

# INTERNATIONAL AS MATHEMATICS MA02

(9660/MA02) Unit PSM1 Pure Mathematics, Statistics and Mechanics

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Mark scheme

June 2024

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Version: 1.0 Final



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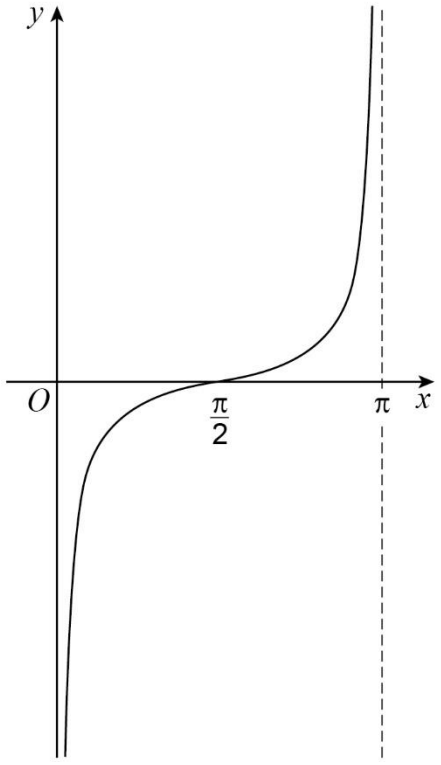
### Key to mark scheme abbreviations

|                |                                                                    |
|----------------|--------------------------------------------------------------------|
| <b>M</b>       | Mark is for method                                                 |
| <b>m</b>       | Mark is dependent on one or more M marks and is for method         |
| <b>A</b>       | Mark is dependent on M or m marks and is for accuracy              |
| <b>B</b>       | Mark is independent of M or m marks and is for method and accuracy |
| <b>E</b>       | Mark is for explanation                                            |
| <b>✓ or ft</b> | Follow through from previous incorrect result                      |
| <b>CAO</b>     | Correct answer only                                                |
| <b>CSO</b>     | Correct solution only                                              |
| <b>AWFW</b>    | Anything which falls within                                        |
| <b>AWRT</b>    | Anything which rounds to                                           |
| <b>ACF</b>     | Any correct form                                                   |
| <b>AG</b>      | Answer given                                                       |
| <b>SC</b>      | Special case                                                       |
| <b>oe</b>      | Or equivalent                                                      |
| <b>A2, 1</b>   | 2 or 1 (or 0) accuracy marks                                       |
| <b>–x EE</b>   | Deduct x marks for each error                                      |
| <b>NMS</b>     | No method shown                                                    |
| <b>PI</b>      | Possibly implied                                                   |
| <b>SCA</b>     | Substantially correct approach                                     |
| <b>sf</b>      | Significant figure(s)                                              |
| <b>dp</b>      | Decimal place(s)                                                   |
| <b>ISW</b>     | Ignore subsequent working                                          |

| Q    | Answer                                                                                                                                            | Marks | Comments                                                                                                                                                                    |
|------|---------------------------------------------------------------------------------------------------------------------------------------------------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1(a) | $5x = \frac{\log_a 7}{\log_a 4}$<br>or $5x = \log_4 7$ [=1.40367...]<br>or $10x = \log_2 7$ [=2.80735...]<br>or $x = \log_{1024} 7$ [=0.28073...] | M1    | Correctly expresses $x$ , $5x$ or $10x$ in terms of logarithms.<br>PI by correct final answer or correct value of $x$ , $5x$ or $10x$ rounded or truncated to at least 3dp. |
|      | $\left[ x = \frac{1}{5} \log_4 7 = \right] 0.281$                                                                                                 | A1    | CAO                                                                                                                                                                         |
|      |                                                                                                                                                   | 2     |                                                                                                                                                                             |

