

**CAMBRIDGE INTERNATIONAL EXAMINATIONS****Cambridge International General Certificate of Secondary Education****MARK SCHEME for the May/June 2015 series****0606 ADDITIONAL MATHEMATICS****0606/22**

Paper 2, maximum raw mark 80

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### Abbreviations

|      |                            |
|------|----------------------------|
| awrt | answers which round to     |
| cao  | correct answer only        |
| dep  | dependent                  |
| FT   | follow through after error |
| isw  | ignore subsequent working  |
| oe   | or equivalent              |
| rot  | rounded or truncated       |
| SC   | Special Case               |
| soi  | seen or implied            |
| www  | without wrong working      |

|   |       |                                                                                                                        |          |                                                                                                                                                                                                                                                      |
|---|-------|------------------------------------------------------------------------------------------------------------------------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | (i)   |                                                                                                                        | B3,2,1,0 | 2 correctly placed in Venn diagram;<br>1, 3, 4, 6 correctly placed;<br>12, 8, 0, 7, 9, 10 correctly placed;<br>11, 5 correctly placed                                                                                                                |
|   | (ii)  | 3                                                                                                                      | B1ft     | correct or correct ft <i>their</i> (i), provided non-zero                                                                                                                                                                                            |
|   | (iii) | {4, 6}                                                                                                                 | B1ft     | correct or correct ft <i>their</i> (i), provided not the empty set                                                                                                                                                                                   |
| 2 | (i)   | $[P] = \begin{pmatrix} 60 & 70 & 58 \\ 50 & 52 & 34 \end{pmatrix}$ and $[Q] = \begin{pmatrix} 120 & 300 \end{pmatrix}$ | B2       | or $[P] = \begin{pmatrix} 50 & 52 & 34 \\ 60 & 70 & 58 \end{pmatrix}$ and<br>$[Q] = \begin{pmatrix} 300 & 120 \end{pmatrix}$<br>or B1 if one error<br><br>may be written as an unevaluated product;<br>B0 if choice of <b>P</b> and <b>Q</b> offered |
|   | (ii)  | (22200 24000 17160)                                                                                                    | B2       | must have brackets and must not have commas; must be a 1 by 3 matrix; must be from correct product; working may be seen in (i)<br><br>or B1 for any two elements correct                                                                             |
|   | (iii) | The <b>total</b> (amount of revenue) <b>from all</b> (three) flights. oe                                               | B1       | do not accept, e.g. The total amount from <b>each</b> flight; must be a comment not just a figure; must not contain a contradiction                                                                                                                  |

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|   |      |                                                                                                                                                                                                                                                                                                                                    |                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
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| 3 | (i)  | $\frac{(36 + 15\sqrt{5})}{(6 + 3\sqrt{5})} \times \frac{(6 - 3\sqrt{5})}{(6 - 3\sqrt{5})} \text{ oe}$ $\frac{216 + 90\sqrt{5} - 108\sqrt{5} - 225}{-9}$ $1 + 2\sqrt{5} \text{ cao}$ <p><b>Alternative method:</b></p> $36 + 15\sqrt{5} = (6a + 15b) + (3a + 6b)\sqrt{5}$ $6a + 15b = 36$ $3a + 6b = 15$ $a = 1 \text{ and } b = 2$ | M1<br>DM1<br>A1<br>M1<br>DM1<br>A1 | $\text{or } \frac{(12 + 5\sqrt{5})}{(2 + \sqrt{5})} \times \frac{(2 - \sqrt{5})}{2 - \sqrt{5}} \text{ oe}$ $\text{or } \frac{24 + 10\sqrt{5} - 12\sqrt{5} - 25}{-1}$ $\text{or } -(24 + 10\sqrt{5}) - 12\sqrt{5} - 25$ <p>allow <math>a = 1</math> and <math>b = 2</math></p>                                                                                                                                                                                                                                                                                                                   |
|   | (ii) | $\left[ AC^2 = (6 + 3\sqrt{5})^2 + \text{their } (1 + 2\sqrt{5})^2 \right]$ $= 36 + 36\sqrt{5} + 45 + \text{their } (1 + 4\sqrt{5} + 20)$ $102 + 40\sqrt{5} \text{ cao}$                                                                                                                                                           | M1<br>A1                           | <p>correct or correct ft expansions, using Pythagoras with <math>(6 + 3\sqrt{5})</math> and <i>their</i> <math>BC</math></p> <p>ignore attempts to square root after correct answer seen</p>                                                                                                                                                                                                                                                                                                                                                                                                    |
| 4 | (i)  | $\cos(x) = \frac{2}{3} \text{ oe soi}$ $48.189...^\circ \text{ or } 131.810...^\circ \text{ or } 0.8410... \text{ rad or } 2.3(00...) \text{ rad oe isw}$ <p>with reference axis indicated by comment, e.g. “to the bank” or “upstream”, etc. or clearly marked on a diagram</p>                                                   | M1<br>A1                           | <p><b>Alternatively</b></p> $\sin(y) = \frac{2}{3} \text{ oe soi}$ $41.810...^\circ \text{ or } 0.7297... \text{ or } 0.73(0) \text{ rad oe isw}$ <p>with reference axis indicated by comment, e.g. “to the perpendicular with the bank”, etc. or clearly marked on a diagram</p> <p>If M0 then SC1 for an unsupported answer of <math>138.189...^\circ</math> or <math>2.4118... \text{ rad}</math> or <math>318.189...^\circ</math> or <math>5.5534... \text{ rad}</math> with reference axis indicated by comment, e.g. “on a bearing of” or “from North” or clearly marked on a diagram</p> |

