</p>                                                |
| <b>A1</b>            | Correct unsimplified expression with at most one error/slip                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>A1</b>            | Correct unsimplified expression                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>M1</b>            | <p>Clear attempt to equate their distance to the given distance in part (a) to give an equation in <math>T</math> only i.e. the <math>V</math>'s <b>must</b> cancel but they do not need to be cancelled for this mark.</p> <p><b>N.B.</b> This is an independent mark.</p>                                                                                                                                                                                    |
| <b>A1</b>            | cao                                                                                                                                                                                                                                                                                                                                                                                                                                                            |

| Question Number             | Scheme                                                                                                                                                                                                                                                                                                                                      | Marks      |
|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| 6                           | Vertical<br>$R - P \sin \alpha = W$                                                                                                                                                                                                                                                                                                         | M1<br>A1   |
|                             | Horizontal<br>$F = P \cos \alpha$<br><b>OR</b> $F_{MAX} \geq P \cos \alpha$                                                                                                                                                                                                                                                                 | M1<br>A1   |
|                             | $F \leq \frac{1}{4}R$ <b>or</b> $F = \frac{1}{4}R$ seen or implied                                                                                                                                                                                                                                                                          | M1         |
|                             | Produce a dimensionally correct inequality or equation in $P$ and $W$ only, trig does not need to be substituted                                                                                                                                                                                                                            | M1         |
|                             | Reach the <b>given</b> answer, with exact working.<br>$P \leq \frac{5W}{8}^*$ <b>or</b> $\frac{5W}{8} \geq P$                                                                                                                                                                                                                               | A1*<br>cso |
|                             |                                                                                                                                                                                                                                                                                                                                             | (7)        |
| (7)                         |                                                                                                                                                                                                                                                                                                                                             |            |
| <b>Notes for Question 6</b> |                                                                                                                                                                                                                                                                                                                                             |            |
| <b>M1</b>                   | Equation for vertical equilibrium. Correct number of terms, forces resolved where appropriate, condone sign errors and sin/cos confusion. M0 for an inequality                                                                                                                                                                              |            |
| <b>A1</b>                   | Correct unsimplified equation.                                                                                                                                                                                                                                                                                                              |            |
| <b>M1</b>                   | Equation for horizontal equilibrium. Correct number of terms, forces resolved where appropriate, condone sign errors and sin/cos confusion.<br><b>N.B.</b> Allow $F \geq P \cos \alpha$                                                                                                                                                     |            |
| <b>A1</b>                   | Either $F = P \cos \alpha$<br>or $F_{MAX} \geq P \cos \alpha$ where $F_{MAX}$ may be implied by use of $\frac{1}{4}R$                                                                                                                                                                                                                       |            |
| <b>M1</b>                   | M0 for $F < \frac{1}{4}R$ or $F > \frac{1}{4}R$ or $F \geq \frac{1}{4}R$                                                                                                                                                                                                                                                                    |            |
| <b>M1</b>                   | Eliminate $F$ and $R$ to form an inequality or equation in $P$ and $W$ only but allow trig to be unsubstituted.<br>e.g. $\frac{1}{4}(W + P \sin \alpha) \geq P \cos \alpha$ or $\frac{1}{4}(W + P \sin \alpha) = P \cos \alpha$<br>M0 for use of $F < \frac{1}{4}R$ or $F > \frac{1}{4}R$ or $F \geq \frac{1}{4}R$ to form their inequality |            |
| <b>A1* cso</b>              | Reach the <b>given</b> answer with at least one line of working. Must come from exact working and correct use of the inequality                                                                                                                                                                                                             |            |

| Question Number             | Scheme                                                                                                                                                                                                                           | Marks       |
|-----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| 7(a)                        | Whole system:<br>$3000 - 1200g \sin \alpha - 600g \sin \alpha - 2R - R = 1800(0.75)$                                                                                                                                             | M1<br>A1 A1 |
|                             | From exact working<br>$R = 60 *$                                                                                                                                                                                                 | A1*<br>cso  |
|                             |                                                                                                                                                                                                                                  | (4)         |
| 7(b)                        | Trailer: $T - 600g \sin \alpha - 60 = 600(0.75)$<br><b>OR</b><br>Car: $3000 - 1200g \sin \alpha - 2(60) - T = 1200(0.75)$<br>( $T$ could be replaced by $(-T)$ in either equation, leading to $T = -1000$ , so tension is 1000 ) | M1 A1       |
|                             | $T = 1000(\text{N})$                                                                                                                                                                                                             | A1          |
|                             |                                                                                                                                                                                                                                  | (3)         |
| 7(c)                        | Equation of motion<br>$-60 - 600g \sin \alpha = 600a$ (or $-600a$ )<br>$\left[ a = -\frac{11}{12} = -0.9166... \right]$                                                                                                          | M1<br>A1    |
|                             | $0 = 12^2 + 2\left(-\frac{11}{12}\right)d$                                                                                                                                                                                       | M1          |
|                             | $d = 78.5, 79 (\text{m})$                                                                                                                                                                                                        | A1          |
|                             |                                                                                                                                                                                                                                  | (4)         |
| (11)                        |                                                                                                                                                                                                                                  |             |
| <b>Notes for question 7</b> |                                                                                                                                                                                                                                  |             |
| (a)                         | Equation of motion for the whole system ( <b>or</b> for car AND trailer with $T$ eliminated) to give an <u>equation in <math>R</math> only</u> .                                                                                 |             |
| M1                          | $\sin \alpha$ does not need to be substituted<br>Correct number of terms, forces resolved where appropriate, condone sign errors and sin/cos confusion.                                                                          |             |
| A1                          | Correct equation with at most one error.<br>$\sin \alpha$ does not need to be substituted                                                                                                                                        |             |
| A1                          | Correct equation.<br>$\sin \alpha$ does not need to be substituted                                                                                                                                                               |             |
| A1*                         | Reach the GIVEN answer with at least one intermediate line of working and must come from exact working.                                                                                                                          |             |
| (b)                         | Equation of motion for the trailer or for the car. Correct number of terms, forces resolved where appropriate, condone sign errors and sin/cos confusion.                                                                        |             |
| M1                          | $\sin \alpha$ does not need to be substituted but $R = 60$ does                                                                                                                                                                  |             |
| A1                          | Correct unsimplified equation.<br>$\sin \alpha$ does not need to be substituted                                                                                                                                                  |             |
| A1                          | Correct answer for $T$                                                                                                                                                                                                           |             |
| (c)                         | Form an equation of motion for the trailer to find the new acceleration. Correct number of terms, forces resolved where appropriate, condone sign errors and sin/cos confusion.                                                  |             |
| M1                          | $\sin \alpha$ does not need to be substituted but $R = 60$ does                                                                                                                                                                  |             |
| A1                          | Correct unsimplified equation.<br>$\sin \alpha$ does not need to be substituted                                                                                                                                                  |             |
| M1                          | Complete method, with a calculated acceleration that is not $g$ , to find the distance travelled.                                                                                                                                |             |
| A1                          | Cao 2 or 3sf Must be positive.<br><b>N.B.</b> Allow a negative value of $d$ and made positive for the distance.                                                                                                                  |             |

