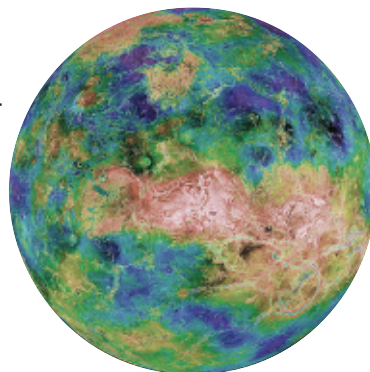


## SAMPLE PROBLEM D

### Period and Speed of an Orbiting Object

#### PROBLEM

The color-enhanced image of Venus shown here was compiled from data taken by *Magellan*, the first planetary spacecraft to be launched from a space shuttle. During the spacecraft's fifth orbit around Venus, *Magellan* traveled at a mean altitude of 361 km. If the orbit had been circular, what would *Magellan*'s period and speed have been?



#### SOLUTION

##### 1. DEFINE

**Given:**  $r_1 = 361 \text{ km} = 3.61 \times 10^5 \text{ m}$

**Unknown:**  $T = ?$   $v_t = ?$

##### 2. PLAN

**Choose an equation or situation:** Use the equations for the period and speed of an object in a circular orbit.

$$T = 2\pi \sqrt{\frac{r^3}{Gm}} \quad v_t = \sqrt{G \frac{m}{r}}$$

Use **Table 1** to find the values for the radius ( $r_2$ ) and mass ( $m$ ) of Venus.

$$r_2 = 6.05 \times 10^6 \text{ m} \quad m = 4.87 \times 10^{24} \text{ kg}$$

Find  $r$  by adding the distance between the spacecraft and Venus's surface ( $r_1$ ) to Venus's radius ( $r_2$ ).

$$r = r_1 + r_2 = (3.61 \times 10^5 \text{ m}) + (6.05 \times 10^6 \text{ m}) = 6.41 \times 10^6 \text{ m}$$

##### 3. CALCULATE

**Substitute the values into the equations and solve:**

$$T = 2\pi \sqrt{\frac{(6.41 \times 10^6 \text{ m})^3}{\left(6.673 \times 10^{-11} \frac{\text{N} \cdot \text{m}^2}{\text{kg}^2}\right)(4.87 \times 10^{24} \text{ kg})}} = 5.66 \times 10^3 \text{ s}$$

$$v_t = \sqrt{\left(6.673 \times 10^{-11} \frac{\text{N} \cdot \text{m}^2}{\text{kg}^2}\right) \left(\frac{4.87 \times 10^{24} \text{ kg}}{6.41 \times 10^6 \text{ m}}\right)} = 7.12 \times 10^3 \text{ m/s}$$

##### 4. EVALUATE

*Magellan* takes  $(5.66 \times 10^3 \text{ s})(1 \text{ min}/60 \text{ s}) \approx 94 \text{ min}$  to complete one orbit.

## PRACTICE D

### Period and Speed of an Orbiting Object

- Find the orbital speed and period that the *Magellan* satellite from Sample Problem D would have at the same mean altitude above Earth, Jupiter, and Earth's moon.
- At what distance above Earth would a satellite have a period of 125 min?