| Q    | Answer                                                                                                                                                                                 | Marks | Comments                                                                                                                                 |
|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|------------------------------------------------------------------------------------------------------------------------------------------|
| 1(b) | $\left[ \log_6 180 = \right]$<br>$\log_6 36 + \log_6 5$<br>or $\log_6 6^2 + \log_6 5$<br>or $\log_6 6 + \log_6 6 + \log_6 5$<br>or $\log_6 2 + \log_6 90$<br>or $\log_6 6 + \log_6 30$ | M1    | oe Use of addition property of logarithms to form a correct numerical expression.<br>Condone omission of base of logarithm               |
|      | $\left[ \log_6 180 = \right] 2 + \log_6 5$                                                                                                                                             | A1    | Correct answer in the correct form, including base of logarithm.<br>M1 not scored or working seen in relation to $a$ and $b$ scores M0A0 |
|      |                                                                                                                                                                                        | 2     |                                                                                                                                          |

|  |                  |   |  |
|--|------------------|---|--|
|  | Question 1 Total | 4 |  |
|--|------------------|---|--|

| Q    | Answer                                                                             | Marks                                                                                                                                                                                                                                                                                                                                                                                                                                 | Comments |
|------|------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 2(a) |  | <p><b>B1</b></p> <p>Curve in the correct form and only in the first and fourth quadrants. Must appear to be asymptotic to the <math>y</math>-axis and the line <math>x = \pi</math>. Line <math>x = \pi</math> need not be seen.</p> <p><b>B1</b></p> <p>Correct value of the <math>x</math>-intercept marked at point where their curve intersects the <math>x</math>-axis. Condone coordinates given or value given in degrees.</p> |          |
|      |                                                                                    | <b>2</b>                                                                                                                                                                                                                                                                                                                                                                                                                              |          |

| Q    | Answer          | Marks     | Comments                  |
|------|-----------------|-----------|---------------------------|
| 2(b) | $\pi$ [radians] | <b>B1</b> | Condone given in degrees. |
|      |                 | <b>1</b>  |                           |

|  |                         |          |  |
|--|-------------------------|----------|--|
|  | <b>Question 2 Total</b> | <b>3</b> |  |
|--|-------------------------|----------|--|

| Q    | Answer                                                                                                                                                         | Marks                                                      | Comments                                                                                                                                                                                                                                                                                                                                                                                                                               |
|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3(a) | $\frac{\sin \theta}{15} = \frac{\sin \frac{\pi}{5}}{9}$<br>$[\theta = \sin^{-1}(0.97964\dots) =] \quad 1.369$<br>$[\theta = \pi - 1.36867\dots =] \quad 1.773$ | <p><b>M1</b></p><br><p><b>A1</b></p><br><p><b>A1ft</b></p> | <p><b>oe</b> Correct use of Sine Rule.<br/>Allow <math>36^\circ</math> for <math>\frac{\pi}{5}</math> radians.</p> <p><b>AWRT</b> 1.369<br/>Condone answer given in degrees.<br/><b>AWRT</b> <math>78.4^\circ</math></p> <p><b>ft</b> their acute angle.<br/><b>AWRT</b> 1.773<br/>Condone answer given in degrees.<br/><b>AWRT</b> <math>101.6^\circ</math></p> <p>If <b>M1 A0 A0</b> awarded, allow <b>SC1</b> for 1.37 and 1.77</p> |
|      |                                                                                                                                                                | <b>3</b>                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                        |

