



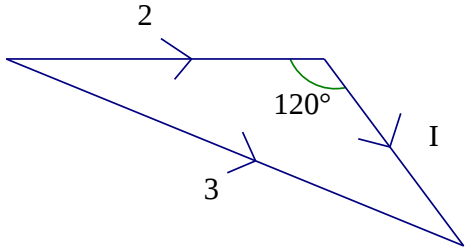
# Mark Scheme (Results)

October 2023

Pearson Edexcel International Advanced Level  
in Mechanics (WME02) Paper 01

| Question | Scheme                                                                                         | Mark | Notes                                                                                                                                                                                    |
|----------|------------------------------------------------------------------------------------------------|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1        | Accept column vectors throughout this question                                                 |      |                                                                                                                                                                                          |
| 1a       | Differentiate $\mathbf{r}$ (both components)                                                   | M1   | In each component at least one power going down by 1                                                                                                                                     |
|          | $\mathbf{v} = (4t^3 - 16t)\mathbf{i} + (12t - 3\sqrt{t})\mathbf{j}$                            | A1   | Accept as two separate components                                                                                                                                                        |
|          | Equate $\mathbf{i}$ component of $\mathbf{v}$ to zero and solve for $t$                        | DM1  | Dependent on the first M1.<br>Must start with a component of the vector for $\mathbf{v}$<br>Can have more than one value at this stage.                                                  |
|          | Obtain $(24 - 3\sqrt{2})\mathbf{j} \text{ (ms}^{-1}\text{)}$                                   | A1   | Accept $20\mathbf{j} \text{ (ms}^{-1}\text{)}$ or better.<br>(19.757359...)<br>Correct answer only<br>Answer must be a vector                                                            |
|          |                                                                                                | [4]  |                                                                                                                                                                                          |
| 1b       | Differentiate $\mathbf{v}$ (both components)                                                   | M1   | For differentiating their $\mathbf{v}$ , even if the method for obtaining it was incorrect. Their $\mathbf{v}$ must be a vector.<br>In each component at least one power going down by 1 |
|          | Obtain<br>$\mathbf{a} = (12t^2 - 16)\mathbf{i} + (12 - \frac{3}{2}t^{-\frac{1}{2}})\mathbf{j}$ | A1   | Any equivalent form for acceleration                                                                                                                                                     |
|          | Obtain $176\mathbf{i} + \frac{45}{4}\mathbf{j} \text{ (ms}^{-2}\text{)}$                       | A1   | Accept $180\mathbf{i} + 11\mathbf{j} \text{ (ms}^{-2}\text{)}$ or better<br>ISW                                                                                                          |
|          |                                                                                                | [3]  |                                                                                                                                                                                          |
|          |                                                                                                | (7)  |                                                                                                                                                                                          |

