Question Number	Scheme	Notes	Marks
3(a) Way 1 Identities first then squares	$y=\frac{1}{2}\left(\tan x+\cot x\right)\Rightarrow \frac{\mathrm{d}y}{\mathrm{d}x}=\frac{1}{2}\left(\sec^2 x-\operatorname{cosec}^2 x\right)$ oe	Correct derivative. Any equivalent.	B1
	$=\frac{1}{2}\left(1+\tan^2 x-\left(1+\cot^2 x\right)\right) \quad \left\{=\frac{1}{2}\left(\tan^2 x-\cot^2 x\right)\right\}$	Applies $\sec^2 x=\pm\tan^2 x\pm 1$ and $\operatorname{cosec}^2 x=\pm\cot^2 x\pm 1$ to their derivative	M1
	$\left(\frac{\mathrm{d}y}{\mathrm{d}x}\right)^2=\frac{1}{4}\left(\tan^4 x+\cot^4 x-2\tan^2 x\cot^2 x\right)$	Squares to a 3 term expression (or 4 if middle terms uncollected) $2\tan^2 x\cot^2 x$ can be seen as 2 **Requires previous M mark.**	**d**M1
	$\left\{1+\left(\frac{\mathrm{d}y}{\mathrm{d}x}\right)^2=1+\frac{1}{4}\left(\tan^4 x+\cot^4 x-2\right)\right\}$ $\Rightarrow \frac{1}{4}\left(\tan^4 x+\cot^4 x+2\right)$ or $\frac{1}{4}\tan^4 x+\frac{1}{4}\cot^4 x+\frac{1}{2}$ **Not implied. Must be seen**	Adds the 1 and achieves either expression shown but allow the constant to be multiplied by $\tan^2 x\cot^2 x$ May be seen as e.g., $\frac{1}{2}\sqrt{\tan^4 x+\cot^4 x+2\tan^2 x\cot^2 x}$	A1
	$s=\int_{\frac{\pi}{6}}^{\frac{\pi}{3}}\sqrt{1+\left(\frac{\mathrm{d}y}{\mathrm{d}x}\right)^2}\,\mathrm{d}x=\frac{1}{2}\int_{\frac{\pi}{6}}^{\frac{\pi}{3}}\left(\tan^2 x+\cot^2 x\right)\mathrm{d}x$ * Allow $\int\frac{1}{2}\left(\tan^2 x+\cot^2 x\right)$ or $\frac{1}{2}\int\tan^2 x+\cot^2 x$	M1: Applies the arc length formula with their $\frac{\mathrm{d}y}{\mathrm{d}x}$ A1: Correct result achieved with no clear mathematical errors seen. Condone omission of "dx" and/or limits and **occasional** missing arguments.	M1 A1*
	Converting to sin & cos: likely to score max of 100010 unless tan & cot are convincingly recovered		**(6)**
Way 2 Squares first then identities	$y=\frac{1}{2}\left(\tan x+\cot x\right)\Rightarrow \frac{\mathrm{d}y}{\mathrm{d}x}=\frac{1}{2}\left(\sec^2 x-\operatorname{cosec}^2 x\right)$ oe	Correct derivative. Any equivalent.	B1
	$\left(\frac{\mathrm{d}y}{\mathrm{d}x}\right)^2=\frac{1}{4}\left(\sec^4 x+\operatorname{cosec}^4 x-2\sec^2 x\operatorname{cosec}^2 x\right)$	Squares a derivative **of the correct form** to obtain a 3 (or 4 if middle terms uncollected) term expression.	M1
	$=\frac{1}{4}\left(\left(1+\tan^2 x\right)^2+\left(1+\cot^2 x\right)^2-2\left(1+\tan^2 x\right)\left(1+\cot^2 x\right)\right)$ $\left\{=\frac{1}{4}\left(1+2\tan^2 x+\tan^4 x+1+2\cot^2 x+\cot^4 x-2-2\tan^2 x-2\cot^2 x-2\tan^2 x\cot^2 x\right)\right\}$	Applies $\sec^2 x=\pm\tan^2 x\pm 1$ **twice and** $\operatorname{cosec}^2 x=\pm\cot^2 x\pm 1$ **twice**. **Requires previous M mark.**	**d**M1
