| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 1 | $\frac{1}{2}n\left[-24+(n-1)6\right] \sim 3000$<br>Note: $\sim$ denotes <u>any</u> inequality or equality | **M1** | Use correct formula with RHS ≈ 3000 (e.g. 3010). |
| | $(3)\left(n^2-5n-1000\right)\ (\sim 0)$ | **A1** | Rearrange into a 3-term quadratic. |
| | $n \sim 34.2\ (\&-29.2)$ | **A1** | |
| | 35. Allow $n \geqslant 35$ | **A1** | |
| | | **4** | |
| 2 | $ax+3a=-\frac{2}{x} \rightarrow ax^2+3ax+2\ (=0)$ | ***M1** | Rearrange into a 3-term quadratic. |
| | Apply $b^2-4ac>0$ SOI | **DM1** | Allow $\geqslant$. If no inequalities seen, **M1** is implied by 2 correct final answers in $a$ or $x$. |
| | $a<0,\ a>\frac{8}{9}$ (or 0.889) OE | **A1 A1** | For final answers accept $0>a>\frac{8}{9}$ but not $\leqslant$, $\geqslant$. |
| | | **4** | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 3(i) | $6C3\left(\frac{2}{x}\right)^3(-3x)^3$ SOI also allowed if seen in an expansion | **M1** | Both $x$'s can be missing. |
| | $-4320$ Identified as answer | **A1** | Cannot be earned retrospectively in **(ii)**. |
| | | **2** | |
| 3(ii) | $6C2\left(\frac{2}{x}\right)^4[(-)3x]^2$ SOI clearly identified as critical term | **M1** | Both $x$'s and minus sign can be missing. |
| | $15a\times16\times9-their4320(=0)$ | **A1 FT** | FT on *their* 4320. |
| | $a=2$ | **A1** | |
| | | **3** | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 4 | $f'(x)=\left[\left(\frac{3}{2}\right)(2x-1)^{1/2}\right]\times[2]-[6]$ | **B2, 1, 0** | Deduct 1 mark for each [...] incorrect. |
| | $f'(x)<0$ or $\leqslant 0$ or $=0$ SOI | **M1** | |
| | $(2x-1)^{1/2}<2$ or $\leqslant 2$ or $=2$ OE | **A1** | Allow with $k$ used instead of $x$ |
| | Largest value of $k$ is $\frac{5}{2}$ | **A1** | Allow $k\leqslant\frac{5}{2}$ or $k=\frac{5}{2}$ Answer must be in terms of $k$ (not $x$) |
| | | **5** | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 5(i) | $\cos\theta + 4 + 5\sin^2\theta + 5\sin\theta - 5\sin\theta - 5\ (=0)$ | **M1** | Multiply throughout by $\sin\theta + 1$. Accept if $5\sin\theta - 5\sin\theta$ is not seen |
| | $5\left(1-\cos^2\theta\right) + \cos\theta - 1\ (=0)$ | **M1** | Use $s^2 = 1 - c^2$ |
| | $5\cos^2\theta - \cos\theta - 4 = 0$ AG | **A1** | Rearrange to AG |
| | | **3** | |
| 5(ii) | $\cos\theta = 1$ and $-0.8$ | **B1** | Both required |
| | $\theta = [0°, 360°],\quad [143.1°],\quad [216.9°]$ | **B1 B1 B1 FT** | Both solutions required for 1st mark. For 3rd mark FT for $(360° - \textit{their}\,143.1°)$<br>Extra solution(s) in range (e.g. 180º) among 4 correct solutions scores $\frac{3}{4}$ |
| | | **4** | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 6(i) | $y = \frac{2}{x^2 - 1} \Rightarrow x^2 = \frac{2}{y} + 1$ OE | **M1** | |
| | $x = (\pm)\sqrt{\frac{2}{y} + 1}$ OE | **A1** | With or without $x$/$y$ interchanged. |
| | $\mathrm{f}^{-1}(x) = -\sqrt{\frac{2}{x} + 1}$ OE | **A1** | Minus sign obligatory. Must be a function of $x$. |
| | | **3** | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 6(ii) | $\left(\frac{2}{x^2-1}\right)^2+1=5$ | **B1** | |
| | $\frac{2}{x^2-1}=(\pm)2$ OE OR $x^4-2x^2=0$ OE<br>$x^2-1=(\pm)1 \Rightarrow x^2=2\ (\text{or}\ 0)$<br>$x=-\sqrt{2}$ or $-1.41$ only | **B1** | Condone $x^2=0$ as an additional solution |
| | | **4** | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 7(i) | $\sin^{-1}\left(\frac{3}{5}\right)=0.6435$ AG | **M1** | OR $(PBC=)\cos^{-1}\left(\frac{3}{5}\right)=0.9273 \Rightarrow (ABP=)\frac{\pi}{2}-0.9273=0.6435$<br>Or other valid method. Check working and diagram for evidence of incorrect method |