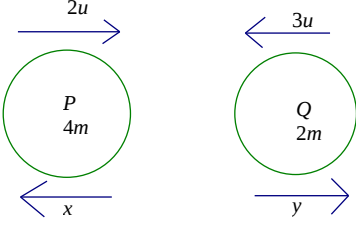
| Question | Scheme                                                                                                                         |             |                 |                 | Mark       | Notes                                                                                                                                                                                                                                                          |
|----------|--------------------------------------------------------------------------------------------------------------------------------|-------------|-----------------|-----------------|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2a       |                                                                                                                                | <i>PQUY</i> | <i>RSTU</i>     | <i>VWXY</i>     | B1<br>B1   | Correct mass ratios (accept 2:1:1)<br>Correct vertical distances                                                                                                                                                                                               |
|          | Mass                                                                                                                           | $16a^2$     | $2 \times 4a^2$ | $2 \times 4a^2$ |            |                                                                                                                                                                                                                                                                |
|          | From <i>PX</i>                                                                                                                 | $2a$        | $5a$            | $a$             |            |                                                                                                                                                                                                                                                                |
|          | Moments about <i>PX</i> or a parallel axis                                                                                     |             |                 |                 | M1         | Dimensionally correct equation.<br>All terms required<br>Allow for an equation within a vector equation.                                                                                                                                                       |
|          | $16a^2 \times 2a + 8a^2 \times 5a + 8a^2 \times a = 32a^2d$<br>$(= (16+8+8)a^2 \times d)$<br>or equivalent for a parallel axis |             |                 |                 | A1         | Correct unsimplified equation<br>Allow for an equation within a vector equation.<br>Could have <i>y</i> for <i>d</i> here o.e.                                                                                                                                 |
|          | $80a = 32d \Rightarrow d = \frac{5}{2}a$ *                                                                                     |             |                 |                 | A1*        | Obtain given answer from correct working. At least one stage of simplifying the moments equation is required.<br>e.g. $32a^3 + 40a^3 + 8a^3$ seen,<br>or they might have simplified the mass ratios at the start.<br>Must get to $d = \dots$ in the final line |
|          |                                                                                                                                |             |                 |                 | [5]        |                                                                                                                                                                                                                                                                |
| 2b       | Moments about <i>PQ</i> or a parallel axis                                                                                     |             |                 |                 | M1         | Dimensionally correct equation.<br>All terms required                                                                                                                                                                                                          |
|          | $16a^2 \times 2a + 8a^2 \times 3a + 8a^2 \times 5a$<br>$= (16+8+8)a^2 \times h$<br>or equivalent for a parallel axis           |             |                 |                 | A1ft<br>A1 | Unsimplified equation with at most one error. Follow their mass ratios.<br>Correct unsimplified equation                                                                                                                                                       |
|          | $\Rightarrow h = 3a$ from <i>PQ</i>                                                                                            |             |                 |                 | A1         | <i>a</i> from <i>YT</i> , $3a$ from <i>XW</i>                                                                                                                                                                                                                  |
|          | <b>The working for the first 4 marks must be seen or used in part (b)</b>                                                      |             |                 |                 |            |                                                                                                                                                                                                                                                                |
|          | Correct use of trig. to find the tangent of a relevant angle.                                                                  |             |                 |                 | M1         | With <i>their</i> $3a$ e.g.<br>$\tan \theta = \frac{3}{4 - \frac{5}{2}}$                                                                                                                                                                                       |
|          | $\tan \theta = 2$                                                                                                              |             |                 |                 | A1         | Correct only                                                                                                                                                                                                                                                   |
|          |                                                                                                                                |             |                 |                 | [6]        |                                                                                                                                                                                                                                                                |
| 2c       | Complete method to obtain an equation in <i>M</i> and <i>F</i>                                                                 |             |                 |                 | M1         | e.g. Moments about <i>Q</i><br>Dimensionally correct equation.                                                                                                                                                                                                 |
|          | $3a \times Mg = 4a \times F$                                                                                                   |             |                 |                 | A1         | Correct unsimplified equation<br>Condone if <i>a</i> missing throughout                                                                                                                                                                                        |
|          | $F = \frac{3}{4}Mg$                                                                                                            |             |                 |                 | A1         | Correct only                                                                                                                                                                                                                                                   |
|          |                                                                                                                                |             |                 |                 | [3]        |                                                                                                                                                                                                                                                                |
|          |                                                                                                                                |             |                 |                 | (14)       |                                                                                                                                                                                                                                                                |

| Question | Scheme                                                                              | Mark | Notes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|----------|-------------------------------------------------------------------------------------|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3        | Form impulse-momentum equation                                                      | M1   | Dimensionally correct.<br>Accept answers in “vector” form, or as separate components. Condone sine / cosine confusion.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|          | One correct equation                                                                | A1   | e.g. one correct component of<br>$\begin{pmatrix} I \cos 60^\circ \\ I \sin 60^\circ \end{pmatrix} = \frac{1}{4} \left[ \begin{pmatrix} 12 \cos \alpha \\ 12 \sin \alpha \end{pmatrix} - \begin{pmatrix} 8 \\ 0 \end{pmatrix} \right]$ or<br>$\begin{pmatrix} \\ \\ \end{pmatrix} = \begin{pmatrix} 3 \cos \alpha - 2 \\ 3 \sin \alpha \end{pmatrix}$ $\begin{pmatrix} I \cos 60^\circ \\ I \sin 60^\circ \end{pmatrix} = \frac{1}{4} \left[ \begin{pmatrix} v_x \\ v_y \end{pmatrix} - \begin{pmatrix} 8 \\ 0 \end{pmatrix} \right]$ $\begin{pmatrix} \\ \\ \end{pmatrix} = \begin{pmatrix} 3 \cos \alpha - 2 \\ 3 \sin \alpha \end{pmatrix}$ if working parallel and perpendicular to the initial direction<br>or one of $8 \sin 60^\circ = 12 \cos(30^\circ + \alpha)$<br>or $I = 0.25(12 \sin(30^\circ + \alpha) - 8 \cos 60^\circ)$<br>if working parallel and perpendicular to the impulse |
|          | Form a second impulse-momentum equation                                             | M1   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|          | correct second equation                                                             | A1   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|          | Complete method to solve for $I$                                                    | DM1  | Dependent on the two preceding M marks. e.g. from<br>$36 = (I + 4)^2 + 3I^2 \quad (4I^2 + 8I - 20 = 0)$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|          | $I = \sqrt{6} - 1$ (or 1.45 or 1.4)                                                 | A1   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|          |                                                                                     | [6]  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 3 alt    |  | M1   | Use of $I = mv - mu$ to draw a vector triangle. Dimensionally consistent.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|          |                                                                                     | A1   | Correct diagram                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|          | Form an equation in $I$                                                             | M1   | e.g. by using cosine rule                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|          | $4 + I^2 - 4I \cos 120^\circ = 9$                                                   | A1   | Correct unsimplified equation<br>A correct cosine rule equation can imply the first M1A1 if no diagram seen                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|          | Solve for $I$                                                                       | DM1  | Dependent on the 2 preceding M marks<br>$I^2 + 2I - 5 = 0$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|          | $I = \sqrt{6} - 1$ (or 1.45 or 1.4)                                                 | A1   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|          |                                                                                     | (6)  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |

