Exercise 1.73

The distance from Earth to the Moon is approximately 240,000 mi. (**a**) What is this distance in meters? (**b**) The peregrine falcon has been measured as traveling up to 350 km/hr in a dive. If this falcon could fly to the Moon at this speed, how many seconds would it take? (**c**) The speed of light is 3.00×10^8 m/s. How long does it take for light to travel from Earth to the Moon and back again? (**d**) Earth travels around the Sun at an average speed of 29.783 km/s. Convert this speed to miles per hour.

Solution

Part (a)

Use dimensional analysis and the conversion factors on the inside back cover to convert from miles to meters.

$$240{,}000 \text{ mi} = 240{,}000 \cancel{\text{mi}} \times \frac{5280 \cancel{\text{ft}}}{1 \cancel{\text{mi}}} \times \frac{12 \cancel{\text{in}}}{1 \cancel{\text{ft}}} \times \frac{2.54 \cancel{\text{cm}}}{1 \cancel{\text{in}}} \times \frac{1 \text{ m}}{100 \cancel{\text{cm}}} \approx 3.9 \times 10^8 \text{ m}$$

The uncertainty in 240,000 mi is assumed to be in the ten thousands place (hence two significant figures).

Part (b)

The formula relating distance, speed, and time is as follows.

$$\text{distance} = \text{speed} \times \text{time}$$

Solve this formula for time, plug in the numbers, and make sure the units cancel appropriately to give seconds.

$$\begin{aligned}
\text{time} &= \frac{\text{distance}}{\text{speed}} \\
&= \frac{240{,}000 \text{ mi}}{350 \frac{\text{km}}{\text{hr}}} \\
&= \frac{240{,}000 \cancel{\text{mi}} \times \frac{5280 \cancel{\text{ft}}}{1 \cancel{\text{mi}}} \times \frac{12 \cancel{\text{in}}}{1 \cancel{\text{ft}}} \times \frac{2.54 \cancel{\text{cm}}}{1 \cancel{\text{in}}} \times \frac{1 \cancel{\text{m}}}{100 \cancel{\text{cm}}} \times \frac{1 \text{ km}}{1000 \cancel{\text{m}}}}{350 \frac{\text{km}}{\cancel{\text{hr}}} \times \frac{1 \cancel{\text{hr}}}{60 \cancel{\text{min}}} \times \frac{1 \cancel{\text{min}}}{60 \text{ s}}} \\
&= \frac{240{,}000 \times 5280 \times 12 \times 2.54 \times \frac{1}{100} \times \frac{1}{1000} \cancel{\text{km}}}{350 \times \frac{1}{60} \times \frac{1}{60} \frac{\cancel{\text{km}}}{\text{s}}} \\
&\approx 4.0 \times 10^6 \text{ s}
\end{aligned}$$

Part (c)

The formula relating distance, speed, and time is as follows.

$$\text{distance} = \text{speed} \times \text{time}$$

Solve this formula for time, plug in the numbers, and make sure the units cancel appropriately.

$$\begin{aligned}
\text{time} &= \frac{\text{distance}}{\text{speed}} \\
&= \frac{2(240{,}000)\ \text{mi}}{3.00 \times 10^8\ \frac{\text{m}}{\text{s}}} \\
&= \frac{2(240{,}000)\ \cancel{\text{mi}} \times \frac{5280\ \cancel{\text{ft}}}{1\ \cancel{\text{mi}}} \times \frac{12\ \cancel{\text{in}}}{1\ \cancel{\text{ft}}} \times \frac{2.54\ \cancel{\text{cm}}}{1\ \cancel{\text{in}}} \times \frac{1\ \text{m}}{100\ \cancel{\text{cm}}}}{3.00 \times 10^8\ \frac{\text{m}}{\text{s}}} \\
&= \frac{2(240{,}000) \times 5280 \times 12 \times 2.54 \times \frac{1}{100}\ \cancel{\text{m}}}{3.00 \times 10^8\ \frac{\cancel{\text{m}}}{\text{s}}} \\
&\approx 2.6\ \text{s}
\end{aligned}$$

Part (d)

Use dimensional analysis and the conversion factors on the inside back cover to convert from kilometers per second to miles per hour.

$$29.783\ \frac{\cancel{\text{km}}}{\cancel{\text{s}}} \times \frac{1000\ \cancel{\text{m}}}{1\ \cancel{\text{km}}} \times \frac{100\ \cancel{\text{cm}}}{1\ \cancel{\text{m}}} \times \frac{1\ \cancel{\text{in}}}{2.54\ \cancel{\text{cm}}} \times \frac{1\ \cancel{\text{ft}}}{12\ \cancel{\text{in}}} \times \frac{1\ \text{mi}}{5280\ \cancel{\text{ft}}} \times \frac{60\ \cancel{\text{s}}}{1\ \cancel{\text{min}}} \times \frac{60\ \cancel{\text{min}}}{1\ \text{hr}} \approx 66\,623\ \frac{\text{mi}}{\text{hr}}$$