| 7(ii) | Use (once) of sector area $=½r^2\theta$ | **M1** | |
| | Area sector $BAP=½\times5^2\times0.6435$ = 8.04 | **A1** | |
| | Area sector $DAQ=½\times½\pi\times3^2$ = 7.07 , Allow $\frac{9\pi}{4}$ | **A1** | |
| | | **3** | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 7(iii) | *EITHER:*<br>Region = sect + sect – (rect – Δ) or sect – [rect – (sect + Δ)] | **(M1** | Use of correct strategy |
| | (Area Δ *BPC* =) ½ × 3 × 4 = 6 Seen | **A1** | |
| | 8.04 + 7.07 – (15 – 6) = 6.11 | **A1)** | |
| | *OR1:*<br>Region = sector *ADQ* – (trap *ABPD* – sector *ABP*). | **(M1** | Use of correct strategy |
| | (Area trap *ABPD* = ) ½ (5 + 1) × 3 = 9 Seen | **A1** | |
| | 7.07 – (9 – 8.04) = 7.07 – 0.96 = 6.11 | **A1)** | |
| | *OR2:*<br>Area segment *AP*= 2.5686 Area segment *AQ* = 0.5438<br>Region = segment *AP* + segment *AQ* + Δ*APQ*. | **(M1** | Use of correct strategy |
| | (Area Δ*APQ* =) ½ × 2 × 3 = 3 Seen | **A1** | |
| | 2.57 + 0.54 + 3 = 6.11 | **A1)** | |
| | | **3** | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 8(i) | *EITHER:*<br>$4 - 3\sqrt{x} = 3 - 2x \rightarrow 2x - 3\sqrt{x} + 1\ (=0)$ or e.g. $2k^2 - 3k + 1\ (=0)$ | **(M1** | Form 3-term quad & attempt to solve for $\sqrt{x}$. |
| | $\sqrt{x} = ½, 1$ | **A1** | Or $k = ½$ or 1 (where $k = \sqrt{x}$). |
| | $x = ¼, 1$ | **A1)** | |
| | *OR1:*<br>$(3\sqrt{x})^2 = (1 + 2x)^2$ | **(M1** | |
| | $4x^2 - 5x + 1\ (=0)$ | **A1** | |
| | $x = ¼, 1$ | **A1)** | |
| | *OR2:*<br>$\frac{3-y}{2} = \left(\frac{4-y}{3}\right)^2 \left(\rightarrow 2y^2 - 7y + 5(=0)\right)$ | **(M1** | Eliminate $x$ |
| | $y = \frac{5}{2}, 1$ | **A1** | |
| | $x = ¼, 1$ | **A1)** | |
| | | **3** | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 8(ii) | *EITHER:*<br>Area under line = $\int(3-2x)\,dx = 3x - x^2$ | **(B1** | |
| | $= \left[(3-1) - \left(\frac{3}{4} - \frac{1}{16}\right)\right]$ | **M1** | Apply *their* limits (e.g. ¼ → 1) after integn. |
| | Area under curve $= \int\left(4 - 3x^{1/2}\right)dx \;=\; 4x - 2x^{3/2}$ | **B1** | |
| | $\left[(4-2) - (1-¼)\right]$ | **M1** | Apply *their* limits (e.g. ¼ → 1) after integration. |
| | Required area = $\frac{21}{16} - \frac{5}{4} = \frac{1}{16}$ (or 0.0625) | **A1)** | |
| | *OR:*<br>$+/-\int(3-2x) - \left(4 - 3x^{\frac{1}{2}}\right) = +/-\int(-1-2x+3x^{\frac{1}{2}})$ | **(*M1** | Subtract functions and then attempt integration |
| | $+/-\left[-x - x^2 + \frac{3x^{3/2}}{3/2}\right]$ | **A2, 1, 0 FT** | FT on *their* subtraction. Deduct 1 mark for each term incorrect |
| | $+/-\left[-1-1+2-\left(-\frac{1}{4}+\frac{1}{16}+\frac{1}{8}\right)\right] = \frac{1}{16}$ (or 0.0625) | **DM1 A1)** | Apply *their* limits ¼ → 1 |
| | | **5** | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 9(i) | $\overrightarrow{AB} = +/-\begin{pmatrix}-18\\9\\-18\end{pmatrix}$, $\overrightarrow{BC} = +/-\begin{pmatrix}12\\-6\\12\end{pmatrix}$, | **B1 B1** | Allow **i**, **j**, **k** form throughout. |
| | $\left\lvert\overrightarrow{AB}\right\rvert = 27$, $\left\lvert\overrightarrow{BC}\right\rvert = 18$ | **B1 FT**<br>**B1 FT** | FT on *their* $\overrightarrow{AB}$, *their* $\overrightarrow{OD}$. |
| | $\left\lvert\overrightarrow{CD}\right\rvert = \left(\frac{18}{27}\right)\times 18$ OR $\left(\frac{18}{27}\right)^2 \times 27 = 12$ | **B1** | |
| | | **5** | |
| 9(ii) | $\overrightarrow{CD} = (\pm)\,their\,\frac{18}{27}\times their\ \overrightarrow{BC}$ SOI | **M1** | Expect $(\pm)\begin{pmatrix}8\\-4\\8\end{pmatrix}$. |
| | $\overrightarrow{OD} = \begin{pmatrix}2\\-3\\-1\end{pmatrix}(\pm)\ their\ \frac{18}{27}\begin{pmatrix}12\\-6\\12\end{pmatrix} = \begin{pmatrix}10\\-7\\7\end{pmatrix}, \begin{pmatrix}-6\\1\\-9\end{pmatrix}$ | **M1 A1 A1** | Other methods possible for $\overrightarrow{OD}$, e.g. $\overrightarrow{OB} + \frac{5}{2}\overrightarrow{CD}$, $\overrightarrow{OB} + \frac{1}{2}\overrightarrow{CD}$<br>(One soln **M2A1**, 2nd soln **A1**) OR $\overrightarrow{OB} + \frac{5}{3}\overrightarrow{BC}$, $\overrightarrow{OB} + \frac{1}{3}\overrightarrow{BC}$<br>(One soln **M2A1**, 2nd soln **A1**) |
| | | **4** | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 10(i) | $ax^2 + bx = 0 \rightarrow x(ax+b) = 0 \rightarrow x = \frac{-b}{a}$ | **B1** | |
| | Find $f''(x)$ and attempt sub *their* $\frac{-b}{a}$ into *their* $f''(x)$ | **M1** | |
| | When $x = \frac{-b}{a}$, $f''(x) = 2a\left(\frac{-b}{a}\right) + b = -b$ MAX | **A1** | |
| | | **3** | |
| 10(ii) | Sub $f'(-2) = 0$ | **M1** | |
| | Sub $f'(1) = 9$ | **M1** | |
| | $a = 3 \quad b = 6$ | ***A1** | Solve simultaneously to give both results. |
| | $f'(x) = 3x^2 + 6x \rightarrow f(x) = x^3 + 3x^2 \ (+c)$ | ***M1** | Sub *their a, b* into $f'(x)$ and integrate 'correctly'. Allow $\frac{ax^3}{3} + \frac{bx^2}{2}(+c)$ |
| | $-3 = -8 + 12 + c$ | **DM1** | Sub $x = -2,\ y = -3$. Dependent on *c* present. Dependent also on *a*, *b* substituted. |
| | $f(x) = x^3 + 3x^2 - 7$ | **A1** | |
| | | **6** | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 11(i) | Gradient of $AB = \frac{1}{2}$ | **B1** | |
| | Equation of $AB$ is $y = \frac{1}{2}x - \frac{1}{2}$ | **B1** | |
| | | **2** | |
| 11(ii) | $\frac{\mathrm{d}y}{\mathrm{d}x} = ½(x-1)^{-\frac{1}{2}}$ | **B1** | |
| | $½(x-1)^{-\frac{1}{2}} = ½$ . Equate *their* $\frac{\mathrm{d}y}{\mathrm{d}x}$ to *their* ½ | ***M1** | |
| | $x = 2,\ \ y = 1$ | **A1** | |
| | $y - 1 = ½(x - 2)$ (thro' *their*(2,1) & *their* ½) $\rightarrow\ y = ½x$ | **DM1 A1** | |
| | | **5** | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 11(iii) | *EITHER:*<br>$\sin\theta = \frac{d}{1} \quad \rightarrow \quad d = \sin\theta$ | **(M1** | Where $\theta$ is angle between $AB$ and the $x$-axis |
| | gradient of $AB = ½ \Rightarrow \tan\theta = ½ \Rightarrow \theta = 26.5(7)°$ | **B1** | |
| | $d = \sin 26.5(7)° = 0.45$ (or $\frac{1}{\sqrt{5}}$) | **A1)** | |
| | *OR1:*<br>Perpendicular through $O$ has equation $y = -2x$ | **(M1** | |
| | Intersection with $AB$: $-2x = ½x - ½ \rightarrow \left(\frac{1}{5}, \frac{-2}{5}\right)$ | **A1** | |
| | $d = \sqrt{\left(\frac{1}{5}\right)^2 + \left(\frac{2}{5}\right)^2} = 0.45$ (or $\frac{1}{\sqrt{5}}$) | **A1)** | |
| | *OR2:*<br>Perpendicular through (2, 1) has equation $y = -2x + 5$ | **(M1** | |
| | Intersection with $AB$: $-2x + 5 = ½x - ½ \rightarrow \left(\frac{11}{5}, \frac{3}{5}\right)$ | **A1** | |
| | $d = \sqrt{\left(\frac{1}{5}\right)^2 + \left(\frac{2}{5}\right)^2}$ = 0.45 (or $1/\sqrt{5}$) | **A1)** | |

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 11(iii) | *OR3:*<br>$\Delta OAC$ has area $\frac{1}{4}$ [where $C = (0, -\frac{1}{2})$] | **(B1** | |
| | $\frac{1}{2} \times \frac{\sqrt{5}}{2} \times d = \frac{1}{4} \rightarrow d = \frac{1}{\sqrt{5}}$ | **M1 A1)** | |
| | | **3** | |