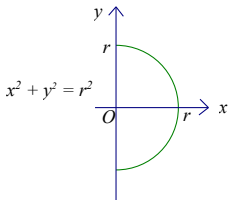
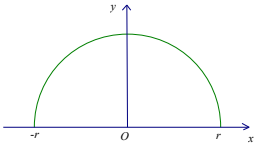
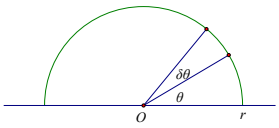
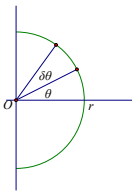
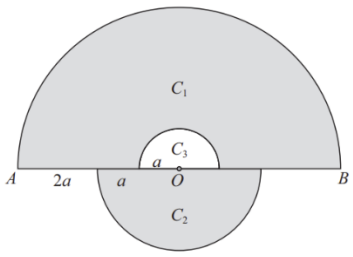
Question Number	Answer	Mark
3(a) ALT 1		
	Use $y = \sqrt{r^2 - x^2}$ in an integral of the form $\lambda \int xy \, dx$	M1
	Method to take moments about the y-axis $\lambda \int x(r^2 - x^2)^{\frac{1}{2}} \, dx = \cdots (r^2 - x^2)^{\frac{3}{2}}$	DM1
	$= \cdots \left(-\frac{1}{3}\right)(r^2 - x^2)^{\frac{3}{2}}$	A1
	Use limits 0 and r in a complete method $\frac{2\int_0^r xy \, dx}{\frac{1}{2}\pi r^2}$ For a quadrant: $\frac{\int_0^r xy \, dx}{\frac{1}{4}\pi r^2}$ N.B. Complete solution for a quadrant must include reference to symmetry.	DM1
	Obtain given answer from correct working $\left(\frac{\frac{2}{3}r^2}{\frac{1}{2}\pi r^2} = \right) \quad \frac{4r}{3\pi} \quad *$	A1*
		(5)
3(a) ALT2		
	Use $y = \sqrt{r^2 - x^2}$ in an integral of the form $\lambda \int y^2 \, dx$	M1
	Method to take moments about the x-axis $\lambda \int (r^2 - x^2) \, dx = \cdots \left(xr^2 - \frac{x^3}{3}\right)$	DM1
	$\frac{1}{2}\left(xr^2 - \frac{x^3}{3}\right)$	A1
	Use limits $-r$ and r in an expression of the form $ar^2x + bx^3$ in a complete method. $\frac{\int_{-r}^{r} \frac{1}{2}y^2 \, dx}{\frac{1}{2}\pi r^2}$ or $\frac{2 \times \int_0^r \frac{1}{2}y^2 \, dx}{\frac{1}{2}\pi r^2}$ For a quadrant:	DM1

	$\dfrac{\int_0^r \frac{1}{2}y^2\,\mathrm{d}x}{\frac{1}{4}\pi r^2}$	
	$\left(\dfrac{\frac{2}{3}r^2}{\frac{1}{2}\pi r^2} = \right)\ \dfrac{4\mathrm{r}}{3\pi}$ * N.B. Complete solution for a quadrant must include reference to symmetry.	A1*
		(5)
3(a) ALT3	 $\frac{2}{3}r\sin\theta$  $\frac{2}{3}r\cos\theta$	
	Use of $\frac{2}{3}r\sin\theta$ or $\frac{2}{3}r\cos\theta$ in the relevant integral	M1
	Method to take moments about the x-axis or y-axis $\int \frac{1}{2}r^2 \times \frac{2}{3}r\sin\theta\ \mathrm{d}\theta$ or $\int \frac{1}{2}r^2 \times \frac{2}{3}r\cos\theta\ \mathrm{d}\theta$	DM1
	$-\frac{1}{3}r^3\cos\theta$ or $\frac{1}{3}r^3\sin\theta$	A1
	Use limits 0 and π in an expression of the form $\mu r^3\cos\theta$ or limits $-\frac{\pi}{2}$ and $\frac{\pi}{2}$ in an expression of the form $\mu r^3\sin\theta$ in a complete method.	DM1
	$\left(\dfrac{\frac{2}{3}r^2}{\frac{1}{2}\pi r^2} = \right)\ \dfrac{4\mathrm{r}}{3\pi}$ *	A1*
		(5)
3(b)		
	<table><tr><td></td><td>area</td><td>C of M from O</td></tr><tr><td>large</td><td>$\frac{1}{2}\pi\times16a^2$ [16]</td><td>$\frac{4\times4a}{3\pi}$</td></tr><tr><td>medium</td><td>$\frac{1}{2}\pi\times4a^2$ [4]</td><td>$\frac{4\times2a}{3\pi}$</td></tr><tr><td>small</td><td>$\frac{1}{2}\pi\times a^2$ [1]</td><td>$\frac{4\times a}{3\pi}$</td></tr><tr><td>template</td><td>$\frac{1}{2}\pi\times19a^2$ [16+4-1]</td><td>d</td></tr></table>	B1 mass ratio B1 distance