| Q    | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Marks                                                                                    | Comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3(b) | <p>[Area of Sector <math>OPQ</math>]</p> $\frac{1}{2} \times 15^2 \times \frac{\pi}{5}$ <p>[Area of Sector <math>OPQ</math> =]</p> $70.68583... \text{ [cm}^2\text{]} \text{ or } \frac{45\pi}{2} \text{ [cm}^2\text{]}$ <p>[Area of Triangle <math>OQR</math>]</p> $\frac{1}{2} \times 9 \times 15 \times \sin\left(\pi - \frac{\pi}{5} - 1.773\right)$ <p>or</p> $\frac{1}{2} \times 9 \times 15 \times \sin 0.74035...$ <p>[Area of Triangle <math>OQR</math> =]</p> $45.53199... \text{ [cm}^2\text{]}$ <p>[A =] <math>70.68583... - 45.53199...</math></p> <p>[A =] 25.2</p> | <p><b>M1</b></p> <p><b>A1</b></p> <p><b>M1</b></p> <p><b>A1ft</b></p> <p><b>A1ft</b></p> | <p>Use of <math>\text{Area} = \frac{1}{2}r^2\theta</math><br/>Condone use of degrees.</p> <p><b>AWRT 70.7</b><br/><b>PI</b> by correct final answer.</p> <p>Use of <math>\text{Area} = \frac{1}{2}ab \sin C</math><br/><b>ft</b> their obtuse or acute angle from <b>part (a)</b><br/>Condone use of degrees.</p> <p><b>AWRT 45.5</b><br/><b>ft</b> their obtuse angle from <b>part (a)</b><br/><b>PI</b> by correct final answer.</p> <p><b>AWRT 25.2</b><br/><b>ft</b> their area of sector <math>OPQ</math> – their area of triangle <math>OQR</math> provided at least both M1 marks awarded <u>and</u> obtuse angle used</p> <p>Ignore units if included.</p> |
|      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>5</b>                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|      | <b>Question 3 total</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>8</b>                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

| Q    | Answer                                                                                                                                     | Marks                                                                          | Comments                                                                                                                                                                                                                                                                                                                                                                                                 |
|------|--------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 4(a) | $\frac{17-8}{9-12} [= -3]$<br>$[\text{Gradient of } l =] \frac{1}{3}$<br>$y-8 = \frac{1}{3}(x-12)$<br>or $y = \frac{1}{3}x + 4$<br>$(0,4)$ | <p><b>M1</b></p><br><p><b>A1ft</b></p><br><p><b>M1</b></p><br><p><b>A1</b></p> | <p>Method for finding the gradient of <i>AP</i><br/><b>PI</b> by correct gradient of <i>AP</i></p><br><p><b>ft</b> their gradient of <i>AP</i><br/>May see in later working.</p><br><p><b>oe</b> Correct equation of <i>l</i><br/><b>ft</b> their gradient of <i>l</i><br/><b>PI</b> by correct final answer.</p><br><p>Correct coordinates of <i>B</i><br/>Condone value of y-intercept given only.</p> |
|      |                                                                                                                                            | <b>4</b>                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                          |



| Q    | Answer                                                                                                                                                                                                                                                                                                                                                                                                                       | Marks                                                               | Comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 4(b) | $\sqrt{9^2 + (17 - 4)^2}$ <p>[Length of AB =] <math>5\sqrt{10}</math></p> $x^2 + (y - 4)^2 [= k]$ <p>or</p> $\left[ k = (5\sqrt{10} - 3\sqrt{10})^2 = 40 \Rightarrow \right]$ $x^2 + (y - n)^2 = 40$ <p>or</p> $\left[ k = (5\sqrt{10} + 3\sqrt{10})^2 = 640 \Rightarrow \right]$ $x^2 + (y - n)^2 = 640$ <p>[C<sub>2</sub>] <math>x^2 + (y - 4)^2 = 40</math></p> <p>[C<sub>3</sub>] <math>x^2 + (y - 4)^2 = 640</math></p> | <p><b>M1</b></p> <p><b>A1</b></p> <p><b>M1</b></p> <p><b>A2</b></p> | <p><b>oe PI</b><br/>ft their coordinates of <i>B</i><br/>Method for finding the length of <i>AB</i> using their <i>y</i>-coordinate of <i>B</i></p> <p>Accept <math>\sqrt{250}</math><br/><b>PI</b> by <math>2\sqrt{10}</math>, <math>8\sqrt{10}</math>, 40 or 640</p> <p>Correct LHS of equation.<br/>ft their coordinates of <i>B</i></p> <p>or</p> <p>Equation of the correct form set equal to 40 or 640</p> <p><b>A1:</b> One correct equation.<br/><b>A2:</b> Both correct equations. Equations do not need to be identified.</p> |
|      |                                                                                                                                                                                                                                                                                                                                                                                                                              | 5                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|      | Question 4 Total                                                                                                                                                                                                                                                                                                                                                                                                             | 9                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |

| Q    | Answer                                                                                                                                                                                                                                                                                                                                                        | Marks                                              | Comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5(a) | $\left[ 6 \sin \theta = \frac{\cos^2 \theta - 9}{3 - \sin \theta} \right]$ $6 \sin \theta (3 - \sin \theta) = \cos^2 \theta - 9$ or<br>$18 \sin \theta - 6 \sin^2 \theta = \cos^2 \theta - 9$ $18 \sin \theta - 6 \sin^2 \theta = (1 - \sin^2 \theta) - 9$ $18 \sin \theta - 6 \sin^2 \theta = -8 - \sin^2 \theta$ $5 \sin^2 \theta - 18 \sin \theta - 8 = 0$ | <p><b>M1</b></p> <p><b>M1</b></p> <p><b>A1</b></p> | <p>Forms a correct equation containing <math>\cos^2 \theta</math> with fractions removed</p> <p>Use of <math>\sin^2 \theta + \cos^2 \theta = 1</math> to eliminate <math>\cos^2 \theta</math><br/>                     eg <math>6 \sin \theta = \frac{(1 - \sin^2 \theta) - 9}{3 - \sin \theta}</math></p> <p>A correct unsimplified equation in <math>\sin \theta</math> and <math>\sin^2 \theta</math> with brackets removed before <b>AG</b><br/>                     Must be convincingly shown.</p> |
|      |                                                                                                                                                                                                                                                                                                                                                               | <b>3</b>                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |

| Q    | Answer                                                                                                                                                                                                                                                                                           | Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Comments |
|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 5(b) | $\left[ 5 \sin^2 3x - 18 \sin 3x - 8 = 0 \Rightarrow \right]$ $(5 \sin 3x + 2)(\sin 3x - 4) [= 0]$<br>$\sin 3x = -\frac{2}{5}$<br>and<br>$\sin 3x = 4 \text{ rejected}$<br>$[3x =] 203.5[78178...]^\circ$<br>or<br>$[3x =] 336.4[21821...]^\circ$<br><br><br><br>$[x =] 67.9^\circ, 112.1^\circ$ | <p><b>M1</b></p> <p>Attempt to solve the quadratic equation. May see use of the quadratic formula but must be a correct substitution.<br/>Condone <math>\theta</math> for <math>3x</math></p> <p><b>PI</b> by <math>[\sin 3x =] -\frac{2}{5}</math> and <math>[\sin 3x =] 4</math> seen.</p> <p><b>A1</b></p> <p>Both correct values for <math>\sin 3x</math> with <math>\sin 3x = 4</math> rejected.<br/>Rejection <b>PI</b> in later working<br/>Condone <math>\theta</math> for <math>3x</math></p> <p><b>A1</b></p> <p>Anything that rounds or truncates correctly to 1 dp.<br/><b>PI</b> by <b>AWRT</b> <math>67.9^\circ</math> or <b>AWRT</b> <math>112.1^\circ</math></p> <p>Allow <math>[3x =] -23.5[78178...]^\circ</math><br/>Condone more accurate values:<br/><math>x = 67.85939...^\circ</math><br/><math>x = 112.14060...^\circ</math></p> <p>Ignore values outside the given interval.</p> <p><b>B2,1</b></p> <p>If both correct answers given deduct 1 mark for each extra incorrect value in the given interval to a minimum of <b>B0</b></p> <p>If one correct answer only given then <b>B1</b> if there is no more than one incorrect answer in the given interval.</p> | <p>5</p> |

