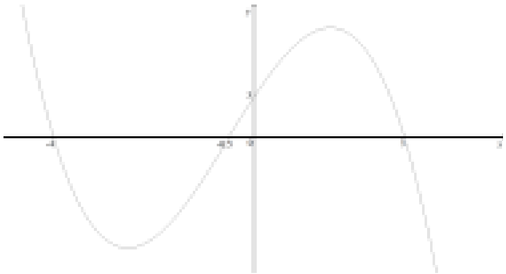
| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 1 |  | 3 | **B1** for a cubic shape with a maximum in the first quadrant, a minimum in the third quadrant, extending into the second and 4th quadrants. The extensions must not curve incorrectly and not lead to a complete stationary point.<br>**B1** for $x$-intercepts $-4, -\frac{1}{2}, 3$ either on diagram or stated but must be with a cubic graph.<br>**B1** for $y$-intercept 3 either on diagram or stated but must be with a cubic graph. |
| 2 | $v = -4.91$ soi | **B1** | |
| | Speed = 4.91 | **B1** | |
| 3 | $\tan\left(2x - \frac{\pi}{3}\right) = \pm\sqrt{3}$ soi<br>or $\sin\left(2x - \frac{\pi}{3}\right) = \pm\frac{\sqrt{3}}{2}$ soi | **B1** | **B0** if negative root is rejected<br>Allow truncated decimals<br>May be implied by subsequent work<br>From use of<br>$\text{cosec}^2\left(2x - \frac{\pi}{3}\right) - 1 = \cot^2\left(2x - \frac{\pi}{3}\right)$ |
| | $2x - \frac{\pi}{3} = -\frac{\pi}{3}, \frac{\pi}{3}, \frac{2\pi}{3}, \frac{4\pi}{3}$<br>$2x = 0, \frac{2\pi}{3}, \pi, \frac{5\pi}{3}$<br>$x = 0, \frac{\pi}{3}, \frac{\pi}{2}, \frac{5\pi}{6}$<br>or 0, 1.05, 1.57, 2.62 or greater accuracy | 4 | **M1** for correct order of operations to obtain one solution in the range using<br>$\tan\left(2x - \frac{\pi}{3}\right) = k$<br>or $\sin\left(2x - \frac{\pi}{3}\right) = m,\ \lvert m \rvert < 1$<br>**Dep M1** for correct order of operations to obtain a second solution in the range using<br>$\left(2x - \frac{\pi}{3}\right) = \tan^{-1}(k) \pm \pi$<br>or $\left(2x - \frac{\pi}{3}\right) = \pi - \sin^{-1}(m),\ \lvert m \rvert < 1$ oe<br>$\left(2x - \frac{\pi}{3}\right) = -\sin^{-1}(m),\ \lvert m \rvert < 1$ oe<br>**A1** for any pair of correct solutions<br>**A1** for remaining pair of solutions, with no extra solutions within the range |
| 4(a) | $\frac{1}{256} - \frac{x^2}{24} + \frac{7x^4}{36}$ | 3 | **B1** for $\frac{1}{256}$<br>**B1** for $-\frac{x^2}{24}$<br>**B1** for $\frac{7x^4}{36}$ |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 4(b) | $4x^2+4+\frac{1}{x^2}$ soi | **B1** | |
| | Coefficient of $x^2$ $\left(their\,4\times their\,\frac{1}{256}\right)$ $+\left(their\,4\times their\,-\frac{1}{24}\right)$ $+\left(their\,\frac{7}{36}\right)$ | **M1** | Allow one sign error, but must have 3 terms in $x^2$ only, with an attempt at addition. |
| | $\frac{25}{576}$ | **A1** | |
| 5(a) | $\frac{a\left(r^4-1\right)}{r-1}=17\frac{a\left(r^2-1\right)}{r-1}$ | **M1** | Allow equivalents<br>Allow if '$a$' terms missing (assume to have been cancelled) |
| | $\left(r^2-1\right)\left(r^2+1\right)=17\left(r^2-1\right)$ or better<br>$r^4-17r^2+16=0$ oe<br>$r^3+r^2-16r-16=0$ oe | **M1** | **Dep M1** for a correct simplified equation in $r$ only |
| | $r=4$ only, from correct working | **A1** | |
| 5(b) | $ar^5=64$ | **M1** | For use of $ar^5$ with *their* positive $r$ |
