Name of the Student:_____
Max. Marks : 17 Marks **Time : 17 Minutes**

Mark Schemes

Q1.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	• Use of $v = u + at$ (1) • $a = 0.81\ \text{m s}^{-2}$ (1)	Example of calculation $a = \frac{v-u}{t} = \frac{97\ \text{m s}^{-1}}{120\ \text{s}} = 0.808\ \text{m s}^{-2}$	2
(ii)	• Use of $s = ut + \frac{1}{2}at^2$ **Or** $v^2 = u^2 + 2as$ **Or** $s = \left(\frac{(v+u)}{2}\right)t$ (1) • Use of $v_{av} = \frac{s}{t}$ with $t = 320$ s (1) • $v_{av} = 75\ \text{m s}^{-1}$ (1)	Ecf acceleration from (a)(i) Example of calculation $s = ut + \frac{1}{2}at^2 = 0.5 \times 0.808\ \text{m s}^{-2}\ (120\ \text{s})^2 = 5820\ \text{m}$ $s_2 = 29900\ \text{m} - 5820\ \text{m} = 24\,080\ \text{m}$ $t = 440\text{s} - 120\ \text{s} = 320\ \text{s}$ $v_{av} = \frac{24\,080\ \text{m}}{320\ \text{s}} = 75.3\ \text{m s}^{-1}$	3

Q2.

Question Number	Acceptable answers	Additional guidance	Mark
	Use of $F = mv^2 / r$ with $F = Gm_1 m_2 / r^2$ (1) Use of $v = 2\pi r / T$ (1) $T = 6.64 \times 10^8$ s (= 21 years) (1) **Or** Use of $F = m\omega^2 r$ with $F = Gm_1 m_2 / r^2$ Use of $\omega = 2\pi / T$ $T = 6.64 \times 10^8$ s (= 21 years)	Example of calculation $F = Gm_1 m_2 / r^2 = m_2 v^2 / r = (2\pi r)^2 m_2 / rT^2$ $T^2 = 4\pi^2 r^3 / G m_1$ $= 4\pi^2 \times (1.9 \times 10^{14}\ \text{m})^3 / (6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2} \times 9.2 \times 10^{36}\ \text{kg})$ $T = 6.64 \times 10^8$ s (= 21 years)	3

Q3.

Question Number	Acceptable Answer		Additional Guidance	Mark
(i)	• Use of $F = \frac{GMm}{r^2}$ with $F = \frac{mv^2}{r}$	(1)	Example of calculation: $\frac{GMm}{r^2} = \frac{mv^2}{r}$ $r = \frac{GM}{v^2}$ $r = \frac{6.67\times10^{-11}\text{ N m}^2\text{kg}^{-2}\times5.97\times10^{24}\text{ kg}}{(7.59\times10^{3}\text{ m s}^{-1})^2}$ $r = 6.91\times10^{6}\text{m}$ $\therefore h = (6.91\times10^{6} - 6.37\times10^{6})\text{ m} = 5.42\times10^{5}\text{m}$	3
	• Correct substitutions to calculate r	(1)		
	• $h = 5.4\times10^{5}$m	(1)		
	OR			
	• Use of $g = \frac{GM}{r^2}$ to find value of g at orbit height	(1)		
	• Use of $a = \frac{v^2}{r}$ with value of g at orbit height	(1)		
	• $h = 5.4\times10^{5}$m	(1)		
(ii)	• Use of $GPE = \frac{GMm}{r}$	(1)	Example of calculation: $GPE = GMm\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$ $\therefore$GPE$= 6.67\times10^{-11}\text{Nm}^2\text{kg}^{-2} \times 5.97\times10^{24}\text{ kg} \times 11600\text{ kg}\left(\frac{1}{6.37\times10^{6}\text{m}} - \frac{1}{6.91\times10^{6}\text{m}}\right)$ $\therefore$GPE$= 5.67\times10^{10}$J	2
	• GPE = 5.7×10^{10} J (ecf from (a)(i))	(1)		

Question Number	Acceptable Answer	Additional Guidance	Mark
(iii)	• This would bring the gravitational potential energy closer to zero (1) • This would mean that the satellite would orbit at a greater height as $GPE \propto \frac{1}{r}$ (1) • To remain in orbit the centripetal acceleration must equal the gravitational field strength at the orbit height **Or** Since gravitational force smaller, $\frac{mv^2}{r}$ would be reduced (1) • (Hence) r is greater so v must be smaller **Or** $v^2 = \frac{GM}{r}$ and satellite would orbit at lower speed (1) **OR** • HST will have more kinetic energy at the original orbit height (1) • The centripetal force will be too small to keep it in this orbit (1) • The satellite would be travelling too fast, so it would move to a higher orbit (1) • (Hence) r is greater so v must be smaller **Or** $v^2 = \frac{GM}{r}$ and satellite would orbit at lower speed (1)		4