| Q    | Answer                                                                                   | Marks       | Comments                                                                                         |
|------|------------------------------------------------------------------------------------------|-------------|--------------------------------------------------------------------------------------------------|
| 5(c) | $[3y + 15^\circ = 3x \Rightarrow y = x - 5^\circ]$<br>$[y = ] \ 62.9^\circ, 107.1^\circ$ | <b>B1ft</b> | ft their answer(s) to <b>part (b)</b> provided their value(s) for $y$ are in the given interval. |
|      |                                                                                          | <b>1</b>    |                                                                                                  |

|  |                         |          |  |
|--|-------------------------|----------|--|
|  | <b>Question 5 Total</b> | <b>9</b> |  |
|--|-------------------------|----------|--|

| Q    | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                   | Marks                                                                                | Comments                                                                                                                                                                                                                                                                                                                                                                                                           |
|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 6(a) | $\left[ 2\log_3(4x-1) - \log_3(2x+7) = \right] 3$ <p style="text-align: right;">or <math>\log_3 27</math></p> $\left[ 2\log_3(4x-1) = \right] \log_3(4x-1)^2$ $\left[ \log_3(4x-1)^2 - \log_3(2x+7) = \right]$ $\log_3 \frac{(4x-1)^2}{2x+7}$ $\left[ \log_3 \frac{(4x-1)^2}{2x+7} = 3 \Rightarrow \right]$ $\frac{(4x-1)^2}{2x+7} = 27$ $16x^2 - 8x + 1 = 54x + 189$ <p>or</p> $16x^2 - 62x - 188 = 0$ <p>and</p> $8x^2 - 31x - 94 = 0$ | <p><b>B1</b></p> <p><b>M1</b></p> <p><b>M1</b></p> <p><b>M1</b></p> <p><b>A1</b></p> | <p>Elimination of <math>\log_3</math> from LHS<br/><b>PI</b> in later working.</p> <p>Use of logarithm property seen inside or outside of an equation.</p> <p>Use of a second logarithm property seen inside or outside of an equation.</p> <p><b>oe</b> Correct equation with logarithms eliminated.</p> <p><b>oe</b> Brackets expanded and fraction cleared before <b>AG</b><br/>Must be convincingly shown.</p> |
|      |                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>5</b>                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                    |

| Q    | Answer                                                                                                 | Marks                             | Comments                                                                                                                                                                                                                |
|------|--------------------------------------------------------------------------------------------------------|-----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 6(b) | $\left[ 8x^2 - 31x - 94 = 0 \Rightarrow \right]$ $(8x-47)(x+2) [=0]$ $\left[ x = \right] \frac{47}{8}$ | <p><b>M1</b></p> <p><b>A1</b></p> | <p>Attempt to solve the quadratic equation. May see use of the quadratic formula but must be a correct substitution.</p> <p><b>PI</b> by <math>x = \frac{47}{8}</math> and <math>x = -2</math></p> <p><b>oe</b> CAO</p> |
|      |                                                                                                        | <b>2</b>                          |                                                                                                                                                                                                                         |

|  |                         |          |  |
|--|-------------------------|----------|--|
|  | <b>Question 6 Total</b> | <b>7</b> |  |
|--|-------------------------|----------|--|

| Q    | Answer                                                                                                                                | Marks                      | Comments                                                                                                    |
|------|---------------------------------------------------------------------------------------------------------------------------------------|----------------------------|-------------------------------------------------------------------------------------------------------------|
| 7(a) | $[P(A) \times P(B) = ]$<br>$0.37 \times 0.16 [= 0.0592]$<br>Not independent as<br>$P(A) \times P(B) = 0.0592 \neq 0.07 = P(A \cap B)$ | <b>M1</b><br><br><b>A1</b> | Correct method to find $P(A) \times P(B)$<br><b>PI</b> by 0.0592<br>Correct conclusion from correct working |
|      |                                                                                                                                       | <b>2</b>                   |                                                                                                             |

| Q    | Answer                                                               | Marks                      | Comments   |
|------|----------------------------------------------------------------------|----------------------------|------------|
| 7(b) | $[P(A \cup B) = ]$ $0.37 + 0.16 - 0.07$<br>$[P(A \cup B) = ]$ $0.46$ | <b>M1</b><br><br><b>A1</b> | <b>CAO</b> |
|      |                                                                      | <b>2</b>                   |            |