| | $a=0.0625$ or $\frac{1}{16}$ | **A1** | Must be exact<br>A0 if $r=4$ not from correct working in **(a)** |
| 5(c) | Because $r>1$ oe | **B1** | **FT** on *their* $r>1$<br>Must have a value for $r$ |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 6(a) | **Either**<br>Starts with 8: 1680 | **B1** | 1680 must not be part of a product.<br>May be implied by final answer |
| | Starts with 7 or 9: 2688 | **B1** | May be implied by final answer |
| | Total: 4368 | **B1** | |
| | **Or Alternative 1**<br>Starts with 7, 8 or 9 and ends in 1, 3 or 5: 3024 | **(B1)** | Allow for 1008 three times<br>May be implied by final answer |
| | Starts with 8 or 9 and ends in 7: 672<br>Starts with 7 or 8 and ends in 9: 672 | **(B1)** | For both<br>May be implied by final answer |
| | Total: 4368 | **(B1)** | |
| | **Or Alternative 2**<br>13 ways of obtaining odd 5-digit numbers which start with 7, 8 or 9 | **(B1)** | Needs to be part of a product. May be implied by final answer |
| | ${}^{8}P_{3}$ ways of arranging the remaining 3 digits: 336 | **(B1)** | Needs to be part of a product. May be implied by final answer |
| | Total = $13 \times 336 = 4368$ | **(B1)** | |
| | **Or Alternative 3**<br>Last digit is 7 or 9: 1344 | **B1** | May be implied by final answer |
| | Last digit is 1, 3 or 5: 3024 | **B1** | May be implied by final answer |
| | Total: 4368 | **B1** | |
| | **Or Alternative 4**<br>${}^{10}P_{5} - \left({}^{9}P_{4} \times 7\right) - \left({}^{8}P_{3} \times 5\right) - \left({}^{8}P_{3} \times 4\right)$<br>$-\left({}^{8}P_{3} \times 5\right)$ | **B2** | Must be complete |
| | Total: 4368 | **B1** | |
| 6(b) | $\frac{n!}{(n-3)!3!} = \frac{2n!}{(n-2)!2!}$ soi | **B1** | |
| | $(n-2) = 6$ soi | **B2** | **Dep B1** on first **B** for $(n-2)$ soi<br>**Dep B1** on first **B** for 6 soi |
| | $n = 8$ | **B1** | **Dep** on previous **B** marks |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 7(a) | $\sin AOQ = \frac{7}{10}$<br>$POA = \pi - AOQ$<br>or<br>$14^2 = 10^2 + 10^2 - 200\cos AOB$ oe<br>$POA = \frac{2\pi - AOB}{2}$ | **M1** | Allow alternatives, but must be a complete method to find *POA* |
| | $POA = 2.366195157 = 2.366$ to 3 dp | **A1** | Must see an angle correct to more than 3dp used in order to justify 3 dp |
| 7(b) | Area of sector = $\frac{1}{2}10^2(2.366)$<br>$(118.3)$ | **B1** | Allow unsimplified. Also allow use of 2.37 |
| | Area of triangle = $\frac{1}{2}10^2 \sin 2.366$<br>$(35)$ | **B1** | Allow unsimplified. Also allow use of 2.37 |
| | Total area = awrt 153 | **B1** | Allow greater accuracy |
| 7(c) | Major arc *PB* = $10 \times 2.366$ | **B1** | Allow unsimplified. Also allow use of 2.37 |
| | $\sin\frac{POA}{2} = \frac{AP/2}{10}$<br>or $AP^2 = 10^2 + 10^2 - 200\cos POA$ | **M1** | For a valid attempt to find *AP* – may be seen in **(a)** or **(b)** but *AP* must be stated in this part. |
