MARK SCHEME for the March 2016 series

0606 ADDITIONAL MATHEMATICS

0606/22

Paper 22, 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 |
| nfww | not from wrong working |
| oe | or equivalent |
| rot | rounded or truncated |
| SC | Special Case |
| soi | seen or implied |
| WWW | without wrong working |
| | |

| Question | Answer | Marks | Guidance |
|----------|--|----------|---|
| 1 (i) | $\frac{\mathrm{d}y}{\mathrm{d}x} = k(x-9)^{-\frac{3}{2}}$ | M1 | If M0 then SC1 for the correct answer with an extra term. |
| | $k = -\frac{5}{2}$ isw | A1 | condone $5 \times -\frac{1}{2}$ |
| (ii) | $\delta y = their\left(\frac{\mathrm{d}y}{\mathrm{d}x}\Big _{x=13}\right) \times h$ | M1 | |
| | -0.3125 <i>h</i> oe | A1 | |
| 2 | $\begin{array}{c c} & & & \\ & & & \\ & & \\ & & \\ & & & \\ & & \\ & & \\ & & \\ & & & \\ & & \\ & & \\ &$ | B3,2,1,0 | B2 for C as a proper subset of A A and B with an intersection B and C mutually exclusive Or B1 for any two of the these and B1 for the number of elements correctly placed |
| | 5 | B1FT | FT their 5 |
| 3 | Integrates $9x^2 - 3x^{-2}$ | M1 | condone one rearrangement error |
| | $(y=)\frac{9x^3}{3} - \frac{3x^{-1}}{-1}(+c)$ | A1 | |
| | Substitute $x = 1$ and $y = 7$ into <i>their</i> expression with 'c' | M1 | <i>their</i> expression must be from an attempt to integrate |
| | $y = 3x^3 + 3x^{-1} + 1$ oe isw | A1 | condone $y = 3x^3 + 3x^{-1} + c$ and $c = 1$ seen, isw |

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| Q | uestion | Answer | Marks | | Guidance | | |
| 4 | (a) | a = 10 b = 6 c = 4 or $10\cos 6x + 4$ | B2,1,0 | for B a e.g. t | for B1 allow correct FT of <i>c</i> from <i>a</i> e.g. <i>their</i> $c = 14 - their a$ | | |
| | (b) | y 1 0 45° 90° 135° 180° X -2 -5 | B3,2,1,0 | Corre maxir -5; st at (18 | ect shape; tw mum at 1 an arting at (0, 30, -2) | o cycles; bo d minimum −2) and end | oth at ling |
| 5 | (i) | $2187 + 5103kx + 5103k^2x^2$ | B3 | 1 for | each term; i | gnore extra | terms |
| | (ii) | $2(5103k) = 5103k^2$ | M1 | must | not include | x, x^2 | |
| | | <i>k</i> = 2 | A1 | A0 if | k = 0 also g | iven as a so | lution |
| 6 | | $\frac{x}{1+3\sqrt{3}} = \frac{5-\sqrt{3}}{6+2\sqrt{3}}$ oe soi | M1 | | | | |
| | | $(x=)\frac{-4+14\sqrt{3}}{6+2\sqrt{3}}$ oe | M1 | | | | |
| | | $(x=)\frac{-4+14\sqrt{3}}{6+2\sqrt{3}} \times \frac{6-2\sqrt{3}}{6-2\sqrt{3}}$ | M1 | | | | |
| | | p = -27, q = 23 isw | A1 + A1 | allow | $(x=)\frac{-27}{-27}$ | $\frac{+23\sqrt{3}}{6}$ | |