| Q    | Answer                                                                        | Marks                      | Comments   |
|------|-------------------------------------------------------------------------------|----------------------------|------------|
| 7(c) | $[P(A B) = ]$ $\frac{0.07}{0.16}$<br>$[P(A B) = ]$ $0.4375$ or $\frac{7}{16}$ | <b>M1</b><br><br><b>A1</b> | <b>CAO</b> |
|      |                                                                               | <b>2</b>                   |            |

|  |                         |          |  |
|--|-------------------------|----------|--|
|  | <b>Question 7 Total</b> | <b>6</b> |  |
|--|-------------------------|----------|--|

| Q    | Answer                               | Marks     | Comments                                                                                        |
|------|--------------------------------------|-----------|-------------------------------------------------------------------------------------------------|
| 8(a) | $[p =] 1 - 0.2 - 0.41 - 0.23 = 0.16$ | <b>B1</b> | <b>AG</b> Must be convincingly shown.<br>Condone: $p + 0.20 + 0.41 + 0.23 = 1$<br>so $p = 0.16$ |
|      |                                      | <b>1</b>  |                                                                                                 |

| Q    | Answer                                                        | Marks     | Comments                       |
|------|---------------------------------------------------------------|-----------|--------------------------------|
| 8(b) | $-2 \times 0.16 + 1 \times 0.2 + 3 \times 0.41 + 0.23a = 4.1$ | <b>M1</b> | Correct equation.<br><b>oe</b> |
|      | $[a = ] 13$                                                   | <b>A1</b> |                                |
|      |                                                               | <b>2</b>  |                                |

| Q    | Answer                                                                                                   | Marks     | Comments                                                                                                                                           |
|------|----------------------------------------------------------------------------------------------------------|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| 8(c) | $[E(X^2) =] (-2)^2 \times 0.16 + 1^2 \times 0.2$<br>$+ 3^2 \times 0.41 + 13^2 \times 0.23$<br>$[= 43.4]$ | <b>M1</b> | <b>oe</b> Correct expression for $E(X^2)$<br>simplified or unsimplified.<br><b>ft</b> their $a$<br><b>PI</b> by correct value or correct variance. |
|      | $[Var(X) =] 43.4 - 4.1^2 [= 26.59]$                                                                      | <b>M1</b> | Correct expression for $Var(X)$<br>simplified or unsimplified.<br><b>ft</b> their $E(X^2)$<br><b>PI</b> by correct variance.                       |
|      | $[Standard\ deviation = \sqrt{26.59} =] 5.16$                                                            | <b>A1</b> | <b>AWRT</b> 5.16                                                                                                                                   |
|      |                                                                                                          | <b>3</b>  |                                                                                                                                                    |

|  |                         |          |  |
|--|-------------------------|----------|--|
|  | <b>Question 8 Total</b> | <b>6</b> |  |
|--|-------------------------|----------|--|

| Q       | Answer                                       | Marks     | Comments                                             |
|---------|----------------------------------------------|-----------|------------------------------------------------------|
| 9(a)(i) | $[E(X) = ] \quad 9 \times 0.4 \quad [= 3.6]$ | <b>M1</b> | <b>oe</b> Correct expression for $E(X)$<br><b>PI</b> |
|         | $[E(Y - X) = 16.2 - 3.6 =] \quad 12.6$       | <b>A1</b> | <b>oe</b>                                            |
|         |                                              | <b>2</b>  |                                                      |

| Q        | Answer                                                     | Marks     | Comments                                               |
|----------|------------------------------------------------------------|-----------|--------------------------------------------------------|
| 9(a)(ii) | $[Var(X) = ] \quad 9 \times 0.4 \times 0.6 \quad [= 2.16]$ | <b>M1</b> | <b>oe</b> Correct expression for $Var(X)$<br><b>PI</b> |
|          | $[Var(Y) = 5 - 2.16 =] \quad 2.84$                         | <b>A1</b> | <b>oe</b>                                              |
|          |                                                            | <b>2</b>  |                                                        |