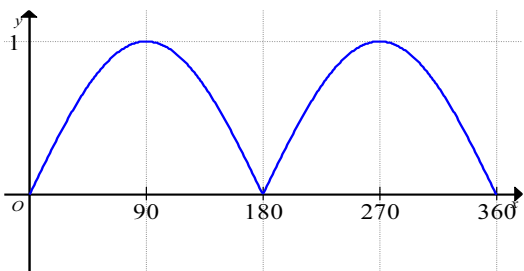
| Page 4 | Mark Scheme                                                                                                                                                                                                                                                                                                                                                                                                     | Syllabus                                          | Paper                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
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| (ii)   | <p>Speed = <math>\sqrt{9-4} (= \sqrt{5})</math> or <math>3 \sin 48.2</math> or <math>2 \tan 48.2</math> or <math>3 \cos 41.8</math> or <math>\frac{2}{\tan 41.8}</math> or <math>\sqrt{2^2 + 3^2 - 2 \times 2 \times 3 \cos 48.2}</math> oe</p> <p>or 2.236(0...) rot to 4 or more figs or 2.24 [m/s] soi</p> <p>time = <math>\frac{80}{\text{their } \sqrt{5}}</math> oe</p> <p>35.66 to 35.8 (seconds) oe</p> | <p>B1</p> <p>M1</p> <p>A1</p>                     | <p>Or Distance = <math>\frac{80}{\sin 48.2} = 107.(33\dots)</math> oe soi</p> <p>time = <math>\frac{\text{their } 107.33\dots}{3}</math></p> <p>ignore subsequent rounding or attempted conversion to, e.g. minutes but A0 if answer spoiled by continuation of method</p> <p>if no working, so B0 M0, then allow B3 for an answer 35.66 to 35.8 oe</p>                                                                                                                                   |
| 5      | <p>Substitution of either <math>4 - x</math> or <math>4 - y</math> into equation of curve and brackets expanded</p> <p><math>12x^2 - 52x + 48 [= 0]</math><br/>or <math>12y^2 - 44y + 32 [= 0]</math> oe</p> <p>Solve their 3-term quadratic</p> <p><math>x = \frac{4}{3}</math> and 3 isw</p> <p><math>y = \frac{8}{3}</math> and 1 isw</p>                                                                    | <p>M1</p> <p>A1</p> <p>M1</p> <p>A1</p> <p>A1</p> | <p>condone one sign error or slip in either equation of curve or expansion of brackets; condone omission of <math>= 0</math>, BUT <math>4 - x</math> or <math>4 - y</math> must be correct</p> <p>dep on a valid substitution attempt</p> <p>or <math>x = \frac{4}{3}</math> <math>y = \frac{8}{3}</math><br/>not from wrong working</p> <p>or <math>x = 3</math> <math>y = 1</math><br/>not from wrong working</p> <p>if no working, allow full marks for fully correct answer only.</p> |
| 6 (a)  | <p><math>(x-2) \log 6 = \log \left( \frac{1}{4} \right)</math> oe or</p> <p><math>\log_6 \left( \frac{1}{4} \right) = x - 2</math> oe</p> <p>1.23 or 1.226(29...) rot to 4 or more figures isw</p>                                                                                                                                                                                                              | <p>M1</p> <p>A1</p>                               | <p>or <math>x \log 6 = \log \left( \frac{36}{4} \right)</math> oe</p> <p>or <math>x \log 6 - \log 36 = \log 1 - \log 4</math> oe</p> <p>correct answer or 1.22 implies M1</p>                                                                                                                                                                                                                                                                                                             |

