## Solutions

Each answer shows the steps, then the **result**.

**2.1**

- the gravitational force between two **point masses** is **proportional to the product of the masses**
- and **inversely proportional to the square of their separation**

**2.2**

- $G = 6.67 \times 10^{-11}\ \text{N m}^2\,\text{kg}^{-2}$

**2.3**

- $F = Gm_1m_2/r^2$

$$F = \frac{Gm_1m_2}{r^2} = \frac{(6.67 \times 10^{-11}\ \text{N m}^2\,\text{kg}^{-2})(1000\ \text{kg})(1000\ \text{kg})}{(2.0\ \text{m})^2} = \mathbf{1.67 \times 10^{-5}}\ \text{N}$$

**2.4**

- any two: period of **24 h**; orbits **west to east**; stays **above the equator**; appears fixed over one point on Earth

**3.1 C**

- $F \propto 1/r^2$, so doubling $r$ makes $F$ **one quarter**
- **A** would be $1/r$; **B** is twice as far so half the force; **D** is four times larger

**3.2**

- $g = GM/R^2$

$$g = \frac{GM}{R^2} = \frac{(6.67 \times 10^{-11}\ \text{N m}^2\,\text{kg}^{-2})(6.0 \times 10^{24}\ \text{kg})}{(6.4 \times 10^{6}\ \text{m})^2} = \mathbf{9.8}\ \text{N kg}^{-1}$$

**3.3**

- gravity provides the centripetal force: $GMm/r^2 = mv^2/r$
- $v = 2\pi r/T$

$$\frac{GM}{r^2} = \frac{4\pi^2 r}{T^2}$$

- $T^2 = 4\pi^2 r^3/(GM)$

**3.4**

- its orbital plane must contain the **Earth's centre**; only an equatorial orbit keeps it over a **fixed point** as the Earth spins

**3.5**

(a)

- gravitational force provides the centripetal force: $\dfrac{GMm}{r^2} = \dfrac{mv^2}{r}$
- $m$ and one $r$ cancel, so $v^2 = \dfrac{GM}{r}$ and $v = \sqrt{\dfrac{GM}{r}}$

(b)

- $v = \sqrt{\dfrac{(6.67 \times 10^{-11})(6.4 \times 10^{23})}{9.4 \times 10^{6}}}$
- $v = \mathbf{2.1 \times 10^{3}}\ \text{m s}^{-1}$

(c)

- $T = \dfrac{2\pi r}{v} = \dfrac{2\pi(9.4 \times 10^{6})}{2.13 \times 10^{3}} = 2.77 \times 10^{4}\ \text{s}$
- $T = \mathbf{7.7}$ hours