| Question Number             | Scheme                                                                                                                              | Marks  |
|-----------------------------|-------------------------------------------------------------------------------------------------------------------------------------|--------|
|                             | <b>Allow working in column vectors and penalise answers to (a) and (b) in column vector form ONCE at the first time it occurs.</b>  |        |
| 8(a)                        | $\mathbf{v} = \frac{(9\mathbf{i} + 23\mathbf{j}) - (-2\mathbf{i} + \mathbf{j})}{11}$                                                | M1     |
|                             | Expression for $\mathbf{r}$ with correct structure                                                                                  | M1     |
|                             | $\mathbf{r} = (-2\mathbf{i} + \mathbf{j}) + t(\mathbf{i} + 2\mathbf{j})$ or $\mathbf{r} = (t - 2)\mathbf{i} + (2t + 1)\mathbf{j}$   | A1 cao |
|                             |                                                                                                                                     | (3)    |
| 8(b)                        | Or $\mathbf{s} = (25\mathbf{i} + 25\mathbf{j}) + t(-\mathbf{i} - \mathbf{j})$                                                       | B1     |
|                             | $\mathbf{s} = (25 - t)\mathbf{i} + (25 - t)\mathbf{j}$                                                                              |        |
|                             |                                                                                                                                     | (1)    |
| 8(c)                        | Either $\mathbf{r} - \mathbf{s}$<br>Or $\mathbf{s} - \mathbf{r}$<br>with their $\mathbf{r}$ and $\mathbf{s}$ substituted            | M1     |
|                             | $\overrightarrow{SR} = [(2t - 27)\mathbf{i} + (3t - 24)\mathbf{j}] \text{ m}^*$                                                     | A1*    |
|                             |                                                                                                                                     | (2)    |
| 8(d)                        | Distance $(d) = \sqrt{(2t - 27)^2 + (3t - 24)^2}$<br>$(d^2) = (2t - 27)^2 + (3t - 24)^2$                                            | M1     |
|                             | $(d^2) = 13t^2 - 252t + 1305$                                                                                                       | A1     |
|                             | $t = \frac{126}{13} = 9.7 \text{ (s) or better}$                                                                                    | A1     |
|                             |                                                                                                                                     | (3)    |
| (9)                         |                                                                                                                                     |        |
| <b>Notes for Question 8</b> |                                                                                                                                     |        |
| (a)                         |                                                                                                                                     |        |
| M1                          | Use of displacement/time to find velocity. Allow the difference either way round.                                                   |        |
| M1                          | Expression for $\mathbf{r}$ with correct structure using <i>their</i> $\mathbf{v}$ and the correct initial position vector.         |        |
| A1                          | Correct expression in terms of $t$ , $\mathbf{i}$ and $\mathbf{j}$                                                                  |        |
| (b)                         |                                                                                                                                     |        |
| B1                          | Any correct expression for $\mathbf{s}$ in terms of $t$ , $\mathbf{i}$ and $\mathbf{j}$                                             |        |
| (c)                         |                                                                                                                                     |        |
| M1                          | (Their $\mathbf{r} - \text{their } \mathbf{s}$ ) or vice versa, unsimplified                                                        |        |
| A1*                         | Correct answer correctly obtained. Allow missing square brackets and m, but rest must be identical to given answer.                 |        |
| (d)                         |                                                                                                                                     |        |
| M1                          | Use of Pythagoras to find an expression for distance (or distance squared)                                                          |        |
| A1                          | Correct 3 term quadratic expression<br>N.B. If no 3 term quadratic expression is seen but a correct derivative is, award this mark. |        |
| A1                          | 9.7 or better.<br>N.B. If a fraction is given as the answer, it must be the ratio of two positive integers or a mixed fraction.     |        |