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| (b)    | <p><b>Method 1</b></p> $\log\left(\frac{8 \times 2y^2 \times 16y}{64y}\right) = \log 4^2 \text{ oe}$ <p><math>y = 2</math></p> <p><b>Method 2</b></p> $\log 2 + 2 \log y + 3 \log 2 + 4 \log 2 + \log y - 6 \log 2 - \log y = 4 \log 2$ <p><math>y = 2</math></p> | <p>B3</p> <p>B1</p> <p>B3,2,1,0</p> <p>B1</p> | <p>or B2 if at most one error or omitted step<br/>or B1 if at most two errors or omitted steps<br/>not from wrong working</p> <p><u>LHS terms</u><br/> <math>\log 2y^2 = \log 2 + 2 \log y</math>;<br/> <math>\log 8 = 3 \log 2</math>;<br/> <math>\log 16y = 4 \log 2 + \log y</math>;<br/> <math>-\log 64y = -6 \log 2 - \log y</math>;<br/> <u>RHS term</u><br/> <math>2 \log 4 = 4 \log 2</math></p> <p>not from wrong working</p>                                                                                                                                                                                                                             |
| 7      | $\frac{n(n-1)(n-2)(n-3)(2^4)}{4 \times 3 \times 2 \times 1} = 10 \frac{n(n-1)(2^2)}{2 \times 1}$ <p>or better</p> <p><math>n^2 - 5n - 24 [= 0] \text{ oe}</math></p> <p><math>(n+3)(n-8) [= 0]</math></p> <p><math>n = 8 \text{ only}</math></p>                  | <p>M3</p> <p>A1</p> <p>M1</p> <p>A1</p>       | <p>condone omitting the factor of <math>n</math> and/or <math>n-1</math>; must have dealt with factorials</p> <p>M2 if one slip/omission<br/>or M1 if two slips/omissions</p> <p>or</p> <p>B1 for <math>\frac{n(n-1)}{2}(2)^2[x^2]</math> seen</p> <p>and</p> <p>B1 for <math>\frac{n(n-1)(n-2)(n-3)}{24}(2)^4[x^4]</math></p> <p>seen</p> <p>equivalent must be 3-terms, e.g.<br/> <math>n^2 - 5n = 24</math></p> <p>or any valid method of solution for their 3-term quadratic</p> <p>A0 if <math>-3</math> also given as a final solution, i.e. not discarded</p> <p>If zero scored, allow SC1 for <math>n = 8</math> unsupported or without correct method</p> |