| Question | Scheme                                                                                   | Mark | Notes                                                                                                                                                                                                                                                                                                                          |
|----------|------------------------------------------------------------------------------------------|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 4a       | $4 - gT_1 = 0$ or $T_1 = \frac{\sqrt{32} \sin 45^\circ}{g}$                              | M1   | Complete method using <i>suvat</i>                                                                                                                                                                                                                                                                                             |
|          | $T_1 = 0.408$ (0.41)                                                                     | A1   | 3 sf or 2 sf only. Not $\frac{20}{49}$                                                                                                                                                                                                                                                                                         |
|          |                                                                                          | [2]  |                                                                                                                                                                                                                                                                                                                                |
| 4b       | Height of Q above P:                                                                     | M1   | Complete method using <i>suvat</i> and 7 and 4 for the initial vertical components                                                                                                                                                                                                                                             |
|          | $h = (7T_1 - \frac{1}{2}gT_1^2) - (4T_1 - \frac{1}{2}gT_1^2) (= 3T_1)$                   | A1   | Correct unsimplified expression in $T_1$ or their $T_1$ . They do not need to have substituted for $T_1$ (2.0408... - 0.8163...)                                                                                                                                                                                               |
|          | $h = 1.2$ (m)                                                                            | A1ft | 2 sf only ( $3 \times$ their $T_1$ )                                                                                                                                                                                                                                                                                           |
|          |                                                                                          | [3]  |                                                                                                                                                                                                                                                                                                                                |
| 4c       | Correct time for P to reach B.<br>( $\frac{40}{49}$ , 0.816, or $\frac{8}{g}$ or better) | B1   | Seen or implied.                                                                                                                                                                                                                                                                                                               |
|          | Vertical component of speed<br>$= 7 - g \times 2T_1 (= -1)$                              | M1   | Complete method using <i>suvat</i> with $2T_1$ or their $t$ for the time at B<br>M0 if not using 7                                                                                                                                                                                                                             |
|          | $\tan \alpha = \pm \frac{\text{their } 1}{5}$                                            | M1   | Correct use of <i>their</i> 1 and 5 to find an equation in a relevant angle (e.g. $90 - \alpha$ )                                                                                                                                                                                                                              |
|          | $\alpha = 11$                                                                            | A1   | 11 or better (e.g. 11.3)                                                                                                                                                                                                                                                                                                       |
|          | <b>If they use <math>T_1</math> in place of <math>2T_1</math> can score B0M0M1A0</b>     |      |                                                                                                                                                                                                                                                                                                                                |
|          |                                                                                          | [4]  |                                                                                                                                                                                                                                                                                                                                |
| 4d       | Form an equation in $T_2$ only                                                           | M1   | Complete method using <i>suvat</i> and perpendicular gradients.<br>e.g. $\begin{pmatrix} 5 \\ 7 \end{pmatrix} \cdot \begin{pmatrix} 5 \\ 7 - gT_2 \end{pmatrix} = 0$<br>Condone sign errors<br>(Vertical component of speed $= \pm \frac{25}{7}$ )<br>(perpendicular direction is downwards at $35.5^\circ$ to the horizontal) |
|          | $-\frac{25}{7} = 7 - gT_2$                                                               | A1   | Correct unsimplified equation                                                                                                                                                                                                                                                                                                  |
|          | $T_2 = 1.08$ or $T_2 = 1.1$                                                              | A1   | 3 sf or 2 sf only                                                                                                                                                                                                                                                                                                              |
|          |                                                                                          | [3]  |                                                                                                                                                                                                                                                                                                                                |
|          |                                                                                          | (12) |                                                                                                                                                                                                                                                                                                                                |