	$\left\{1+\left(\frac{\mathrm{d}y}{\mathrm{d}x}\right)^2=1+\frac{1}{4}\left(\tan^4 x+\cot^4 x-2\right)\right\}$ $\Rightarrow \frac{1}{4}\left(\tan^4 x+\cot^4 x+2\right)$ or $\frac{1}{4}\tan^4 x+\frac{1}{4}\cot^4 x+\frac{1}{2}$ **Not implied. Must be seen**	Adds the 1 and achieves either expression shown but allow the constant to be multiplied by $\tan^2 x\cot^2 x$ May be seen as e.g., $\frac{1}{2}\sqrt{\tan^4 x+\cot^4 x+2\tan^2 x\cot^2 x}$	A1
	$s=\int_{\frac{\pi}{6}}^{\frac{\pi}{3}}\sqrt{1+\left(\frac{\mathrm{d}y}{\mathrm{d}x}\right)^2}\,\mathrm{d}x=\frac{1}{2}\int_{\frac{\pi}{6}}^{\frac{\pi}{3}}\tan^2 x+\cot^2 x\,\mathrm{d}x$ * Allow $\int\frac{1}{2}\left(\tan^2 x+\cot^2 x\right)$ or $\frac{1}{2}\int\tan^2 x+\cot^2 x$	M1: Applies the arc length formula with their $\frac{\mathrm{d}y}{\mathrm{d}x}$ A1: Correct result achieved with no clear mathematical errors seen. Condone omission of "dx" and/or limits and **occasional** missing arguments.	M1 A1*
	Converting to sin & cos: likely to score max of 100010 unless tan & cot are convincingly recovered		**(6)**

Question Number	Scheme	Notes	Marks
3(b)	$\frac{1}{2}\int_{\frac{\pi}{6}}^{\frac{\pi}{3}}\left(\tan^2 x+\cot^2 x\right)\mathrm{d}x=\frac{1}{2}\int_{\frac{\pi}{6}}^{\frac{\pi}{3}}\left(\sec^2 x-1+\mathrm{cosec}^2 x-1\right)\mathrm{d}x$	Applies $\tan^2 x=\pm\sec^2 x\pm 1$ and $\cot^2 x=\pm\mathrm{cosec}^2 x\pm 1$ to the integral	M1
	Work in sin and cos must use identities (sign errors only) and lead to a result of the form below after integration condoning the absence of a term in x but allow the last M to be available following a completed attempt at integration.		
	$=\frac{1}{2}\left[\tan x-\cot x-2x\right]_{\frac{\pi}{6}}^{\frac{\pi}{3}}$	M1: For $\pm\sec^2 x\to\pm\tan x$ and $\pm\mathrm{cosec}^2 x\to\pm\cot x$ **Requires previous M mark.** A1: Correct integration. Limits not required.	**d**M1 A1
	$\frac{1}{2}\left(\tan\frac{\pi}{3}-\cot\frac{\pi}{3}-\frac{2\pi}{3}-\left(\tan\frac{\pi}{6}-\cot\frac{\pi}{6}-\frac{2\pi}{6}\right)\right)$ $\left\{\frac{1}{2}\left(\sqrt{3}-\frac{2\pi}{3}-\frac{\sqrt{3}}{3}-\left(\frac{\sqrt{3}}{3}-\frac{\pi}{3}-\sqrt{3}\right)\right)\right\}$	Applies the limits (see note below) following any completed attempt at integration. Allow slips provided it is a clear attempt at $\mathrm{f}\left(\frac{\pi}{3}\right)-\mathrm{f}\left(\frac{\pi}{6}\right)$	M1
	Correct answer in any exact simplified form with 2 terms e.g. $\frac{1}{2}\left(\frac{4\sqrt{3}}{3}-\frac{\pi}{3}\right),\ \frac{2\sqrt{3}}{3}-\frac{\pi}{6},\ \frac{2}{\sqrt{3}}-\frac{\pi}{6},\ \frac{1}{3}\left(2\sqrt{3}-\frac{\pi}{2}\right),\ \frac{4\sqrt{3}-\pi}{6}$		A1
	Note they may apply the limits $\frac{\pi}{4}\&\frac{\pi}{6}$ or $\frac{\pi}{3}\&\frac{\pi}{4}$ and then double the result.		**(5)**
	Just the answer or decimal answer (0.6311017628) is 0/5		**Total 11**