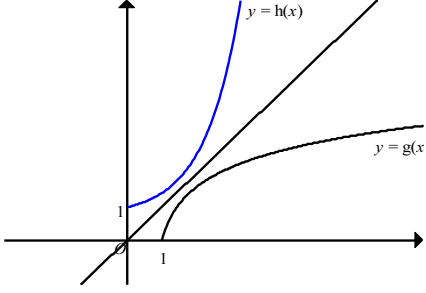
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|   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
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| 8 | <p><b>Method 1</b> (Separate areas subtracted)</p> <p><math>[x_B = x_C =] 7</math> soi</p> <p><math>\left[ \int (x^2 - 6x + 10) dx = \right] \frac{x^3}{3} - \frac{6x^2}{2} + 10x</math></p> <p>Correct or correct ft substitution of limits 0 and <i>their</i> 7 into <i>their</i> <math>\left[ \frac{x^3}{3} - \frac{6x^2}{2} + 10x \right]</math></p> <p><math>\frac{1}{2}(10+17) \times 7</math> oe or</p> <p><math>\int_0^7 (x+10) dx = \left[ \frac{x^2}{2} + 10x \right]_0^7 = \frac{(7)^2}{2} + 10(7)</math> oe</p> <p><i>their</i> <math>\left( \frac{189}{2} - \frac{112}{3} \right)</math></p> <p><math>\frac{343}{6}</math> or <math>57\frac{1}{6}</math> or 57.2 to 3 sf or 57.16(6...) rot to 4 figs isw</p> <p><b>Method 2</b> (Subtracting and using integration once)</p> <p><math>[x_B = x_C =] 7</math> soi</p> <p><math>\int (-x^2 + 7x) dx</math></p> <p><math>\left[ -\frac{x^3}{3} + \frac{7x^2}{2} \right]</math> oe or <math>\left[ \frac{x^3}{3} - \frac{7x^2}{2} \right]</math> oe</p> <p>Correct or correct ft substitution of limits 0 and <i>their</i> 7</p> <p>into <i>their</i> <math>\left[ -\frac{x^3}{3} + \frac{7x^2}{2} \right]</math></p> <p><math>\frac{343}{6}</math> or <math>57\frac{1}{6}</math> or 57.2 to 3 sf or 57.16(6...) rot to 4 figs isw</p> | <p>B1</p> <p>M2</p> <p>DM1</p> <p>B2</p> <p>M1</p> <p>A1</p> <p>B1</p> <p>B1</p> <p>M3</p> <p>M2</p> <p>A1</p> | <p>or M1 for at least one term correct</p> <p>dep on at least M1 being earned; evidence of substitution must be seen in <i>their</i> integral which must be at least two terms; condone omission of lower limit;</p> <p>or M1 for <math>\frac{1}{2}(\text{their } 10 + \text{their } 17) \times \text{their } 7</math> oe</p> <p>or B1 for <math>\int (x+10) dx = \frac{x^2}{2} + 10x</math></p> <p>dep on a genuine attempt to integrate the equation of the curve; must be <i>their</i> area trapezium/under the line – <i>their</i> attempt at area under curve</p> <p>from full and correct working with no omitted steps</p> <p>condone omission of dx</p> <p>or M2 for <math>\int (px^2 + qx) dx = \frac{px^3}{3} + \frac{qx^2}{2}</math> oe either with <math>p = \pm 1</math> or <math>q = \pm 7</math></p> <p>or M1 for <math>\int (px^2 + qx) dx = \frac{px^3}{3} + \frac{qx^2}{2}</math> with non-zero constants <math>p</math> and <math>q</math>, with <math>p \neq \pm 1</math> and <math>q \neq \pm 7</math></p> <p>dep on a valid integration attempt; evidence of substitution must be seen; condone omission of lower limit;</p> <p>from full and correct working with no omitted steps</p> |
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| 9  | (i)   | $10 = 2m + 4$ soi<br><br>$m = 3$                                                                                                                  | M1       | or $[m = ]\frac{10-4}{2-0}$ oe soi                                                                                                                                                                                                                            |
|    | (ii)  | 1                                                                                                                                                 | A1       |                                                                                                                                                                                                                                                               |
|    | (iii) | $\frac{10 - y_R}{2 - -1} = 1$ oe soi<br>$(-1, 7)$ or $x = -1$ and $y = 7$                                                                         | B1       |                                                                                                                                                                                                                                                               |
|    |       |                                                                                                                                                   | M1       | or $y = x + 8$ oe                                                                                                                                                                                                                                             |
|    |       |                                                                                                                                                   | A1       | if $y = 7$ only stated, provided that $x = -1$ is soi in working allow both marks                                                                                                                                                                             |
|    |       |                                                                                                                                                   |          | if M0 then B1 for $y = 7$ only with no working                                                                                                                                                                                                                |
|    | (iv)  | Use of $m_1 m_2 = -1$ with <i>their</i> $m$ from (i)<br><br>$y - 10 = \left( \text{their} - \frac{1}{3} \right) (x - 2)$<br><br>$3y + x = 32$ isw | M1       | may be implied by perpendicular gradient seen in equation                                                                                                                                                                                                     |
|    |       |                                                                                                                                                   | A1       | or $\left( \text{their} - \frac{1}{3} \right) x + c$ and<br><br>$10 = \left( \text{their} - \frac{1}{3} \right) 2 + c$                                                                                                                                        |
|    |       |                                                                                                                                                   | A1       | allow for correct equation with integer coefficients in any simplified form                                                                                                                                                                                   |
|    | (v)   | $\left( \frac{1}{2}, \text{their} \frac{11}{2} \right)$ oe isw                                                                                    | B1, B1ft | ft <i>their</i> $y_0$<br><br>or M1 for $\left( \frac{2-1}{2}, \frac{10+1}{2} \right)$ seen                                                                                                                                                                    |
|    | (vi)  | 4.5 oe cao                                                                                                                                        | B2       | not from wrong working<br><br>or M1 for any correct method with correct coordinates                                                                                                                                                                           |
| 10 | (a)   |                                                                | B2, 1, 0 | correct sinusoidal/reflected sinusoidal shape, all above $x$ -axis with intent to have all maximum points of equal height;<br><br>2 maximum points of intended equal height only over 0 to 360;<br><br>all max points clearly at $y = 1$ ;<br><br>cusp at 180 |

