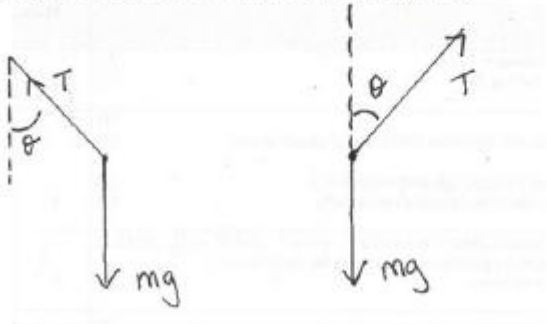
Name of the Student:_____
Max. Marks : 23 Marks **Time : 23 Minutes**

Mark Schemes

Q1.

Question Number	Answer	Mark
	Free body force diagram showing 2 forces only Weight/W/mg **(1)** Tension / T **(1)** (Each additional forces e.g. horizontal component or resultant force, 1 mark penalty) **If θ is angle to the vertical then**: (Resolving vertically): $T\cos\theta = mg$ **(1)** (Resolving horizontally): $T\sin\theta = mv^2/r$ **Or** $T\sin\theta = mr\omega^2$ **(1)** Derives $\tan\theta = v^2/rg$ **and** links to observations **Or** Derives $\tan\theta = r\omega^2/g$ **and** links to observations **(1)** If angle to horizontal is used candidates can score MP3 and 4.[then sin and cos swop over and tan of angle will be reciprocal of above] <u>Examples of free body force diagrams</u>  (full credit for the last 3 marks can be given to candidates who draw a vector triangle and derive $\tan\theta = T_{horzt}/mg$ and then $\tan\theta = r\omega^2/g$ **and** observation)	**5**
	Total for question	**5**

Q2.

Question Number	Acceptable Answer	Additional Guidance	Mark
*	This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The table shows how the marks should be awarded for indicative content and structure and lines of reasoning. **Indicative content:** IC1 The rider experiences a resultant force acting towards the centre (of the circular path) IC2 This (resultant) force is constant, as the rider has a constant (angular) velocity **Or** the weight W is constant IC3 At the bottom of the circle P and W act in opposite directions, so P must be greater than W IC4 At the top of the circle P and W act in the same direction, and so P must be less (than at the bottom of the circle) IC5 P is the weight the rider appears to have IC6 The rider would feel heavier at the bottom of the circle **Or** the rider would feel lighter at the top of the circle	Total marks awarded is the sum of marks for indicative content and the marks for structure and lines of reasoning Accept "the rider experiences a centripetal force"	6

Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points
6	4
5–4	3
3–2	2
1	1
0	0

	Number of marks awarded for structure of answer and sustained line of reasoning
Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2
Answer is partially structured with some linkages and lines of reasoning	1
Answer has no linkages between points and is unstructured	0

IC points	IC mark	Max linkage mark	Max final mark
6	4	2	6
5	3	2	5
4	3	1	4
3	2	1	3
2	2	0	2
1	1	0	1
0	0	0	0

Q3.

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

Q4.

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

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