| | $AP = 18.5$ | **A1** | Allow awrt 18.5 |
| | Perimeter: major arc *PB* + 20 + *their AP* | **B1** | For plan, may be implied, but must have an attempt to calculate *AP* |
| | Total perimeter = 62.2 | **A1** | Allow awrt 62.2 |
| 8(a) | $2x^2 + 2x - 2 = x^2 + 6x - 2$<br>$x^2 - 4x = 0$<br>$x(x-4) = 0$<br>$x = 0,\ x = 4$ | **M1** | For obtaining an equation in one variable |
| | | **M1** | **Dep** for a correct attempt to obtain at least one solution |
| | $(0, -1)$ | **A1** | nfww |
| | $(4, 19)$ | **A1** | nfww |
| | Mid-point $(2, 9)$ with sufficient detail | **B1** | **AG** |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 8(b) | **Either**<br>Gradient of perpendicular $= -\frac{1}{5}$ | **M1** | |
| | $y - 9 = -\frac{1}{5}(x - 2)$ | **M1** | **Dep** on previous **M** mark for perpendicular bisector using *their* mid-point and *their* perpendicular gradient |
| | $7 - 9 = -\frac{1}{5}(12 - 2)$ oe | **A1** | For checking by substitution, must see evidence. |
| | **Or Alternative 1**<br>Gradient of perpendicular $= -\frac{1}{5}$ | **(M1)** | |
| | $y - 7 = -\frac{1}{5}(x - 12)$ | **(M1)** | **Dep** on previous **M** mark for perpendicular bisector using $(12, 7)$ and *their* perpendicular gradient |
| | $9 - 7 = -\frac{1}{5}(2 - 12)$ oe | **(A1)** | For checking by substitution, must see evidence |
| | **Or Alternative 2**<br>Gradient of perpendicular $= -\frac{1}{5}$ | **(M1)** | |
| | Gradient of line joining *their* $(2, 9)$ to $(12, 7)$ $= = -\frac{1}{5}$ | **(M1)** | |
| | $(2, 9)$ is a common point and gradients of perpendicular bisector and $l$ are the same so $C$ lies on $l$. | **(A1)** | |
| 8(c) | $(22, 5)$ | **2** | **B1** for 22<br>**B1** for 5 |
| | $(-18, 13)$ | **2** | **B1** for $-18$<br>**B1** for 13 |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 9(a) | $e^{2y} = mx^2 + c$ | B1 | May be implied by later work |
| | **Either**<br>$7.96 = 4m + c$<br>$3.76 = 2m + c$ | M1 | |
| | $m = 2.1$ oe | A1 | |
| | $c = -0.44$ oe | A1 | |
| | $y = \frac{1}{2}\ln\left(2.1x^2 - 0.44\right)$ oe | A1 | Do not isw |
| | **Or**<br>gradient = $2.1$ oe | (B1) | |
| | Use of either $7.96 = 4m + c$<br>or $3.76 = 2m + c$ | (M1) | For use with *their m* |
| | $c = -0.44$ oe | (A1) | |
| | $y = \frac{1}{2}\ln\left(2.1x^2 - 0.44\right)$ oe | (A1) | Must be bracketed correctly |
| 9(b) | $y = \frac{1}{2}\ln\left(\mathit{their}\,2.1x^2 - \mathit{their}\,0.44\right)$ oe | M1 | Must use the form $y = k\ln\left(px^2 \pm q\right)$ $p \neq 1$ and $q \neq 0$<br>or $e^{2y} = mx^2 + c$ |
| | 0.253 | A1 | |
| 9(c) | $\mathit{their}\,2.1x^2 - \mathit{their}\,0.44 > 0$ or $= 0$ or $\geq 0$<br>soi | B1 | |
| | Correct attempt to obtain the critical value using $\mathit{their}\,2.1x^2 - 0.44 = 0$ | M1 | Must be from the form $y = k\ln\left(px^2 - q\right)$, $p \neq 1$ and $q > 0$ |
