1	$f'(x) = 5 - 2x^2$ and (3, 5) $f(x) = 5x - \frac{2x^3}{3}$ $(+c)$ Uses (3, 5) $\rightarrow c = 8$	 B1 M1 A1 [3]	 For integral Uses the point in an integral co
2	Radius of semicircle = $\frac{1}{2}AB = r\sin\theta$ Area of semicircle = $\frac{1}{2}\pi r^2\sin^2\theta = A_1$ Shaded area = semicircle – segment $= A_1 - \frac{1}{2}r^2 2\theta + \frac{1}{2}r^2\sin 2\theta$	B1 B1√ B1B1 [4]	aef Uses $\frac{1}{2}\pi r^2$ with $r = f(\theta)$ B1 (–sector), B1 for + (triangle)
3 (i)	$(2-x)^6$ Coeff of x^2 is 240 Coeff of x^3 is $-20 \times 8 = -160$	 B1 B2,1 [3]	 co B1 for +160
(ii)	$(3x+1)(2-x)^6$ Product needs exactly 2 terms $\rightarrow$ 720 – 160 = 560	 M1 A1√ [2]	 3 × their 240 + their -160 √ for candidate's answers.
4	$u = 2x(y-x)$ and $x + 3y = 12$, $u = 2x\left(\frac{12-x}{3} - x\right)$ $= 8x - \frac{8x^2}{3}$ $\frac{du}{dx} = 8 - \frac{16x}{3}$ $= 0$ when $x = 1\frac{1}{2}$ $\rightarrow (y = 3\frac{1}{2})$ $\rightarrow u = 6$	 M1 A1 M1 A1 A1 [5]	 Expresses u in terms of x Differentiate candidate's quadratic, sets to 0 + attempt to find x, or other valid method Complete method that leads to u Co
5 (i)	$\frac{\sin\theta - \cos\theta}{\sin\theta + \cos\theta}$. Divides top and bottom by cos θ $\rightarrow \frac{t-1}{t+1}$	 B1 [1]	 Answer given.
(ii)	$\frac{\sin\theta - \cos\theta}{\sin\theta + \cos\theta} = \frac{1}{6}\tan\theta$ $\rightarrow \frac{t-1}{t+1} = \frac{t}{6}$ $\rightarrow t^2 - 5t + 6 = 0$ $\rightarrow t = 2$ or $t = 3$ $\rightarrow \theta = 63.4°$ or $71.6°$	 B1 M1 A1 A1 [4]	 Using the identity. Forms a 3 term quadratic with terms all on same side. co co

6	$h = 60(1 - \cos kt)$		
(i)	Max h when $\cos = -1 \rightarrow 120$	B1 [1]	Co
(ii)	$h = 0$ and $t = 30$, or $h = 120$ and $t = 15$ $\rightarrow \cos 30k = 1$ or $\cos 15k = -1$ $\rightarrow 30k = 2\pi$ or $15k = \pi$	M1	Substituting a correct pair of values into the equation.
	$\rightarrow k = \dfrac{2\pi}{30} = \dfrac{\pi}{15}$	A1 [2]	co ag
(iii)	$90 = 60(1 - \cos kt)$ $\rightarrow \cos kt = \frac{-30}{60} = -0.5$	B1	co – but there must be evidence of correct subtraction.
	$\rightarrow kt = \dfrac{2\pi}{3}$ or $\rightarrow kt = \dfrac{4\pi}{3}$		
	$\rightarrow$ Either $t = 10$ or 20 or both	B1	
	$\rightarrow t = 10$ minutes	B1 [3]	
7	$A(4, 6)$, $B(10, 2)$.		
(i)	$M = (7, 4)$	B1	co
	m of $AB = -\frac{2}{3}$	B1	co
	m of perpendicular $= \frac{3}{2}$ $\rightarrow y - 4 = \frac{3}{2}(x - 7)$	M1 A1 [4]	Use of $m_1 m_2 = -1$ & their midpoint in the equation of a line. co
(ii)	Eqn of line parallel to AB through $(3, 11)$ $\rightarrow y - 11 = -\frac{2}{3}(x - 3)$	M1	Needs to use m of AB
	Sim eqns $\rightarrow C(9, 7)$	DM1A1 [3]	Must be using their correct lines. Co
8 (a)	1st, 2nd, nth are 56, 53 and -22 $a = 56$, $d = -3$		
	$-22 = 56 + (n - 1)(-3)$	M1	Uses correct u_n formula.
	$\rightarrow n = 27$	A1	co
	$S_{27} = \frac{27}{2}(112 + 26(-3))$	M1	Needs positive integer n
	$\rightarrow 459$	A1 [4]	Co
(b)	1st, 2nd, 3rd are $2k + 6$, $2k$ and $k + 2$.		
(i)	Either $\frac{2k}{2k+6} = \frac{k+2}{2k}$ or uses a, r and eliminates	M1	Correct method for equation in k.
	$\rightarrow 2k^2 - 10k - 12 = 0$	DM1	Forms quad. or cubic equation with no brackets or fractions.
	$\rightarrow k = 6$	A1 [3]	Co

(ii)	$S_\infty = \frac{a}{1-r}$ with $r = \frac{2k}{2k+6}$ or $\frac{k+2}{2k}$ $(= \frac{2}{3})$ $\rightarrow$ 54	M1 A1 [2]	Needs attempt at a and r and S_∞ Co
9	$\overrightarrow{OA} = 2\mathbf{i} + 4\mathbf{j} + 4\mathbf{k}$ and $\overrightarrow{OB} = 3\mathbf{i} + \mathbf{j} + 4\mathbf{k}$		
(i)	$\overrightarrow{OA}.\overrightarrow{OB} = 6 + 4 + 16 = 26$ $\lvert\overrightarrow{OA}\rvert = \sqrt{36}$, $\lvert\overrightarrow{OB}\rvert = \sqrt{26}$ Cos $AOB = \frac{26}{6\sqrt{26}}$ $\rightarrow$ 31.8°	M1 M1 M1 A1 [4]	Must be numerical at some stage Product of 2 moduli All linked correctly co
(ii)	$\overrightarrow{AB} = \mathbf{b} - \mathbf{a} = \begin{pmatrix} 1 \\ -3 \\ 0 \end{pmatrix}$	B1	
	$\overrightarrow{OC} = \begin{pmatrix} 2 \\ 4 \\ 4 \end{pmatrix} + 2\overrightarrow{AB}$ *or* $\begin{pmatrix} 3 \\ 1 \\ 4 \end{pmatrix} + \overrightarrow{AB}$	M1	Correct link
	$\overrightarrow{OC} = \begin{pmatrix} 4 \\ -2 \\ 4 \end{pmatrix}$		
	Unit vector $\div$ modulus $\rightarrow \frac{1}{6}\begin{pmatrix} 4 \\ -2 \\ 4 \end{pmatrix}$	M1 A1 [4]	$\div$ by modulus. co
(iii)	$\lvert\overrightarrow{OC}\rvert = 6$, $\lvert\overrightarrow{OA}\rvert = 6$	B1 [1]	co

10	$y = \dfrac{4}{2x-1}$.	B1	Correct without the ÷2
(i)	$\displaystyle\int \frac{16}{(2x-1)^2}\,dx = \frac{-16}{2x-1} \div 2$	B1	For the ÷2 even if first B1 is lost
	Vol $= \pi\left[\dfrac{-8}{2x-1}\right]$ with limits 1 and 2	M1	Use of limits in a changed expression.
	$\rightarrow \dfrac{16\pi}{3}$	A1 [4]	co
(ii)	$m = \frac{1}{2}$ m of tangent $= -2$	M1	Use of $m_1 m_2 = -1$
	$\dfrac{dy}{dx} = \dfrac{-4}{(2x-1)^2} \times 2$	B1 B1	Correct without the ×2 For the ×2 even if first B1 is lost
	Equating their $\dfrac{dy}{dx}$ to -2	DM1	
	$\rightarrow x = \frac{3}{2}$ or $-\frac{1}{2}$	A1	co
	$(y = 2$ or $-2)$ $\rightarrow c = \frac{5}{2}$ or $-\frac{7}{2}$	A1 [6]	co
11	$f : x \mapsto 2x^2 - 6x + 5$		
(i)	$2x^2 - 6x + 5 - p = 0$ has no real roots	M1	Sets to 0 with p on LHS.
	Uses $b^2 - 4ac \rightarrow 36 - 8(5 - p)$	DM1	Uses discriminant.
	Sets to 0 $\rightarrow p < \frac{1}{2}$	A1 [3]	co – must be "<", not "⩽".
(ii)	$2x^2 - 6x + 5 = 2\left(x - \frac{3}{2}\right)^2 + \frac{1}{2}$	3 × B1 [3]	co
(iii)	Range of g $\frac{1}{2} \leqslant g(x) \leqslant 13$	B1√ B1 [2]	√ on **(ii)** co from sub of $x = 4$
	$h : x \mapsto 2x^2 - 6x + 5$ for $k \leqslant x \leqslant 4$		
(iv)	Smallest $k = \frac{3}{2}$	B1√ [1]	√ on **(ii)**
(v)	$h(x) = 2\left(x - \frac{3}{2}\right)^2 + \frac{1}{2}$	M1	Using comp square form to try and get x as subject or y if transposed.
	Order of operations $\pm\frac{1}{2}, \div 2, \sqrt{}, \pm\frac{3}{2}$	DM1	Order must be correct
	$\rightarrow$ Inverse $= \frac{3}{2} + \sqrt{\left(\frac{x}{2} - \frac{1}{4}\right)}$	A1 [3]	co (without ±)