Question Number	Scheme	Marks
2(a)	$mg = \frac{K}{R^2}$	M1
	$K = mgR^2$ *	A1*
		(2)
(b)	Equation of motion: $\frac{mgR^2}{x^2} = -mv\frac{\mathrm{d}v}{\mathrm{d}x}$	M1
	Integrate: $g\int \frac{R^2}{x^2}\mathrm{d}x = -\int v\,\mathrm{d}v$	DM1
	$-g\frac{R^2}{x} = -\frac{1}{2}v^2 \quad (+c)$	A1ft
	Initial conditions: $x = 3R,\ v = V \Rightarrow -g\frac{R^2}{3R} = -\frac{1}{2}V^2 + c$	M1
	$c = -\frac{Rg}{3} + \frac{1}{2}V^2$	A1
	$\frac{1}{2}v^2 = -\frac{Rg}{3} + \frac{1}{2}V^2 + g\frac{R^2}{R}$	M1
	$v = \sqrt{V^2 + \frac{4Rg}{3}}$	A1
		(7)
		(9 marks)

Notes	
(a) M1	Sets "F" = mg **and** $x = R$
A1*	Deduces given answer from correct working only with no errors seen. Do not allow recovery from an erroneous negative sign. Condone e.g. $F = mg = \frac{K}{x^2}$ followed by $mg = \frac{K}{R^2}$ Allow use of $F = \frac{GMm}{x^2}$ with $x = R$ and $F = mg$ as part of correct working.
(b) M1	Attempts equation of motion with acceleration in the form $v\frac{\mathrm{d}v}{\mathrm{d}x}$. Allow without minus sign.
DM1	Separates the variables and attempts to integrate. Dependent on first M1.
A1ft	Correct integration but ft missing minus sign. Condone missing constant of integration.
M1	Substitutes $x = 3R$, $v = V$ to form an equation for c.
A1	Correct expression for c seen or implied or $3R$ and V correctly substituted
M1	Substitute $x = R$ and find expression for v or v^2.
A1	cao

Alt (b) M1	Attempts equation of motion with acceleration in the form $v\frac{\mathrm{d}v}{\mathrm{d}x}$. Allow without minus sign.
DM1	Separates the variables and attempts to integrate. Dependent on first M1.
A1ft	Correct integration but ft missing minus sign.
M1	Definite integration with limits $3R$ and R, V and "v" $\left[g\frac{R^2}{x}\right]_{3R}^{R}=\left[\frac{1}{2}v^2\right]_{V}^{v} \quad \Rightarrow \quad \left[gR-\frac{gR}{3}\right]=\left[\frac{1}{2}v^2-\frac{1}{2}V^2\right]$
A1	Correct substitution of $3R$ and V seen or implied
M1	Substitute $x = R$ and find expression for v or v^2.
A1	Cao

Alt (b) M1	Forms work-energy equation. Allow without minus sign.
DM1	$\frac{1}{2}mv^2-\frac{1}{2}mV^2=-\int_{3R}^{R}\frac{mgR^2}{x^2}\mathrm{d}x$.
A1ft	Correct integration $\frac{1}{2}v^2-\frac{1}{2}V^2=\left[\frac{gR^2}{x}\right]_{3R}^{R}$
M1	Definite integration with $3R$ and R correct way round
A1	Correct substitution of $3R$ seen or implied and k.e. right way round
M1	Substitute $x = R$ and find expression for v or v^2. $\frac{1}{2}v^2=\frac{1}{2}V^2+\frac{gR^2}{R}-\frac{gR^2}{3R}$
A1	cao

3. A particle P is moving in a straight line with simple harmonic motion about the fixed point O as centre.

When P is a distance 0.02 m from O, the speed of P is $0.3\,\text{m s}^{-1}$ and the magnitude of the acceleration of P is $0.5\,\text{m s}^{-2}$

(a) Find the period of the motion.

(4)

The amplitude of the motion is a metres.

Find

(b) the value of a,

(3)

(c) the total length of time during each complete oscillation for which P is within $\frac{1}{2}a$ metres of O.

(4)

(Total for Question 3 is 11 marks)