| Question | Scheme                                                                                                                                                                                                        | Mark     | Notes                                                                                                                                                  |
|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5a       | Use of $P = Fv$ $\left(F = \frac{500}{6}\right)$                                                                                                                                                              | M1       |                                                                                                                                                        |
|          | Equation of motion                                                                                                                                                                                            | M1       | Dimensionally correct.<br>Required terms and no extras                                                                                                 |
|          | $F - 60 = 80a$                                                                                                                                                                                                | A1       | Correct unsimplified equation in $F$                                                                                                                   |
|          | $a = \frac{7}{24} (\text{ms}^{-2})$                                                                                                                                                                           | A1       | 0.29 or better (0.291666666..)                                                                                                                         |
|          |                                                                                                                                                                                                               | [4]      |                                                                                                                                                        |
| 5b       | Gain in KE = $\frac{1}{2} \times 80 \times 8^2 (\text{J}) (= 2560(\text{J}))$<br>Gain in GPE = $80 \times 9.8 \times 300 (\text{J}) (= 235200(\text{J}))$<br>Work done against resistance = $20000 \times 60$ | B1<br>B1 | Any one correct (seen or implied)<br>A second term correct (seen or implied)<br><br>(KE gain + GPE gain = 237760 J)                                    |
|          | <b>Use of suvat and <math>F = ma</math> is M0A0A0</b>                                                                                                                                                         |          |                                                                                                                                                        |
|          | expression for combined work and energy                                                                                                                                                                       | M1       | All terms required and no double counting. Mass replaced with 80.<br>Condone sign errors.<br>Dimensionally correct.<br>Condone error in zeros in 20000 |
|          | Total work done<br>$= 40 \times 64 + 80 \times 9.8 \times 300 + 20000 \times 60$                                                                                                                              | A1       | Correct unsimplified expression for the work done                                                                                                      |
|          | 1440(kJ) or 1400(kJ)                                                                                                                                                                                          | A1       | Accept answers in joules.<br>3 sf or 2 sf (1437760)                                                                                                    |
|          |                                                                                                                                                                                                               | [5]      |                                                                                                                                                        |
| 5c       | Equation of motion                                                                                                                                                                                            | M1       | Dimensionally correct.<br>Required terms and no extras                                                                                                 |
|          | $F - 60 - 80g \times \sin \alpha = 0$<br>$\frac{P}{7} - 60 - 80g \times \frac{1}{20} = 0$                                                                                                                     | A1<br>A1 | Unsimplified equation in $P$ or $F$ with at most one error<br>Correct unsimplified equation in $P$                                                     |
|          | $P = 694$ or $P = 690$                                                                                                                                                                                        | A1       | 3sf or 2 sf only                                                                                                                                       |
|          |                                                                                                                                                                                                               | [4]      |                                                                                                                                                        |
|          |                                                                                                                                                                                                               | (13)     |                                                                                                                                                        |

| Question | Scheme                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Mark | Notes                                                                                                                                      |
|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|--------------------------------------------------------------------------------------------------------------------------------------------|
| 6a       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |      |                                                                                                                                            |
|          | Moments about A:<br><b>M0 if there is no resolving</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | M1   | Need all terms and no extras. Dimensionally consistent. Condone sign errors and sine/cosine confusion.                                     |
|          | $4a \cos 30^\circ \times W + 8a \cos 30^\circ \times \frac{W}{4} = 5a \cos 30^\circ \times T$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | A1   | Correct unsimplified equation                                                                                                              |
|          | $6W = 5T \Rightarrow T = \frac{6}{5}W \quad *$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | A1*  | Obtain <b>given answer</b> from correct working, e.g. show cancelling of the common factors or some simplification of the moments equation |
|          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | [3]  |                                                                                                                                            |
| 6b       | They need 2 equations. Award M1A1 for the first correct equation seen and M1A1 for the second correct equation. Common alternatives:<br>$M(B): T \cos 30^\circ \times 3a + V \cos 30^\circ \times 8a = W \cos 30^\circ \times 4a + H \cos 60^\circ \times 8a$<br>$M(C): W \cos 30^\circ \times a + H \cos 60^\circ \times 5a = \frac{1}{4}W \cos 30^\circ \times 3a + V \cos 30^\circ \times 5a$<br>Perpendicular to rod: $\frac{1}{4}W \cos 30^\circ + W \cos 30^\circ + H \cos 60^\circ = T \cos 30^\circ + V \cos 30^\circ$<br>Parallel to rod: $\frac{1}{4}W \cos 60^\circ + T \cos 60^\circ + W \cos 60^\circ = V \cos 60^\circ + H \cos 30^\circ$ |      |                                                                                                                                            |
|          | First equation dimensionally correct. Condone sine/cosine confusion and sign errors                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | M1   | e.g. Resolve horizontally                                                                                                                  |
|          | Correct unsimplified equation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | A1   | $H = T \cos 30^\circ \quad \left( H = \frac{3\sqrt{3}}{5}W \right)$                                                                        |
|          | Second equation dimensionally correct. Condone sine/cosine confusion and sign errors                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | M1   | e.g. resolve vertically                                                                                                                    |
|          | Correct unsimplified equation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | A1   | $V + T \cos 60^\circ = W + \frac{W}{4} \quad \left( V = \frac{13}{20}W \right)$                                                            |
|          | $ R  = \sqrt{V^2 + H^2}$ or $ R ^2 = V^2 + H^2$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | DM1  | Correct use of Pythagoras<br>Dependent on two preceding M marks.                                                                           |
|          | $ R  = \frac{W}{20} \sqrt{3 \times 144 + 169} = \frac{\sqrt{601}}{20}W$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | A1   | 1.2W or better (1.22576...)                                                                                                                |
|          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | [6]  |                                                                                                                                            |
|          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | (9)  |                                                                                                                                            |