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| Qu | iestion | Answer | Marks | Guidance |
| 7 | (a) | $ \begin{pmatrix} 4 & 6 & 8 \\ -2 & 0 & 4 \end{pmatrix} - \begin{pmatrix} 18 & 3 & 6 \\ 21 & -6 & 3 \end{pmatrix} $ | M1 | for attempt to multiply and subtract |
| | | $\begin{pmatrix} -14 & 3 & 2 \\ -23 & 6 & 1 \end{pmatrix}$ | A1 | |
| | (b) (i) | $-\frac{1}{2} \begin{pmatrix} 1 & 0 \\ -4 & -2 \end{pmatrix} $ oe | B1 + B1 | 1 mark for $-\frac{1}{2}$ and 1 mark |
| | | Valid mathed | M1 | for $k \begin{pmatrix} 1 & 0 \\ -4 & -2 \end{pmatrix}$ |
| | (11) | | IVII | $\mathbf{A}\mathbf{D}$ \mathbf{D} – $\mathbf{C}\mathbf{D}$ |
| | | $\begin{pmatrix} -8 & -6 \\ 13 & 7 \end{pmatrix}$ | A2,1,0 | -1 each error |
| | | | | If M0 then SC1 for |
| | | | | $\mathbf{DC} = \begin{pmatrix} 4 & 3 \\ -14 & -5 \end{pmatrix}$ |
| 8 | (i) | Eliminate x (or y) | M1 | $3(2y-2)^{2} + (2y-2)y - y^{2} = 12$ |
| | | | | $3x^{2} + x\left(\frac{x+2}{2}\right) - \left(\frac{x+2}{2}\right)^{2} = 12$ |
| | | $13y^2 - 26y = 0$ or $\frac{13}{4}x^2 - 13 = 0$ oe | A1 | |
| | | $13y(y-2)$ or $x^2 = 4$ | M1 | |
| | | $x = -2, \qquad \qquad x = 2$ | A1 | or for $(-2, 0)$ or $(2, 2)$ from correct |
| | | v = 0 $v = 2$ isw | + A1FT | working FT <i>their</i> x or y values to find <i>their</i> |
| | | y o y <u>y</u> .o | | y or x values; or A1 for $(-2, 0)$ and $(2, 2)$ |
| | (ii) | their $m_{AB} = \frac{1}{2}$ or their $m_{BC} = -2$ soi | M1 | may be unsimplified or Pythagoras' theorem correctly applied to <i>their</i> $(0, -2)$, <i>their</i> $(2, 2)$ and $(0, 6)$ |
| | | use of $(m_{AB}) \times (m_{BC}) = -1$ and conclusion | A1 | or use of $h^2 = a^2 + b^2$ and conclusion |

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| Question | Answer | Marks | Guid | ance |
| 9 (i) | $RT = \frac{1}{\tan \theta}$ | B1 | or $RT = \cot \theta$ | |
| | $RS = \frac{1}{\sin \theta}$ | B1 | or $RS = \csc \theta$ | |
| | $x = 1 - \frac{1}{2\tan\theta} - \frac{1}{2\sin\theta}$ oe $\cot\theta \csc\theta$ | B1FT | FT <i>their RT</i> and <i>t</i> provided both are ratios | <i>heir RS</i> , functions of trig |

| | or $x = 1 - \frac{\cot \theta}{2} - \frac{\csc \theta}{2}$ oe | | ratios |
|------------|---|------|---|
| (ii) | $A = x + \frac{1}{2}\cot\theta$ oe soi | M1 | |
| | correct completion to given answer $A = 1 - \frac{\csc \theta}{2}$ | A1 | |
| (iii) | $\csc\theta = \frac{2\sqrt{3}}{3}$ oe | M1 | equivalent must be exact |
| | $\theta = \frac{\pi}{3}$ cao | A1 | implies M1 |
| 10 (a) (i) | $(\alpha + \beta)\mathbf{i} - 20\mathbf{j} = 15\mathbf{i} + (2\alpha - 24)\mathbf{j}$ | M1 | implied by $\alpha + \beta = 15$ or $2\alpha - 24 = -20$ |
| | $\alpha = 2$ | A1 | |
| | $\beta = 13$ | A1 | |
| (ii) | $\sqrt{(their\alpha + their\beta)^2 + (-20)^2}$ oe | M1 | |
| | $\frac{15\mathbf{i}-20\mathbf{j}}{25}$ oe | A1FT | FT <i>their</i> $\alpha + \beta$ provided non-zero |
| (b) | $\overrightarrow{OC} = \overrightarrow{OA} + \lambda \overrightarrow{AB}$ or $\overrightarrow{OC} = OB + (1 - \lambda)\overrightarrow{BA}$ | B1 | |
| | $[\overrightarrow{OC} =] \mathbf{a} + \lambda(\mathbf{b} - \mathbf{a}) \text{ or}$ $[\overrightarrow{OC} =] \mathbf{b} + (1 - \lambda)(\mathbf{a} - \mathbf{b})$ | M1 | |
| | $[\overrightarrow{OC} =] (1 - \lambda)\mathbf{a} + \lambda \mathbf{b}$ | A1 | |
| (c) | $\frac{2}{\mu+3} = \frac{\mu}{9}$ | M1 | or multiplies one of the vectors by a general scale factor and finds a pair of simultaneous equations to solve |
| | Solves $\mu^2 + 3\mu - 18 = 0$ | M1 | or solves <i>their</i> correct equation to find <i>their</i> scale factor and attempts to use it to find μ |
| | $\mu = 3$ | A1 | A0 if -6 not discarded |

