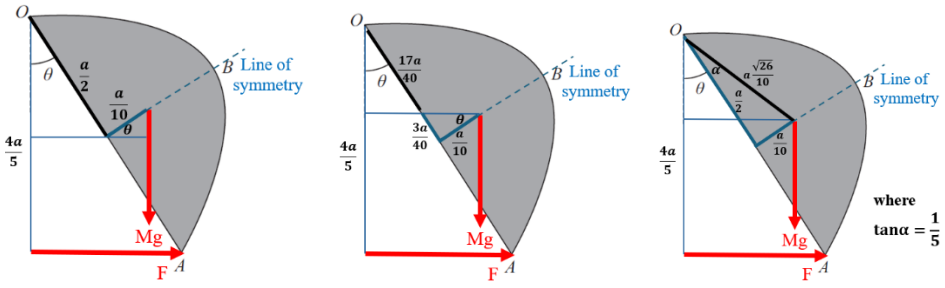
Question Number	Scheme	Marks
	Gain = Loss $\quad \frac{1}{2}mV^2 - \frac{1}{2}mag + \frac{mg}{2a}\left(\frac{3a}{2}\right)^2 - \frac{mg}{2a}\left(\frac{a}{2}\right)^2 = mg \times 2a$	
A1	Correct unsimplified equation	
A1	Correct answer in terms of a and g, accept $1.3\sqrt{ag}$ or better	

Question Number	Scheme	Marks
4(a)	Use of $\frac{1}{2}\int y^2 \, \mathrm{d}x$ with $y = \frac{1}{a}(ax - x^2)$ to integrate the expression $\left(\frac{1}{2}\right)\left(\frac{1}{a}(ax-x^2)\right)^2$ oe	M1
	Correct integration $\left(\frac{1}{2}\right)\frac{1}{a^2}\left[\frac{a^2x^3}{3} - \frac{2ax^4}{4} + \frac{x^5}{5}\right]$	A1
	Use of $\int y \, \mathrm{d}x$ with $y = \frac{1}{a}(ax - x^2)$ to integrate the expression $\frac{1}{a}(ax - x^2)$ oe	M1
	Correct integration $\frac{1}{a}\left[\frac{ax^2}{2} - \frac{x^3}{3}\right]$	A1
	Correct use of centre of mass formula for $\bar{y}$ with $y = \frac{1}{a}(ax - x^2)$ $\bar{y} = \frac{\frac{1}{2}\int_0^a \frac{1}{a^2}(ax-x^2)^2 \mathrm{d}x}{\int_0^a \frac{1}{a}(ax-x^2)\mathrm{d}x} \quad \left(= \frac{\frac{a^3}{60}}{\frac{a^2}{6}}\right)$	M1
	$(\bar{y} =) \frac{1}{10}a$	A1

Question Number	Scheme	Marks
		(6)
4(b)	$\bar{x} = \frac{1}{2}a$	B1
	Horizontal distance of G from the vertical at O Examples of valid methods  $\frac{a}{2}\sin\theta + \frac{a}{10}\cos\theta$ $\quad$ $\frac{17a}{40}\sin\theta + \frac{a}{8}$ $\quad$ $\frac{a\sqrt{26}}{10}\sin(\theta+\alpha)$	M1
	Correct horizontal distance $\frac{19a}{50}$	A1
	Moments equation about O to form an equation in F, M, θ (and g)	DM1
	$Fa\cos\theta = Mg \times d$	A1
	$F = \frac{19Mg}{40}$ oe	A1
		(6)
		(12)
	Notes for question 4	
4(a)		
M1	Attempt to integrate $\frac{1}{2}y^2$ with $y = \frac{1}{a}(ax - x^2)$. Must see at least two powers of x increasing by 1. Ignore any limits and condone missing $\frac{1}{2}$. The correct expansion to integrate is $\left(\frac{1}{2}\right)\frac{1}{a^2}(a^2x^2 - 2ax^3 + x^4)$ oe. Condone a slip when expanding the brackets before integration.	
A1	Correct integrated expression (ignore limits, condone missing $\frac{1}{2}$)	
M1	Attempt to integrate y with $y = \frac{1}{a}(ax - x^2)$. Must see both powers of x increase by 1. Ignore any limits.	
A1	Correct integrated expression (ignore limits)	

Question Number	Scheme	Marks
M1	Complete method to find $\bar{y}$. Use of the correct formula (up the right way). If ρ appears it must appear in both numerator and denominator. Limits must be correct and $\frac{1}{2}$ must be present. $$\bar{y} = \frac{\frac{1}{2}\int_0^a \frac{1}{a^2}(ax - x^2)^2 \,\mathrm{d}x}{\int_0^a \frac{1}{a}(ax - x^2)\mathrm{d}x}$$	
A1	Correct answer, $\frac{1}{10}a$ or $0.1a$ oe	
4(b)		
B1	$\bar{x} = \frac{1}{2}a$ seen or implied. May be seen on diagram, embedded in a length eg $\frac{1}{2}a\sin\theta$ or found from first principles using $\bar{x}\int_0^a y \,\mathrm{d}x = \int_0^a xy \,\mathrm{d}x$	
M1	A complete method to obtain the required horizontal distance from G to the vertical at O. For example, method to find the lengths of two right-angled triangles that sum to the required distance. Condone sin/cos confusion.	
A1	Correct horizontal distance	
DM1	Dependent on first method mark. Moments about O, using the horizontal distance, to obtain an equation in F, M and θ (and a). Dimensionally correct with all required terms of the correct structure and no extras. Condone sin/cos confusion. Missing g is an accuracy error.	
A1	Correct unsimplified equation.	
A1	Accept $0.48Mg$ or $0.475Mg$ (must be in terms of M and g)	