Question Number	Answer		Mark
17(a)	Use of $g = \frac{GM}{r^2}$	(1)	
	$g = 0.40$ N kg^{-1} [allow m s^{-2} for unit] [The correct value is 0.4045 to 4 sig figs, as the value is 0.404459…]	(1)	2
	Example of calculation $g = \frac{6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2} \times 3.1 \times 10^{21}\ \text{kg}}{(7.15 \times 10^5\ \text{m})^2} = 0.404\ \text{N kg}^{-1}$		
17(b)	Equates $F = \frac{GMm}{r^2}$ with $F = m\omega^2 r$	(1)	
	Use of $\omega = \frac{2\pi}{T}$	(1)	
	$T_M = 9.7 \times 10^9$ s	(1)	
	Conversion between seconds and years [Must see a unit for *T*, either in MP3 or MP4]	(1)	
	Calculates ratio of orbital time of Makemake with orbital time of Pluto [Ratio includes a percentage calculation]	(1)	
	Comparison of values **and** consistent conclusion	(1)	
	OR		
	Equates $F = \frac{GMm}{r^2}$ with $F = \frac{mv^2}{r}$	(1)	
	Use of $v = \frac{2\pi r}{T}$	(1)	
	$T_M = 9.7 \times 10^9$ s	(1)	
	Conversion between seconds and years	(1)	
	Calculates ratio of orbital time of Makemake with orbital time of Pluto [Ratio includes a percentage calculation]	(1)	
	Comparison of values **and** consistent conclusion	(1)	6
	Example of calculation $\frac{GMm}{r^2} = m\omega^2 r$ $\omega = \sqrt{\frac{GM}{r^3}} = \sqrt{\frac{6.67 \times 10^{-1}\ \text{N m}^2\ \text{kg}^{-1} \times 1.99 \times 10^{30}\ \text{kg}}{(6.80 \times 10^{12}\ \text{m})^3}}$ $\therefore \omega = 6.50 \times 10^{-10}\ \text{rad}\ s^{-1}$ $T = \frac{2\pi}{\omega} = \frac{2\pi\ \text{rad}}{6.50 \times 10^{-1}\ \text{rad s}^{-1}} = 9.67 \times 10^9\ \text{s} = \frac{9.67 \times 10^9\ \text{s}}{3.15 \times 10^7\ \text{s year}^{-1}}$ $= 307\ \text{year}$ $\text{orbital time ratio} = \frac{307\ \text{year}}{248\ \text{year}} = 1.24$ The orbital time of Makemake is 24% greater than that of Pluto, so website statement is not quite accurate		
	Total for question 17		**8**