| | $x > 0.458$ or $x > \sqrt{\frac{22}{105}}$ oe | A1 | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 10(a) | $\frac{dy}{dx} = (2x+3)^{\frac{1}{2}} + 5x(+c)$ | **B1** | For $(2x+3)^{\frac{1}{2}}$, allow unsimplified |
| | | **M1** | For $k(2x+3)^{\frac{1}{2}} + 5x$ |
| | $10 = 3 + 15 + c$ | **M1** | **Dep** for use of 10 and $x=3$ in *their* $\frac{dy}{dx}$ to obtain $c$ |
| | $\frac{dy}{dx} = (2x+3)^{\frac{1}{2}} + 5x - 8$ soi | **A1** | |
| | When $x = 11$, $\frac{dy}{dx} = 5 + 55 - 8$ oe<br>= 52 | **A1** | **AG** – need to see sufficient detail |
| 10(b) | $f(x) = \frac{1}{3}(2x+3)^{\frac{3}{2}} + \frac{5x^2}{2}(-8x + d)$ | **B1** | For $\frac{1}{3}(2x+3)^{\frac{3}{2}}$, must be $\int (2x+3)^{\frac{1}{2}}\,dx$ |
| | | **M1** | For $k(2x+3)^{\frac{3}{2}} + \frac{5x^2}{2}$ |
| | $\frac{19}{2} = \frac{27}{3} + \frac{45}{2} - 24 + d$<br>$d = 2$ | **M1** | For use of $y = \frac{19}{2}$ and $x = 3$ in *their y* |
| | $(f(x) =)\ \frac{1}{3}(2x+3)^{\frac{3}{2}} + \frac{5x^2}{2} - 8x + 2$ | **A1** | Allow $-8$ if obtained from using $\frac{dy}{dx} = 52$ in **(a)** rather than $\frac{dy}{dx} = 10$ |
| 11(a) | $\frac{dy}{dx} =$<br>$\frac{(x+1)\left(\frac{1}{3}\times 2x\times(x^2-5)^{-\frac{2}{3}}\right) - (x^2-5)^{\frac{1}{3}}}{(x+1)^2}$<br>or<br>$(x+1)^{-1}\left(\frac{1}{3}\times 2x\times(x^2-5)^{-\frac{2}{3}}\right)$<br>$+(x^2-5)^{\frac{1}{3}}\left(-(x+1)^{-2}\right)$ | **3** | **B1** for $\frac{1}{3}\times 2x\times(x^2-5)^{-\frac{2}{3}}$<br>**M1** for an attempt at a quotient or a correct product<br>**A1** for all other terms correct |
| | $\frac{-x^2+2x+15}{3(x+1)^2(x^2-5)^{\frac{2}{3}}}$ | **3** | **Dep on first 3 marks**<br>**A1** for $-x^2$ in a quadratic numerator<br>**A1** for $2x$ in a quadratic numerator<br>**A1** for 15 in a quadratic numerator |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 11(b) | $-x^2 + 2x + 15 = 0$ | **M1** | For attempt to solve *their* $-x^2 + 2x + 15 = 0$ to obtain $x = ..$<br>Must be a quadratic equation. |
| | $x = 5$ only | **A1** | |
| 11(c) | **Either**<br>Find the gradient either side of the stationary point | **B1** | |
| | If gradient changes from +ve to -ve: max<br>If gradient changes from -ve to +ve: min | **B1** | **Dep** on previous **B1** |
| | **Or Alternative 1**<br>Take the second derivative and substitute in the value of *x* obtained in **(b)** | **(B1)** | Allow alternative valid methods<br>Allow a general method as this is not dependent on **(a)** or **(b)** |
| | If second derivative is + ve, then a min<br>If second derivative is – ve, then a max | **(B1)** | **Dep** on previous **B1** |
| | **Or Alternative 2**<br>Consider a *y*-value to one side of the stationary point | **(B1)** | Allow alternative valid methods<br>Allow a general method as this is not dependent on **(a)** or **(b)** |
| | If *y* value of stationary point is greater, then a max.<br>If *y* value of stationary point is less, then a min. | **(B1)** | **Dep** on previous **B1** |