| Q    | Answer                                                                                                                                                              | Marks     | Comments                                                                                                    |
|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-------------------------------------------------------------------------------------------------------------|
| 9(b) | $[P(X \geq 1) > 0.92 \Rightarrow] \quad P(X = 0) < 0.08$                                                                                                            | <b>M1</b> | Use of 0.08<br><b>PI</b>                                                                                    |
|      | $0.6^n < 0.08$                                                                                                                                                      | <b>m1</b> | Forms a relationship involving only $0.6^n$ and 0.08<br><b>PI</b> by 0.1296 or <b>AWRT</b> 0.0778 (0.07776) |
|      | $\left[ \begin{array}{l} \log 0.6^n < \log 0.08 \\ \Rightarrow n \log 0.6 < \log 0.08 \end{array} \right]$ $\Rightarrow n > \frac{\log 0.08}{\log 0.6} [= 4.94...]$ | <b>m1</b> | Attempt at solving their relationship between $0.6^n$ and 0.08<br><b>PI</b> by 4.94...<br><b>oe</b>         |
|      | $[n =] \quad 5$                                                                                                                                                     | <b>A1</b> | <b>CAO</b>                                                                                                  |
|      |                                                                                                                                                                     | <b>4</b>  |                                                                                                             |

|  |                         |          |  |
|--|-------------------------|----------|--|
|  | <b>Question 9 Total</b> | <b>8</b> |  |
|--|-------------------------|----------|--|

| Q         | Answer                                                                                                                                                                                                                                                                    | Marks                                                                           | Comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 10        | $1.6 = 7t + \frac{1}{2} \times (-9.8) \times t^2$ $4.9t^2 - 7t + 1.6 = 0$ $t_1 = \frac{2}{7}, \quad t_2 = \frac{8}{7}$ $[t_2 - t_1 =] \quad \frac{6}{7} \quad [\text{seconds}]$                                                                                           | <b>M1 A1</b><br><br><b>M1</b><br><br><b>A1</b><br><br><b>A1ft</b>               | <b>M1:</b> Use of $s = ut + \frac{1}{2}at^2$<br>Condone $\pm 9.8$ , and 3 instead of 1.6<br><b>A1:</b> Fully correct.<br><br>Arranges to three-term quadratic equation and attempts to solve.<br><br>Both values correct.<br><b>AWRT</b> 0.29, 1.14<br><br><b>AWRT</b> 0.86<br>Allow 0.85<br><b>ft</b> their $t_1$ and $t_2$ (fractions, 2 sf or better)<br><br>Condone $\frac{2}{7} \leq t \leq \frac{8}{7}$ but not $t = \frac{2}{7}, \frac{8}{7}$                                                                                                                                                                                                                                  |
| 10<br>Alt | $0^2 = 7^2 + 2(-9.8)s$ or<br>$v^2 = 7^2 + 2(-9.8)(1.6)$ $s = 2.5 \quad [\text{metres}]$ or<br>$v = 4.2 \quad [\text{m s}^{-1}]$ $-0.9 = \frac{1}{2}(-9.8)t^2$ or<br>$0 = 4.2 - 9.8t$ $[t =] \quad \frac{3}{7}$ $[\text{Time} =] \quad \frac{6}{7} \quad [\text{seconds}]$ | <b>M1</b><br><br><b>A1</b><br><br><b>M1</b><br><br><b>A1</b><br><br><b>A1ft</b> | Correct method to find maximum height above point of projection<br><b>PI</b> in later working or by $s = 3.9$ or $[\pm]0.9$<br>or<br>correct method to find the speed at a height of 1.6 metres above point of projection<br>Correct maximum height above point of projection<br><b>PI</b> in later working or by $s = 3.9$ or $[\pm]0.9$<br>or<br>correct speed at a height of 1.6 metres above point of projection<br><br><b>oe</b><br>Correct method to find time taken to move from 3 metres above ground to maximum height or reverse<br><br><b>oe</b> Correct time.<br><b>PI</b><br><b>AWRT</b> 0.43<br><br><b>ft</b> their $t = \frac{3}{7}$<br><b>AWRT</b> 0.86<br>Allow 0.85 |

|  |                   |   |  |
|--|-------------------|---|--|
|  | Question 10 Total | 5 |  |
|--|-------------------|---|--|



