Name of the Student:_____
Max. Marks : 24 Marks **Time : 24 Minutes**

Mark Schemes

Q1.

Question Number	Acceptable answers	Additional guidance	Mark
	• Use of $F = k\Delta x$ **(1)** • $k = 14.4$ N m^{-1} **(1)** • Use of $T = 2\pi\sqrt{\frac{m}{k}}$ **(1)** • Use of $f = 1/T$ **(1)** • $f = 2.4$ Hz **(1)**	Example of calculation: $k = mg/\Delta x = 66\times 10^{-3}$ kg $\times$ 9.81m s^{-2})/4.5 $\times$ 10^{-2} m = 14.4 N m^{-1} $T = 2\pi(0.066/14.4.0)^{1/2} = 0.425$ s $f=1/T = 1/0.425 = 2.35$ Hz	5

Q2.

Question Number	Acceptable answers	Additional guidance	Mark
(a)	• use of $F = Gm_1m_2/r^2$ **(1)** • force = 6.5 $\times$ 10^{31} N **(1)**	Example of calculation $F = 6.67 \times 10^{-11}$ N m^2 kg^{-2} $\times$ 29 $\times$ 1.99 $\times$ 10^{30} kg $\times$ 36 $\times$ 1.99 $\times$ 10^{30} kg / (6.5 $\times$ 10^{10} m)^2 force = 6.5 $\times$ 10^{31} N	2

Question Number	Acceptable answers	Additional guidance	Mark
(b)	**Either** • use of $F = mv^2/r$ ecf from (a) **(1)** • use of $v = 2\pi r/T$ **(1)** • $T = 1.1 \times 10^6$ s **(1)** **Or** • use of $F = m\omega^2 r$ ecf from (a) **(1)** • use of $\omega = 2\pi/T$ **(1)** • $T = 1.1 \times 10^6$ s **(1)**	Example of calculation $F = mv^2/r = m(2\pi r/T)^2/r$ $T^2 = 4\pi^2 mr/F$ = $4\pi^2$ $\times$ 29 $\times$ 1.99 $\times$ 10^{30} kg $\times$ 3.6 $\times$ 10^{10} m / 6.5 $\times$ 10^{31} N = 1.21 $\times$ 10^{12} s^2 T = 1.12 $\times$ 10^6 s = 18700 min = 312 hours = 13 days	3

Q3.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	• Satellite would always be above the same point on the Earth's surface (1) • So that contact/communication with the space station would be maintained at all times (1)		2
(ii)	Use of $F = \frac{GMm}{r^2}$ with $F = m\omega^2 r$ (1) Use of $\omega = 2\pi/T$ (1) $r = 4.23 \times 10^7$ m (1) $h = 3.6 \times 10^7$ m (1) **OR** Use of $F = \frac{GMm}{r^2}$ with $F = \frac{mv^2}{r}$ (1) Use of $v = 2\pi r/T$ (1) $r = 4.23 \times 10^7$ m (1) $h = 3.6 \times 10^7$ m (1)	Example of calculation: $m\omega^2 r = \frac{GMm}{r^2}$ $\therefore \left(\frac{2\pi}{T}\right)^2 = \frac{GM}{r^3}$ $\therefore r = \sqrt[3]{\frac{GMT^2}{4\pi^2}}$ $r = \sqrt[3]{\frac{6.67\times10^{-11}\text{ N m}^2\text{ kg}^2 \times 6.00\times10^{24}\text{ kg} \times (8.64\times10^4\text{ s})^2}{4\pi^2}}$ $r = 4.23 \times 10^7$ m $h = r - R_E = 4.23 \times 10^7 - 6.4 \times 10^6$ m $= 3.59 \times 10^7$ m	4

Q4.

Question Number	Acceptable answers	Additional guidance	Mark
	• Converts hours to seconds (1) • Equates $F = \frac{GMm}{r^2}$ and $F = \frac{mv^2}{r}$ (1) Or Equates $F = \frac{GMm}{r^2}$ and $F = mr\omega^2$ • Substitutes $v = \frac{2\pi r}{T}$ or $\omega = \frac{2\pi}{T}$ (1) • $GM = \frac{4\pi^2 r^3}{T^2}$ derived and used (1) • $M = 1.9 \times 10^{27}$ kg (1)	Example of calculation: $171 \times 60 \times 60 = 615\,600$ s $\frac{GMm}{r^2} = \frac{mv^2}{r}$ and $v = \frac{2\pi r}{T}$ Leads to $GM = \frac{4\pi^2 r^3}{T^2}$ $M = \frac{4\pi^2 \times (1.07 \times 10^9\text{ m})^3}{6.67 \times 10^{-11}\text{ N m}^2\text{ kg}^{-2}(171 \times 3600)^2(\text{s})^2}$ $M = 1.91 \times 10^{27}$ kg	5

	OR • Converts hours to seconds • Use $v = \frac{2\pi r}{T}$ or $\omega = \frac{2\pi}{T}$ • Equates $F = \frac{GMm}{r^2}$ and $F = \frac{mv^2}{r}$ **Or** Equates $F = \frac{GMm}{r^2}$ and $F = mr\omega^2$ • $GM = r^3\,\omega^2$ **Or** $GM = v^2\,r$ derived and used • $M = 1.9 \times 10^{27}$ kg	Alternative method: $171 \times 60 \times 60 = 615\,600$ s $$v = \frac{2\pi \times 1.07 \times 10^9\ m}{615600\ s}$$ $v = 10900\ \text{ms}^{-1}$ $$\frac{GMm}{r^2} = \frac{mv^2}{r}$$ $$GM = v^2 r$$ $$M = \frac{(10900\ \text{ms}^{-1})^2 \times 1.07 \times 10^9\ \text{m}}{6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}}$$ $M = 1.9 \times 10^{27}$ kg Alternative via $\omega = 1.02 \times 10^{-5}$ rad s^{-1}	

Q5.

Question Number	Acceptable answers		Additional guidance	Mark
	• Use of $F = Gm_1m_2/r^2$ and $F = mv^2/r$ • Use of $v = 2\pi r/T$ • $T = 488\,000$ s = 5.7 days **OR** • Use of $F = Gm_1m_2/r^2$ and $F = m\omega^2 r$ • Use of $\omega = 2\pi/T$ • $T = 488\,000$ s = 5.7 days	**(1)** **(1)** **(1)**	'Use of' can be with any mass m for the orbiting body, or by algebraic combination with no m Example of calculation $F = GMm/r^2 = mv^2/r$ $GM/r^2 = v^2/r$ $v = 2\pi r/T$ $T^2 = 4\pi^2 r^3 / GM$ $= 4\pi^2 (1.34 \times 10^8\ \text{m})^3 / 6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-1} \times 5.97 \times 10^{24}\ \text{kg} = 2.39 \times 10^{11}\ \text{s}^2$ $T = 488\,000$ s = 5.7 days	**3**