

Name of the Student: _____

Max. Marks : 25 Marks

Time : 25 Minutes

Mark Schemes

Q1.

| Question Number | Acceptable answers | Additional guidance | Mark |
|-----------------|--|--|------|
| (i) | <ul style="list-style-type: none"> • use of $F = Gm_1m_2/r^2$ and use of $F = mr\omega^2$ (1) Or use of $F = Gm_1m_2/r^2$ and use of $F = mv^2/r$ • use of $T = 2\pi/\omega$ Or use of $T = 2\pi r/v$ (1) • $T = 12$ hours Or $F = 120$ N by gravitational approach and centripetal force approach (1) Or $\omega = 1.45 \times 10^{-4}$ radians s^{-1} by gravitational approach and circular motion approach Or height of orbit = 7700 km • Comparative statement consistent with their value(s) (1) | MP3 and 4 - for force and angular velocity, both approaches required <u>Example of calculation</u> $T^2 = 4\pi^2 r^3 / G m_1$ $T^2 = 4\pi^2 \times (2\,430\,000\text{ m} + 7\,690\,000\text{ m})^3 / 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2} \times 3.30 \times 10^{23} \text{ kg}$ $T = 43115 \text{ s} = 11.98 \text{ hours}$ | 4 |
| (ii) | Max 2 <ul style="list-style-type: none"> • Allows satellite to get (much) closer to surface (1) • So more detailed photographs/scans possible (1) OR <ul style="list-style-type: none"> • Allows satellite to spend time further from the surface (1) • So prevents exposure to prolonged heat from planet damaging probe (1) OR <ul style="list-style-type: none"> • Satellite varies distance from surface (1) • So it can take wide-angle and close-up pictures of the planet (1) | For each, the second marking point is dependent on the first. Award second marking point for other sensible advantages | 2 |

Q2.

| Question Number | Answer | Mark |
|---------------------------|---|------------------------|
| (a)(i) | See $F = GMm/r^2$ Equated to mg to give required expression Or use of $g = F/m$ | (1) (1) 2 |
| (a)(ii) | Use of $g = \omega^2 r$ OR $g = v^2/r$ Use of $\omega = 2\pi/T$ OR $v = 2\pi r/T$ Correct algebra leading to expression given <u>Example of calculation:</u> $\omega^2 r = \frac{GM}{r^2}$ $\left(\frac{2\pi}{T}\right)^2 = \frac{GM}{r^3}$ $r^3 = \frac{GMT^2}{4\pi^2}$ | (1) (1) (1) 3 |
| (a)(iii) | See $T = 24$ hours T converted into s $r = 4.2 \times 10^7$ m <u>Example of calculation:</u> $T = 24 \times 60 \times 60 \text{ s} = 86\,400 \text{ s}$ $r^3 = \frac{GMT^2}{4\pi^2} = \frac{6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2} \times 6.0 \times 10^{24} \text{ kg} \times (86400 \text{ s})^2}{4\pi^2} = 7.57 \times 10^{22} \text{ m}^3$ $r = \sqrt[3]{7.57 \times 10^{22} \text{ m}^3} = 4.23 \times 10^7 \text{ m}$ | (1) (1) (1) 3 |
| (b) | The satellite must rotate with the Earth Or the satellite must be in a geosynchronous orbit Or any non-equatorial orbit would cause the satellite to move N-S | 1 |
| Total for question | | 9 |

Q3.

| Question Number | Acceptable answers | Additional guidance | Mark |
|-----------------|--|---|------|
| (a) | <ul style="list-style-type: none"> use of density = mass / volume (1) use of $V = \frac{4}{3} \pi r^3$ (1) $r = 1720$ m (1) | <p>Example of calculation:</p> $V = 1.0 \times 10^{13} \text{ kg} \div 470 \text{ kg m}^{-3}$ $= 2.13 \times 10^{10} \text{ m}^3$ $= \frac{4}{3} \pi r^3$ $r = \sqrt[3]{(2.13 \times 10^{10} \text{ m}^3 \times 3) \div 4\pi}$ $= 1720 \text{ m}$ | (3) |
| Question Number | Acceptable answers | Additional guidance | Mark |
| (b) | <ul style="list-style-type: none"> use of $g = GM/r^2$ (1) $g = 2.3 \times 10^{-4} \text{ N kg}^{-1}$ (1) | <p>Example of calculation:</p> $g = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2} \times 1.0 \times 10^{13} \text{ kg} / (1720 \text{ m})^2$ $g = 2.25 \times 10^{-4} \text{ N kg}^{-1}$ | (2) |
| Question Number | Acceptable answers | Additional guidance | Mark |
| (c) | <ul style="list-style-type: none"> use of $s = \frac{1}{2} gt^2$ (1) $s = 1.2 \times 10^3$ m (1) | <p>Example of calculation:</p> $s = 0.5 \times 2.25 \times 10^{-4} \text{ m s}^{-2} \times (3300 \text{ s})^2$ $= 1.2 \times 10^3 \text{ m}$ | (2) |

| Question Number | Acceptable answers | Additional guidance | Mark |
|-----------------|---|---------------------|------|
| (d) | <p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> the calculated height is comparable with the radius (of asteroid) (1) the field should be considered as radial rather than parallel, so the gravitational field strength is decreasing significantly for the probe (1) <p>OR</p> $g = GM/r^2$ <p>the change in r is comparable with the radius, so there will be a significant change in g (1)</p> <ul style="list-style-type: none"> acceleration is less, so the actual height would be less (1) | | (3) |