HW 4.4.1: Angular and Linear Speed

1. You are standing on the equator of the Earth (radius 3960 miles). What is your linear and angular speed (with respect to the center of the earth)?

2. You are standing in New York City, 40.7127º N, 74.0059º W. What is your linear and angular speed (with respect to the center of the earth)?

3. A wheel of radius 14 in. is rotating 0.5 rad/sec. Find:
   a. the angular speed in RPM (revolutions per minute)?

   b. the linear speed v in in/sec?

4. A wheel of radius 8 in. is rotating 15°/sec. Find:
   a. the angular speed in rad/sec?

   b. the angular speed in RPM?

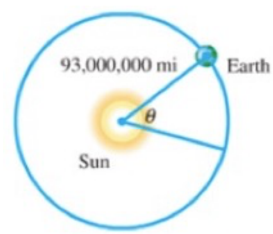
   c. What is the linear speed v in in/sec?

5. A CD has diameter of 120 millimeters. When playing audio, the angular speed varies to keep the linear speed constant where the disc is being read. When reading along the outer edge of the disc, the angular speed is about 200 RPM (revolutions per minute). Find the linear speed (mm/min and m/sec).

6. When being burned in a writable CD-R drive, the angular speed of a CD (diameter of 120 mm) is often much faster than when playing audio, but the angular speed still varies to keep the linear speed constant where the disc is being written. When writing along the outer edge of the disc, the angular speed of one drive is about 4800 RPM (revolutions per minute). Find the linear speed.

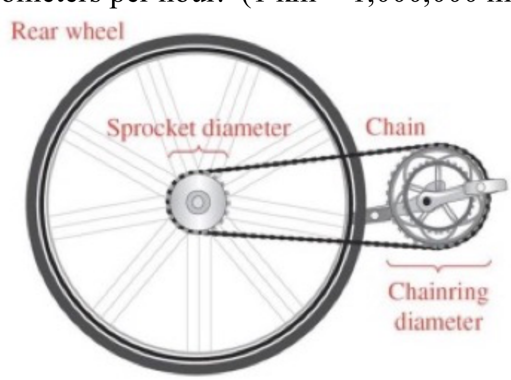
7. Earth travels about the sun in an orbit that is almost circular (eccenctricity close to 0). Assume that the orbit is a circle with radius 93,000,000 mi. Its angular speed and linear speeds are used in designing solar-powered facilities
   a) Assume that a year is 365 days, and find the angle formed by Earth's movement in one day.

   b) Give the angular speed in radians per hour.



   c) Find the linear speed of Earth in miles per hour.

8. (Challenge) When Lance Armstrong blazed up Mount Ventoux in the 2002 tour, he was equipped with a 150 mm-diameter chainring and a 95 mm-diameter sprocket. Lance is known for maintaining a very high cadence, or pedal rate. The sprocket and rear wheel rotate at the same rate, and the diameter of the rear wheel is 700 mm. If he was pedaling at a rate of 90 revolutions per minute, find his speed in kilometers per hour. (1 km = 1,000,000 mm)



9. (Challenge) A truck with 32-in.-diameter wheels is traveling at 60 mi/h. Find the angular speed of the wheels in rad/min. How many revolutions per minute do the wheels make?

10. (Challenge) A bicycle with 24-in.-diameter wheels is traveling at 15 mi/h. Find the angular speed of the wheels in rad/min. How many revolutions per minute do the wheels make?

Selected Answers:

1. $r = 3960$ miles. One full rotation takes 24 hours, so $\omega = \frac{\theta}{t} = \frac{2\pi}{24\text{ hours}} = \frac{\pi}{12}$ rad/hour. To find the linear speed, $v = r\omega$, so $v = (3960\text{ miles})\left(\frac{\pi}{12}\frac{\text{rad}}{\text{hour}}\right) = 1036.73\text{miles/hour}$.

2. Angular Speed. One full rotation takes 24 hours, so $\omega = \frac{\theta}{t} = \frac{2\pi}{24\text{ hours}} = \frac{\pi}{12}$ rad/hour. To find the linear speed, $v = r\omega$, so $v = (3950\text{ miles})(\cos 40.7127)\left(\frac{\pi}{12}\frac{\text{rad}}{\text{hour}}\right) = 783.843\text{ miles/hour}$.

3. a. $\frac{0.5\,rad}{sec} \cdot \frac{60\,sec}{1\,min} \cdot \frac{1\,rev}{2\pi\,rad} = \frac{15\,rev}{\pi\,min}$ b. $v = \omega r, v = (0.5)(14\text{ in}) = \frac{7\text{ in}}{\text{sec}}$

4. a. $\omega = \frac{15°}{\text{sec}} = \frac{\pi}{12}$rad/sec, b. $\frac{\pi\,rad}{12\,sec} \cdot \frac{60\,sec}{1\,min} \cdot \frac{1\,rev}{2\pi\,rad} = 2.5\,RPM$ c. $v = \omega r, v = \left(\frac{\pi}{12}\right)(8\text{ in}) = \frac{2.094\text{ in}}{\text{sec}}$.

5. $\omega = \frac{200\,rev}{1\,min} \cdot \frac{2\pi\,rad}{1\,rev} = \frac{400\pi\,rad}{min}$, $v = (60\text{ mm})\left(400\pi\frac{\text{rad}}{\text{min}}\right) = 75{,}398.22\text{mm/min}$, $\frac{75{,}398.22\,mm}{1\,min} \cdot \frac{1\,min}{60\,sec} \cdot \frac{1\,m}{1000\,mm} = 1.257\text{ m/sec.}$

7. $\frac{360°}{365\,days} = .986\frac{°}{day}$, $\omega = \frac{\theta}{t} = \frac{2\pi\,rad}{365 \cdot 24\,hours} = \frac{\pi}{4380}$ rad/hour, $v = r\omega = 93{,}000{,}000\left(\frac{\pi}{4380}\right) = 66{,}705.05\,mi/hr$

9. $D = 32$ in, speed = 60 mi/hr = 1 mi/min = 63360 in/min =v, $C = \pi D$, $v = \frac{s}{t}$, $s = \theta r$, $v = \frac{\theta r}{t}$, $\frac{v}{t} = \frac{\theta}{t} = \omega$. So ω = $\frac{63360\frac{\text{in}}{\text{min}}}{16\text{ in}}$ = 3960 rad/min. Dividing by 2π will yield 630.25 rotations per minute.