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| Qu | estion | Answer | Marks | Guid | lance | |
| 11 | (i) | $\frac{dy}{dx} = \frac{(x^2 + 1)(1) - (x)(2x)}{(x^2 + 1)^2} \text{oe}$ | M1* | Attempts to differentiate using th quotient rule | | |
| | | | A1 | correct; allow unsimplified | | |
| | | $their(1-x^2) = 0$ | M1 dep* | | | |
| | | x = 1, x = -1 | A1 | from correct wor | king only | |
| | | y = 0.5, $y = -0.5$ oe | A1 | from correct work | king only | |
| | | | | or A1 for each of $(1, 0.5)$, (-1, -0.5) oe from correct working; | | |
| | | | | unsupported answers do not se | | score |
| (| (ii) | $\frac{d}{dx} \left(\left(x^2 + 1 \right)^2 \right) = 2 \left(x^2 + 1 \right) (2x) \text{ soi}$ | B1 | $\frac{\mathrm{d}}{\mathrm{d}x}\left(x^4 + 2x^2 + 1\right)$ | $=4x^3+4x$ | |
| | | $\frac{d^2 y}{dx^2} = (x^2 + 1) \frac{(x^2 + 1)(their - 2x) - (their(1 - x^2))2(2x)}{(x^2 + 1)^4}$ | M1 | Applies quotient rule and fact out | | tors |
| | | Correct completion to given answer $\frac{d^2 y}{dx^2} = \frac{2x^3 - 6x}{(x^2 + 1)^3}$ | A1 | | | |
| | | When $x = 1$ their $\frac{d^2 y}{dx^2}\Big _{x=1} = \frac{2(1)^3 - 6(1)}{(1^2 + 1)^3}$ oe < 0 therefore | B1FT | Complete method including comparison to 0; FT <i>their</i> first second derivative | | st or |
| | | maximum | | | | |
| | | When $x = -1$ their $\frac{d^2 y}{dx^2}\Big _{x=-1} = \frac{2(-1)^3 - 6(-1)}{((-1)^2 + 1)^3}$ or $0 > 0$ therefore minimum | B1FT | Complete method comparison to 0; second derivative | l including FT <i>their</i> fir | st or |

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| 12 (i) | | $9t^{2} - 63t + 90 = 0$ (9t - 18)(t - 5) | M1 | | | | |
| | | showing that $t = 2$ is smaller value of t | A1 | must e.g. <i>t</i> | see evidence $= 5$ and $t = 2$ | e of solving 2 or factors | |
| (ii) | | $(a=)\frac{\mathrm{d}v}{\mathrm{d}t}$ attempted | M1 | | | | |
| | | 18(3.5) - 63 = 0 cao | A1 | | | | |
| (iii) | | $\int (9t^2 - 63t + 90) \mathrm{d}t$ | M1 | | | | |
| | | $(s=)\frac{9t^3}{3} - \frac{63t^2}{2} + 90t$ isw | A2,1,0 | -1 fo | r each error | or for $+c$ lef | t in |
| (iv) (| (a) | $(s =)\frac{9(2)^3}{3} - \frac{63(2)^2}{2} + 90(2)$ | M1 | or $\begin{bmatrix} 9 \\ - \\ - \\ - \\ - \\ - \\ - \\ - \\ - \\ - \\$ | $\frac{9t^3}{3} - \frac{63t^2}{2} + 9$ | $\left[\frac{1}{2} \right]_{0}^{2}$ | |
| | | 78 [m] | A1 | | ieir (m) | | |
| (| (b) | $(s =)\frac{9(3)^3}{3} - \frac{63(3)^2}{2} + 90(3) = 67.5$ | M1 | FT th | heir (iii) | | |
| | | <i>their</i> 78 + 10.5 = 88.5 [m] | A1FT | | | | |