L1

*Tangential speed* is the magnitude of tangential velocity. Take a look at Figure 9-1, where you see a rotating ball going around the origin. As it sweeps around the origin with linear speed v (which keeps changing direction as the ball moves in a circle), the angle θ increases in time.

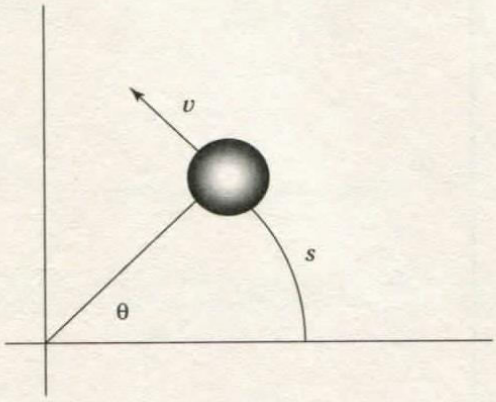


**Figure 9-1:** A rotating ball.

How do you relate the distance the ball has traveled, s, to the angle θ? If you measure θ in radians, that relationship is the following, where r is the radius of the circle:

$$s = r \cdot \theta$$

Also, you know that:

$$v = \frac{s}{t}$$

That means that you can substitute for s to get:

$$v = \frac{s}{t} = \frac{r \cdot \theta}{t}$$

And $\omega = \theta/t$, which means that:

$$v = \frac{s}{t} = \frac{r \cdot \theta}{t} = r \cdot \omega$$

So:

$$v = r \cdot \omega$$

**Q.** A ball on a string is going around in a circle at 6.0 radians/sec. What is its tangential velocity if the radius of the circle is 2.0 m?

**A.** The correct answer is 12 m/sec.

**1.** Use the equation $v = r \cdot \omega$.

**2.** Plug in the numbers:

$$v = r \cdot \omega = (2.0) \cdot (6.0) = 12 \text{ m/sec}$$

**1.** If a satellite is orbiting the Earth, which has an average radius of 3960 miles, at an altitude of 150 miles and an angular speed of $1.17 \times 10^{-3}$ radians/sec, what is the satellite's tangential speed in mph?

*Solve It*

**2.** You're flying a toy plane on a string, and it's going around at 20.0 mph, 100.0 feet from you. What is its angular speed in radians/sec?

*Solve It*

**3.** A racing car is going around a circular track of 400.0-ft radius at 50.0 mph. What is its angular speed in radians/sec?

*Solve It*

**4.** The tip of an airplane propeller is going at 500.0 mph. If the propeller has a radius of 3.0 ft, what is its angular speed?

*Solve It*

**5.** If a point on the edge of a tire with a radius of 0.50 m starts at rest and ends up 3.5 minutes later at 88 m/sec (about 197 mph), what was the magnitude of its angular acceleration?

*Solve It*

**6.** You're flying a toy plane on a string, and it's going around at 20.0 m/sec, 10.0 m from you. If it accelerates to a final velocity of 30.0 m/sec in 80.0 seconds, what is its angular acceleration?

*Solve It*

Angular velocity is really a vector, **ω**. The question is, which way does it point? Think of it this way: If you have a flying disk being tossed back and forth between two players, it's spinning. So which way can **ω** point so that it stays constant in magnitude and direction?

Take a look at Figure 9-2 for the answer. The **ω** vector points out of the plane of rotation.

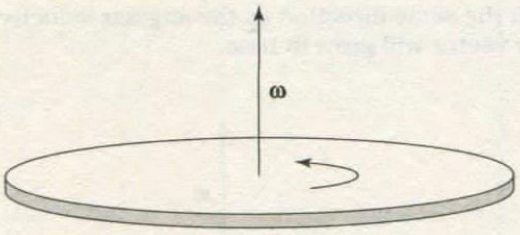


**Figure 9-2:** Angular velocity as a vector.

You find the direction of the **ω** vector by wrapping your right hand around in the direction of rotation. Your right thumb will point in the direction of the **ω** vector.

***Q.*** A helicopter's blades are rotating in a horizontal plane, and they're going counterclockwise when viewed from above. Which way does **ω** point?

***A.*** The correct answer is upward.

1. Curl your right hand in the direction of rotational motion — counterclockwise.
2. Your right thumb points upward, indicating the direction of the **ω** vector.

Like angular velocity, angular acceleration is a vector; it's represented by the symbol $\alpha$. But unlike angular velocity, angular acceleration need not be perpendicular to the plane of rotation. The angular acceleration vector just points in the direction of change of the angular velocity vector.

Figure 9-3 shows angular acceleration in the same direction as the angular velocity vector. That means the angular velocity vector will grow in time.

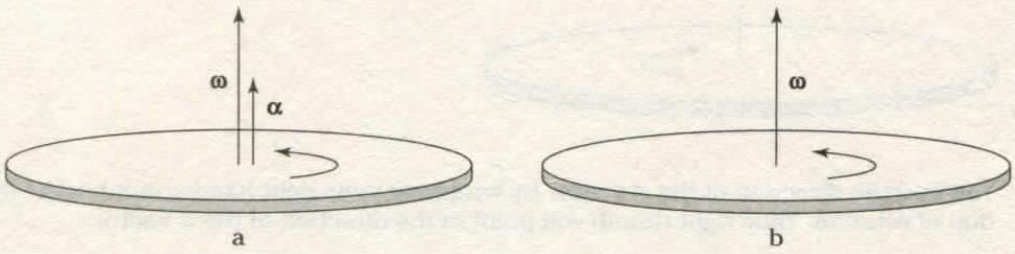


**Figure 9-3:** Angular acceleration as a vector.

Bear in mind that $\alpha$ need not be perpendicular to the rotation — it just points in the direction in which $\omega$ is changing. For example, if you're turning the wheels of a car, the vector $\alpha \cdot t$ points in a direction so that when it's added to the original angular velocity, $\omega_o$, you get the new angular velocity, $\omega_f$.

**9.** Suppose that you're flying a toy plane on a string, and it's going around clockwise as viewed from above. In time, the plane is slowing down. Which way does $\alpha$ point?

*Solve It*

**10.** A flying disc tossed from one player to another spins as it flies and slows down. If it's spinning counterclockwise when viewed from above, which way does $\alpha$ point?

*Solve It*