# Low Earth Orbit

① $F_c = F_g$

$$\frac{mv^2}{r} = \frac{GMm}{r^2}$$

$$v^2 = \frac{GM}{r}$$

$$v = \sqrt{\frac{GM}{r}}$$

$$= \sqrt{\frac{(6.67\times10^{-11})(5.98\times10^{24})}{(6.38\times10^{6} + 150\,000)}}$$

$$v = \boxed{7816 \text{ m/s}}$$

② $v = \frac{2\pi r}{T}$

$$T = \frac{2\pi r}{v} = \frac{2\pi(6.38\times10^{6} + 150\,000)}{7816}$$

$$T = \boxed{5250 \text{ s}} \quad (\sim 1.5 \text{ h})$$

③ a) $v = \sqrt{\frac{GM}{r}}$

$$= \sqrt{\frac{(6.67\times10^{-11})(3.28\times10^{23})}{(2.57\times10^{6} + 265\,000)}}$$

$$v = \boxed{2778 \text{ m/s}}$$

③ b) $T = \frac{2\pi r}{v}$

$= 2\pi \left( \frac{2.57 \times 10^6 + 265\,000}{2778} \right)$

$T = \boxed{6412 \text{ s}}$

④ $v = \sqrt{\frac{GM}{r}}$

$= \sqrt{\frac{(6.67 \times 10^{-11})(1.98 \times 10^{30})}{(5.79 \times 10^{10})}}$

$v = \boxed{47\,759 \text{ m/s}}$

⑤ $v = \sqrt{\frac{GM}{r}}$

$= \sqrt{\frac{(6.67 \times 10^{-11})(1.98 \times 10^{30})}{(1.43 \times 10^{12})}}$

$v = \boxed{9610 \text{ m/s}}$

Mercury moves nearly 5 times faster than Saturn, so it makes sense to name it after a speedy messenger.

⑥ a) $T = 2.5 \times 10^8 \text{ y} = 7.88 \times 10^{15} \text{ s}$

$$v = \frac{2\pi r}{T}$$

$$= \frac{2\pi (2.2 \times 10^{20})}{(7.88 \times 10^{15})}$$

$$v = 175\,330 \text{ m/s}$$

$$v = \sqrt{\frac{GM}{r}}$$

$$M = \frac{v^2 \cdot r}{G}$$

$$= \frac{175\,330^2 (2.2 \times 10^{20})}{(6.67 \times 10^{-11})}$$

$$M = \boxed{1.0 \times 10^{41} \text{ kg}}$$

b) # of stars $= \frac{1.0 \times 10^{41}}{1.98 \times 10^{30}} = \boxed{5.1 \times 10^{10}}$ (51 billion)

c) $v = \boxed{175\,330 \text{ m/s}}$ (see part A)

⑦ a) $T = 24\text{ h} = 86\,400\text{ s}$

$$v = \frac{2\pi r}{T} \qquad v = \sqrt{\frac{GM}{r}}$$

$$\frac{2\pi r}{T} = \sqrt{\frac{GM}{r}}$$

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

$$4\pi^2 r^3 = GMT^2$$

$$r^3 = \frac{GMT^2}{4\pi^2}$$

$$r = \sqrt[3]{\frac{(6.67\times10^{-11})(5.98\times10^{24})(86400)^2}{4\pi^2}}$$

$$r = \boxed{42\,250\,474\text{ m}} \quad (4.2\times10^7\text{ m})$$

b) $\text{Alt} = r - \text{Radius}$

$$= 42\,250\,474 - 6.38\times10^6$$

$$= \boxed{35\,870\,474\text{ m}} \quad (3.6\times10^7\text{ m})$$