Question Number	Scheme	Marks
4(a)	Moments about AC	M1
	$18\times\frac{3a}{2}-2\pi\times\frac{8a}{3\pi}+2\pi\left(3a+\frac{8a}{3\pi}\right)=18\overline{y}$	A1
	NB: valid to use $18\times\frac{3a}{2}-2\pi\times d+2\pi\left(3a+d\right)=18\overline{y}$ for $d\neq 0$ without stating value for d Use of $d=0\Rightarrow$ M0	
	$\left(27a+6\pi a=18\overline{y}\right)$	A1
	The same incorrect distance used twice in place of $\frac{8a}{3\pi}$ is one error The same incorrect area for the semicircle used twice is one error.	A1 (4)
	$27a+6\pi a=18\overline{y}\ \Rightarrow\overline{y}=\frac{9+2\pi}{6}a$ *	
4b	$M\overline{x}+kM\times 6a=\left(1+k\right)M\overline{x}_T$	M1
	$3a+6ak=\left(1+k\right)\overline{x}_T$ o.e.	A1
	$M\overline{y}=\left(1+k\right)M\overline{y}_T$	M1
	$\left(1+k\right)\overline{y}_T=\frac{9+2\pi}{6}a$	A1
NB	For their second equation they could use $\tan\phi$ and their $\overline{x}_T$ or $\overline{y}_T$ to form an expression for $\overline{y}_T$ or $\overline{x}_T$	
	$\tan\phi=\frac{3}{2}=\frac{\overline{x}_T}{\overline{y}_T}\ \Rightarrow\ \frac{3}{2}=\frac{6\left(3a+6ak\right)}{\left(9+2\pi\right)a}$	DM1
	$\Rightarrow k=\frac{\pi}{12}-\frac{1}{8}$ or equivalent	A1 (6)
	Notes	
M1	All terms. Dimensionally correct. Condone sign errors	
A1	Unsimplified equation with at most one error.	
A1	Correct unsimplified equation	
A1	Obtain **given answer** from sufficient correct exact working. Must see a separate conclusion for $\overline{y}$.	
NB	e.g. $\overline{y}_T=\frac{2\left(3+6k\right)a}{3\left(1+k\right)}$	
DM1	Form equation in k and solve for k.Dependent on the previous 2 M marks.	
A1	$k=0.137\ \ \left(0.14\right)$ or better See over for alternative solution to 4(b)	

Question Number	Scheme	Marks
4(b) alt	Distance of original c of m from vertical through A	M1
	$\left(\frac{9+2\pi}{6}a-2a\right)\times\sin\phi\left(=\frac{\sqrt{13}(2\pi-3)a}{26}\right)$	A1
	Distance of additional particle from vertical through A	M1
	$6a\times\cos\phi\left(=\frac{12a}{\sqrt{13}}\right)$	A1
	$mg\times\frac{\sqrt{13}(2\pi-3)a}{26}=kmg\times\frac{12a}{\sqrt{13}}$	DM1
	$k=0.137\quad(0.14)$	A1 **(6)**
	Notes	**[10]**
M1		
A1	Or equivalent	
M1	Distance of additional particle from vertical through A	
M1		
A1	Or equivalent	
DM1	Moments about A Dependent on the 2 previous M marks	
A1	(0.14 or better)	