| Question | Scheme                                                                                         | Mark | Notes                                                                                                                                  |
|----------|------------------------------------------------------------------------------------------------|------|----------------------------------------------------------------------------------------------------------------------------------------|
| 7a       |               |      |                                                                                                                                        |
|          | Equation for CLM                                                                               | M1   | Dimensionally correct.<br>All terms required.<br>Condone sign errors.                                                                  |
|          | $8mu - 6mu = 2my - 4mx$<br>$(u = y - 2x)$                                                      | A1   | Correct unsimplified equation                                                                                                          |
|          | Equation for kinetic energy<br>( $\frac{1}{2}$ or 2 must be used)                              | M1   | Dimensionally correct. Correct masses paired with correct velocities. All terms required. No sign errors. Condone 2 on the wrong side. |
|          | $2mx^2 + my^2 = \frac{1}{2}(2m \times 4u^2 + m \times 9u^2)$<br>$(17u^2 = 4x^2 + 2y^2)$        | A1   | Correct unsimplified equation                                                                                                          |
|          | Solve for y:<br>$17u^2 = 2y^2 + (y - u)^2$<br>$\Rightarrow 3y^2 - 2yu - 16u^2 = 0$             | DM1  | Some working must be shown to obtain the quadratic in y (and u).<br>Dependent on the preceding M marks<br>( $(3y - 8u)(y + 2u) = 0$ )  |
|          | $\Rightarrow y = \frac{8}{3}u$ *                                                               | A1*  | Obtain given answer from correct working                                                                                               |
|          |                                                                                                | [6]  |                                                                                                                                        |
| 7b       | Use of Impact Law: $x + y = e \times 5u$                                                       | M1   | Condone sign errors but must be used the right way round.                                                                              |
|          | $e = \frac{\frac{1}{2}\left(\frac{8}{3}u - u\right) + \frac{8}{3}u}{5u}$                       | A1   | Correct unsimplified equation. $\left(x = \frac{5u}{6}\right)$                                                                         |
|          | $= \frac{7}{10}$                                                                               | A1   | Correct only                                                                                                                           |
|          |                                                                                                | [3]  |                                                                                                                                        |
| 7c       | Velocity of Q after impact $= f \times \frac{8}{3}u$                                           | B1   | Allow $\pm$                                                                                                                            |
|          | No collision if $f \times \frac{8}{3}u \leq \frac{5}{6}u$<br>i.e. speed of P $\geq$ speed of Q | M1   | Correct inequality with their values<br>Accept strict inequality. Dimensionally correct.                                               |
|          | $\Rightarrow 0 < f \leq \frac{5}{16}$                                                          | A1   | Both ends required. $(0 < f \leq 0.3125)$                                                                                              |
|          |                                                                                                | [3]  |                                                                                                                                        |
| 7d       | Use of $I = \pm 2m\left(y - \left(-\frac{1}{4}y\right)\right)$                                 | M1   | Subtraction seen or implied with <i>their</i> $\frac{1}{4}y$<br>Requires correct mass<br>Requires correct impact law                   |
|          | $ I  = \frac{20}{3}mu$                                                                         | A1   | Or equivalent. Must be positive<br>6.7mu or better<br>Condone $-\frac{20}{3}mu \rightarrow \frac{20}{3}mu$ with no explanation         |
|          |                                                                                                | [2]  |                                                                                                                                        |
|          |                                                                                                | (14) |                                                                                                                                        |