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|    |        |                                                                                                   |              |                                                                                                                                                                                       |
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|    | (b)(i) | $[hg(x)] = \frac{e^{\ln(4x-3)} + 3}{4}$                                                           | M1           | <b>Alternative method</b><br>$y = \ln(4x - 3)$ and change of subject to $x$<br>oe,                                                                                                    |
|    |        | fully correct <b>and</b> completion to $[hg(x)] = x$                                              | A1           | fully correct and comment that<br>$h(x) = g^{-1}(x)$ oe                                                                                                                               |
|    | (ii)   |                  | B2,1,0       | correct shape;<br>1 marked on the y-axis or (0, 1) stated<br>close by;<br>curve with positive gradient in first<br>quadrant only                                                      |
|    | (iii)  | $x \geq 0$ or $[0, \infty)$                                                                       | B1           | not domain $\geq 0$                                                                                                                                                                   |
|    | (iv)   | $y \geq 1$ or $[1, \infty)$                                                                       | B1           | or $h(x) \geq 1$ , $h \geq 1$ etc.                                                                                                                                                    |
| 11 | (i)    | $\frac{8-h}{8}$ or $8 : 8 - h$ soi                                                                | M1           | or $\frac{8}{8-h}$ or $8 - h : 8$ soi                                                                                                                                                 |
|    |        | $\frac{8-h}{8} \times 4$ oe                                                                       | A1           | or $4 \div \frac{8}{8-h}$ oe                                                                                                                                                          |
|    |        | $h\left(\frac{8-h}{8} \times 4\right)^2$ oe                                                       | M1           | $h$ must be in the numerator of the<br>expression for this mark;                                                                                                                      |
|    |        | expand and simplify to $\frac{h^3}{4} - 4h^2 + 16h$ <b>AG</b>                                     | A1           |                                                                                                                                                                                       |
|    | (ii)   | $\frac{3}{4}h^2 - 8h + 16$ oe                                                                     | B1           |                                                                                                                                                                                       |
|    |        | $their\left(\frac{3}{4}h^2 - 8h + 16\right) = 0$ and attempt to<br>solve<br>$\frac{8}{3}$ oe only | M1<br><br>A2 | must be a 3-term quadratic; must be an<br>attempt at a derivative<br><br>or A1 for $h = \frac{8}{3}$ and 8<br><br>allow 2.67 or 2.66(6...) rot to 4 or more<br>figs for $\frac{8}{3}$ |

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|    |       |                                                                                                                                                       |                                |                                                                                                                                                                                                       |
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| 12 | (i)   | $-120 + 104 + 22 - 6 = 0$<br><br>or correct unsimplified form, e.g.<br>$15(-2)^3 + 26(-2)^2 - 11(-2) - 6 = 0$ or<br>$15(-8) + 26(4) - 11(-2) - 6 = 0$ | B1                             | or correct synthetic division<br><br>$\begin{array}{r rrrr} -2 & 15 & 26 & -11 & -6 \\ & & -30 & 8 & 6 \\ \hline & 15 & -4 & -3 & 0 \end{array}$                                                      |
|    | (ii)  | Substituting $x = 3$ into $15x^3 + 26x^2 - 11x - 6$<br><br><br><br><br>600                                                                            | M1                             | or correct synthetic division<br><br>$\begin{array}{r rrrr} 3 & 15 & 26 & -11 & -6 \\ & & 45 & 213 & 606 \\ \hline & 15 & 71 & 202 & 600 \end{array}$                                                 |
|    | (iii) | $(x - 1)(15x^3 + 26x^2 - 11x - 6)$ soi                                                                                                                | B1                             | by inspection or division;<br>may be implied by e.g.<br>$(ax + b)(15x^3 + 26x^2 - 11x - 6)$<br>and $a = 1$ , $b = -1$ seen in later work<br>comparing coefficients                                    |
|    |       | Multiply out<br>$(x \pm 1)(15x^3 + 26x^2 - 11x - 6)$<br>and compare coefficients of $x^3$ or $x$ to<br>quartic<br><br>$p = 11$<br>$q = 5$             | M1<br><br><br><br><br>A1<br>A1 | or multiply out, e.g.<br>$(ax + b)(15x^3 + 26x^2 - 11x - 6)$<br>and compare coefficients of $x^3$ or $x$ to<br>quartic<br><br>correct $p$ or $q$ implies M1; correct $p$ and $q$<br>www implies B1 M1 |