Question	Scheme		Marks	AOs
12(a)	$k\sin^2 t\cos t$		M1	1.1b
	$3\sin^2 t\cos t$		A1	1.1b
			(2)	
(b)	$2\sin t\cos t - \sin t = 0$		M1	3.1a
	$\sin t(2\cos t - 1) = 0$ $\cos t = \frac{1}{2} \Rightarrow t = \ldots$	$\sin t(2\cos t - 1) = 0$ $(2x-1)\sqrt{1-x^2} = 0 \Rightarrow x = \frac{1}{2}$ $\cos t = \frac{1}{2} \Rightarrow t = \ldots$	dM1	1.1b
	$t = \frac{\pi}{3}$ clearly identified		A1	1.1b
			(3)	
(c)	$\frac{\mathrm{d}x}{\mathrm{d}t} = -\sin t$		B1	1.1b
	$\int y\,\mathrm{d}x = \int(\sin 2t - \sin t)\ "(-\sin t)"\mathrm{d}t$		M1	2.1
	$\int(\sin^2 t - 2\sin^2 t\cos t)\mathrm{d}t$		A1	1.1b
	$\int\left(\frac{1}{2} - \frac{1}{2}\cos 2t - 2\sin^2 t\cos t\right)\mathrm{d}t$		dM1	3.1a
	$\int_{\frac{\pi}{3}}^{0}\left(\frac{1}{2} - \frac{1}{2}\cos 2t - 2\sin^2 t\cos t\right)\mathrm{d}t = \int_{0}^{\frac{\pi}{3}}\left(2\sin^2 t\cos t + \frac{1}{2}\cos 2t - \frac{1}{2}\right)\mathrm{d}t$		A1	2.1
			(5)	
(d)	$\ldots\sin^3 t + \ldots\sin 2t - \frac{1}{2}t$		M1	1.1b
	$\frac{2}{3}\sin^3 t + \frac{1}{4}\sin 2t - \frac{1}{2}t$		A1ft	1.1b
	$\frac{2}{3}\sin^3\frac{\pi}{3} + \frac{1}{4}\sin\frac{2\pi}{3} - \frac{\pi}{6}\ \{-0\}$		dM1	3.1a
	$\frac{3\sqrt{3}}{8} - \frac{\pi}{6}$		A1	2.1
			(4)	
				(14 marks)

Notes:

(a)

M1: Arrives at the form $\ldots\sin^2 t\cos t$ but allow e.g. $\ldots\sin^2 x\cos x$

A1: $3\sin^2 t\cos t$ cao. Do not worry about what they call it. Must be in terms of *t*.

(b)

M1: For the key step in using $\sin 2t = 2\sin t\cos t$ to write $\{y=\}2\sin t\cos t - \sin t$ and sets equal to 0

dM1: Attempts to factorise and

Way 1: solves for $\cos t$ and then solves for *t*

Way 2: replaces $\cos t$ with *x* and factorises, so either $(2x-1)\sqrt{1-x^2}=0$ or $(2x-1)\sin t = 0$, solves for *x* and then solves for *t*

A1: $t=\frac{\pi}{3}$ clearly identified (other solutions should be attributed to *P* or *S* or discarded).

(c)

B1: Differentiates *x* with respect to *t* correctly, i.e., $\frac{dx}{dt}=-\sin t$

M1: For the key step in setting up the parametric integration:

$\int y\,dx = \int(\sin 2t - \sin t)\text{"}(-\sin t)\text{"}dt$ following through on their $\frac{dx}{dt}$

A1: Reaches $\int\left(\sin^2 t - 2\sin^2 t\cos t\right)dt$

dM1: Uses $\pm\cos 2t = \pm 1 \pm \sin^2 t$ to replace $\sin^2 t$ in the integral.

A1: Reaches $\int_0^{\frac{\pi}{3}}\left(2\sin^2 t\cos t + \frac{1}{2}\cos 2t - \frac{1}{2}\right)dt$ with no errors and with limits correctly shown in at least one previous step.

(d)

M1: Integrates their $\int_\alpha^\beta\left(2\sin^2 t\cos t + a\cos 2t + b\right)\,dt$ to $\frac{2}{3}\sin^3 t + \ldots\sin 2t + \ldots t\{+c\}$

A1ft: $\frac{2}{3}\sin^3 t + \frac{1}{4}\sin 2t - \frac{1}{2}t$ Allow $\frac{2}{3}\sin^3 t + \frac{a}{2}\sin 2t + bt$ following through on their *a* and *b* only

dM1: Substitutes in their limits and subtracts either way round.

There is no need to see the $-(0)$ from the lower limit if it is using $t=0$.

A1: $\frac{3\sqrt{3}}{8}-\frac{\pi}{6}$ cao