	Moments about AB	M1
	$\frac{1}{2}\pi\times 19a^2d =$ $\frac{1}{2}\pi\times 16a^2\times\frac{16a}{3\pi}-\frac{1}{2}\pi\times 4a^2\times\frac{8a}{3\pi}-\frac{1}{2}\pi\times a^2\times\frac{4a}{3\pi}$	A1
	$\left(19d=\frac{256a}{3\pi}-\frac{32a}{3\pi}-\frac{4a}{3\pi}\right)\quad d=\frac{220a}{57\pi}$	A1
	$tan\,\theta\,^\circ=\frac{"\left(\frac{220a}{57\pi}\right)"}{4a}$	M1
	$\theta=17$	A1
		(7)
		(12)
	Notes for Question 3	
3(a) ALT1		
M1	Use $y=\sqrt{r^2-x^2}$ in an integral of the form $\lambda\int xy\,\mathrm{d}x$. No need to attempt integration.	
DM1	Dependent on the previous M. Method to take moments about the y-axis. Ignore constants. Integrate to the required form. $\lambda\int x(r^2-x^2)^{\frac{1}{2}}\,\mathrm{d}x=\cdots(r^2-x^2)^{\frac{3}{2}}$	
A1	Correct integration (constant may be processed later)	
DM1	Dependent on the two preceding M marks Use limits 0 and r in a complete method $\frac{2\int_0^r xy\,\mathrm{d}x}{\frac{1}{2}\pi r^2}$ e.g. $\frac{0+\frac{2}{3}r^3}{\frac{1}{2}\pi r^2}$ Quadrant method must use $\frac{1}{4}\pi r^2$	
A1*	Obtain given answer from complete and correct algebraic integration. N.B. Complete solution for a quadrant must include reference to symmetry.	
3(a) ALT2		
M1	Integrate $y=\sqrt{r^2-x^2}$ in an integral of the form $\lambda\int y^2\,\mathrm{d}x$. No need to attempt integration	
DM1	Dependent on the first M1. Method to take moments about the x-axis. Ignore constants. Integrate to the required form.	

	$\lambda \int r^2 - x^2 \ \mathrm{d}x = \cdots xr^2 - \frac{x^3}{3}$	
A1	Correct integration (constant may be processed later)	
DM1	Dependent on the two preceding M marks. Use limits $-r$ and r in a complete method $\frac{\int_{-r}^{r} \frac{1}{2}y^2 \, \mathrm{d}x}{\frac{1}{2}\pi r^2}$ or $\frac{2\times \int_{0}^{r} \frac{1}{2}y^2 \, \mathrm{d}x}{\frac{1}{2}\pi r^2}$ e.g. $\frac{\frac{1}{2}\left(r^3 - \frac{1}{3}r^3 - \left(-r^3 + \frac{1}{3}r^3\right)\right)}{\frac{1}{2}\pi r^2}$ Quadrant method must use $\frac{1}{4}\pi r^2$	
A1*	Obtain given answer from complete and correct algebraic integration. N.B. Complete solution for a quadrant must include reference to symmetry.	
3(a) **ALT3**		
M1	Use of $\frac{2}{3}r\sin\theta$ or $\frac{2}{3}r\cos\theta$ in the relevant integral. No need to attempt integration.	
DM1	Dependent on the first M1. Ignore constants. Take moments and integrate to the required form. $\ldots r^3\cos\theta$ or $\ldots r^3\sin\theta$	
A1	$-\frac{1}{3}r^3\cos\theta$ or $\frac{1}{3}r^3\sin\theta$ (constant may be processed later)	
DM1	Dependent on the two preceding M marks. Use limits 0 and π in an expression of the form $\gamma r^3\cos\theta$ or use limits $-\frac{1}{2}\pi$ and $\frac{1}{2}\pi$ in an expression of the form $\gamma r^3\sin\theta$ in a complete method.	
A1*	Obtain given answer from complete and correct algebraic integration.	
(b)		
B1	Correct mass ratios	
B1	Correct distances (ignore signs)	
M1	Use their mass ratios and distances to take moments about *AB* or a parallel axis. Must form a dimensionally **consistent** equation. Condone sign errors. Accept mass ratio of 21 instead of 19.	
A1	Correct unsimplified equation.	
A1	Accept, $1.228...a$	
M1	Use their *d* with trig to form a dimensionally correct equation in a relevant angle. Accept the reciprocal and consistent cancelled *a*'s.	

	$\tan\theta° = \dfrac{\dfrac{220a}{57\pi}}{4a}\left(=\dfrac{55}{57\pi}\right)$	
A1	Or better: 17.073… (only)	

4. A light elastic **spring**, of natural length $4a$ and modulus of elasticity $3mg$, has one end attached to a fixed point A.
A particle of mass m is attached to the other end of the spring. The particle hangs vertically below A.

The particle is pulled vertically downwards to the point B, where $AB = 7a$, and released from rest.
Air resistance is ignored.

(a) Find the acceleration of the particle at the instant it is released from rest.

(3)

(b) By considering energy, find in terms of g and a, the speed of the particle when it is a distance $5a$ below A.

(5)

The particle first comes to instantaneous rest at the point C, where $AC = ka$ and k is a constant.

(c) By considering energy, find the value of k.

(5)