[illegible]

| Q     | Answer                                                                                                                                                                                                   | Marks                                                      | Comments                                                                                                                                       |
|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| 11(b) | $v^2 = 0^2 + 2(0.4)(1.8)$<br>or<br>$1.8 = 0.5(0.4)t^2$<br>$v^2 = 1.44 \text{ and } [v =] 1.2 \text{ [m s}^{-1}\text{]}$<br>or<br>$t = 3 \text{ and } [v =] 0.4 \times 3 = 1.2 \text{ [m s}^{-1}\text{]}$ | <b>M1</b><br><br><br><br><br><br><br><br><br><br><b>A1</b> | Attempt at an appropriate equation with values substituted.<br>Allow sign errors.<br><br><br><br><br><br><b>AG</b> Must be convincingly shown. |
|       |                                                                                                                                                                                                          | <b>2</b>                                                   |                                                                                                                                                |

| Q     | Answer                                                                                                                                            | Marks                                                | Comments                                                                                                                                                                                                                                                            |
|-------|---------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 11(c) | $[-0.3 \times 50g = 50a \Rightarrow]$ $a = -2.94$ $0^2 = 1.2^2 + 2 \times (-2.94) \times s$ $[s = 0.24]$ $[0.24 + 1.8 =]$ $2.04 \text{ [metres]}$ | <p><b>B1</b></p> <p><b>M1</b></p> <p><b>A1ft</b></p> | <p>Ignore signs using their <math>a</math><br/>Allow if <math>a</math> value rounded.</p> <p>Sums 1.8 and <math>s</math><br/><b>ft</b> their <math>s</math> provided <b>M1</b> scored and final answer is greater than 1.8<br/><b>AWRT 2.0</b><br/>Condone 2.05</p> |
|       |                                                                                                                                                   | <b>3</b>                                             |                                                                                                                                                                                                                                                                     |

|  |                          |           |  |
|--|--------------------------|-----------|--|
|  | <b>Question 11 Total</b> | <b>10</b> |  |
|--|--------------------------|-----------|--|

| Q  | Answer                                                                                                                                                                                                                                                                                                                                                      | Marks                                                                         | Comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 12 | $3 \times 4 + 2 \times (-7) = 3v_A + 2 \times (-1)$<br><br>$[v_A =] 0 \text{ [m s}^{-1}\text{]}$<br><br>$3 \times 4 + 2 \times (-7) = 3v_A + 2 \times 1$<br><br>$[ v_A  =] \frac{4}{3} \text{ [m s}^{-1}\text{]}$<br>or<br>$[v_A =] -\frac{4}{3} \text{ [m s}^{-1}\text{]}$<br><br>Direction of particle <i>B</i> <b>has</b> been reversed by the collision | <b>M1</b><br><br><b>A1</b><br><br><b>M1</b><br><br><b>A1</b><br><br><b>E1</b> | Considers <i>B</i> not being reversed<br>$v_A$ not required.<br><br>Allow a clear rejection of this case instead of $[v_A =] 0 \text{ [m s}^{-1}\text{]}$<br><br>Considers <i>B</i> being reversed.<br><b>PI</b> by a full correct explanation after considering situation where <i>B</i> is not reversed<br><br><b>PI</b> by a full correct explanation after considering situation where <i>B</i> is not reversed<br><br>If they progress to 2 values for $v_A$ , the valid value should be highlighted or the invalid situation rejected. |
|    | Question 12 Total                                                                                                                                                                                                                                                                                                                                           | 5                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |