Question			Answer	Marks	AO	Guidance	
12	(a)		**DR**				
			area = $\int x \frac{\mathrm{d}y}{\mathrm{d}t}\mathrm{d}t$ $\frac{\mathrm{d}y}{\mathrm{d}t} = 4t + 3$ hence $\int \frac{2}{(2t+1)^4}(4t+3)\mathrm{d}t$	**M1**	**1.2**	Attempt $\int x \frac{\mathrm{d}y}{\mathrm{d}t}\mathrm{d}t$ in terms of t, detail required	Clear indication that integrand is given by $\int x \frac{\mathrm{d}y}{\mathrm{d}t}\mathrm{d}t$ (condone just $\int x \frac{\mathrm{d}y}{\mathrm{d}t}$), along with $\frac{\mathrm{d}y}{\mathrm{d}t} = 4t + 3$ and full substitution into integrand Condone no dt in integrand in initial statement and/or when substituting May instead see integrand as $\int x\mathrm{d}y$ with dy = $(4t + 3)\mathrm{d}t$
			$\int \frac{8t+6}{(2t+1)^4}\mathrm{d}t$ **A.G.**	**A1**	**2.1**	Obtain correct given integrand	dt required throughout
			$a = 0$, from $t = 0$ oe	**B1**	**2.2a**	Determine correct lower limit from solving equation	Evidence for $a = 0$ required eg $2t^2 + 3t = 0$ $a = 0$ doesn't need to be seen explicitly, and could be implied by 0 appearing as the lower limit on an integral sign once sufficient evidence seen Mark independently of any integrand attempted
			$2t^2 + 3t = 2$	**M1**	**2.1**	Equate expression for y to 2	Could be implied by $t = \frac{1}{2}$ seen as a limit
			$(2t – 1)(t + 2) = 0$ $t = \frac{1}{2}$ $t = – 2$ but $t > 0$, so $b = \frac{1}{2}$	**A1**	**2.1**	Obtain $b = \frac{1}{2}$ as upper limit www	No need for $t = – 2$ to be explicitly rejected $b = \frac{1}{2}$ doesn't need to be seen, and may be implied by appearing as the upper limit on an integral sign Mark independently of any integrand attempted

Question			Answer	Marks	AO	Guidance	
				[5]			
12	**(b)**		**DR**				
			$u = 2t + 1$, $du = 2dt$, $8t + 6 = 4u + 2$	**M1***	**3.1a**	Use $u = 2t + 1$ to attempt to change entire integrand to a function of u	Attempt to write numerator, denominator and dt in terms of u
			$\int \frac{4t+3}{(2t+1)^4} 2\mathrm{d}t = \int \frac{2u+1}{u^4} \mathrm{d}u$	**A1**	**1.1**	Obtain correct integrand	Condone no du
			$\int \frac{2}{u^3} + \frac{1}{u^4} \mathrm{d}u = -\frac{1}{u^2} - \frac{1}{3u^3}$	**M1***	**3.1a**	Attempt integration to obtain integral of form $au^{-2} + bu^{-3}$	**M0** if additional terms
				A1	**1.1**	Obtain fully correct integral	
			$\left[-\frac{1}{u^2} - \frac{1}{3u^3}\right]_1^2 = \left(-\frac{1}{4} - \frac{1}{24}\right) - \left(-1 - \frac{1}{3}\right)$	**M1d***	**3.1a**	Attempt use of **correct** limits: either correct t limits (ie $a = 0$ and $b = \frac{1}{2}$) in a t-integral or commensurate upper and lower limits in an integral involving a substitution (eg with $u = 2t + 1$, then upper limit must be 2 and lower limit must be 1)	Dependent on **M1 M1** Minimum evidence needed is two terms ie $\left(-\frac{7}{24}\right) - \left(-\frac{4}{3}\right)$ or $\left(\frac{3}{4}\right) + \left(\frac{7}{24}\right)$ If these values are not seen then **M1** can be awarded for term by term substitution seen (ie 4 terms needed), but allow one error
			$= \frac{25}{24}$	**A1**	**1.1**	Obtain correct area, any exact equivalent	Explicit use of limits must be seen in a correct integral for **A1**

Question			Answer	Marks	AO	Guidance	
				[6]			Candidates may mix and match methods eg start with substitution and then try to do the actual integration by parts – the MS allows **M1A1** for changing the integrand to useable form; **M1A1** for doing the integration; **M1A**1 for use of limits
			Alternative method (integration by parts)				
			$u=8t+6, u'=8$ $v'=(2t+1)^{-4}, v=-\frac{1}{6}(2t+1)^{-3}$ I = $-\frac{1}{6}(8t+6)(2t+1)^{-3}-\int -\frac{8}{6}(2t+1)^{-3}\,\mathrm{d}t$	**M1***		Attempt integration by parts	Correct parts and correct formula
				A1		Obtain correct first step	Allow unsimplified
			I = $(8t+6)\times -\frac{1}{6}(2t+1)^{-3}+\frac{8}{6}\times -\frac{1}{4}(2t+1)^{-2}$	**M1***		Attempt integration to obtain integral of form $a(8t+6)(2t+1)^{-3}+b(2t+1)^{-2}$	
				A1		Obtain fully correct integral	Allow unsimplified
			$\left(-\frac{5}{24}-(-1)\right)+\left(-\frac{1}{12}-(-\frac{1}{3})\right)$ $=\left(\frac{19}{24}\right)+\left(\frac{1}{4}\right)$	**M1d***		Attempt use of **correct** limits	See guidance in main MS
			$=\frac{25}{24}$	**A1**		Obtain correct area, any exact equivalent	

Question			Answer	Marks	AO	Guidance	
			Alternative method (separate fractions)				
			$\frac{4(2t+1)+2}{(2t+1)^4} = \frac{4}{(2t+1)^3} + \frac{2}{(2t+1)^4}$ $\int \frac{8t+6}{(2t+1)^4}\mathrm{d}t = \int \frac{4}{(2t+1)^3} + \frac{2}{(2t+1)^4}\mathrm{d}t$	**M1***		Attempt to rewrite integrand as separate fractions with constant numerators	Could be informal method, or use of partial fractions (extending expected knowledge) As far as $\frac{P}{(2t+1)^3} + \frac{Q}{(2t+1)^4}$, with P and Q as constants, and no other fractions
				A1		Obtain correct integrand	
			$\int \frac{8t+6}{(2t+1)^4}\mathrm{d}t = -\frac{1}{(2t+1)^2} - \frac{1}{3(2t+1)^3}$	**M1***		Attempt integration to obtain integral of form $\frac{a}{(2t+1)^2} + \frac{b}{(2t+1)^3}$	
				A1		Obtain fully correct integral	Allow unsimplified
			$\left(-\frac{1}{4} - \frac{1}{24}\right) - \left(-1 - \frac{1}{3}\right)$	**M1d***		Attempt use of **correct** limits	See guidance in main MS
			$= \frac{25}{24}$	**A1**		Obtain correct area, any exact equivalent	

Question	Answer	Marks	AO	Guidance	
	Alternative method (integrating between curve and *x*-axis)				
	$\int y\frac{\mathrm{d}x}{\mathrm{d}t}\mathrm{d}t = \int -\frac{16(2t^2+3t)}{(2t+1)^5}\mathrm{d}t$	**M1***		Attempt integration by substitution / integration by parts on correct expression	Apply the same MS as for integrating between curve and *y*-axis
	$\int \frac{(u+2)(4-4u)}{u^5}\mathrm{d}u$ or $2(2t^2+3t)(2t+1)^{-4}$ $-\int 2(4t+3)(2t+1)^{-4}\mathrm{d}t$	**A1**		Obtain correct integrand	Using substitution eg $u = 2t + 1$ Using integration by parts – first stage required for **M1**
		M1*		Attempt integration to obtain integral of required form	Apply the same MS as for integrating between curve and *y*-axis
	$\frac{2}{u^2}+\frac{4}{3u^3}-\frac{2}{u^4}$ **or** $2(2t^2+3t)(2t+1)^{-4}+$ $\frac{1}{3}(4t+3)(2t+1)^{-3}+\frac{1}{3}(2t+1)^{-2}$	**A1**		Obtain fully correct integral	Allow unsimplified
	$\left(\frac{4}{3}\right)-\left(\frac{13}{24}\right)+\frac{1}{4}$	**M1d***		Attempt use of **correct** limits, and combine with correct area of rectangle (= $\frac{1}{4}$)	Limits must be $\int_{\frac{1}{2}}^{0}$ or commensurate *u*-limits, and used in the correct order See guidance in main MS, but must also add on the **correct** area of the rectangle

Question			Answer	Marks	AO	Guidance	
			$= \frac{25}{24}$	**A1**		Obtain correct area, any exact equivalent	