Answer on Question #39586, Physics, Other

a) A ball has an angular velocity of 5.0 rad/s counterclockwise. Some time later, after rotating through a total angle of 4.5 radians, the ball has an angular velocity of 1.5 rad/s clockwise. Determine the angular acceleration, the average angular velocity and how much time it takes for the ball to attain this velocity.

b) When a high diver wants to execute a flip in midair, she draws her legs up against her chest. Why does this make her rotate faster? What should she do when she wants to come out of her flip?

**Solution:**

a) The object is rotating and we are asked to find kinematic quantities, so this is a rotational kinematics problem.

Given:

$\omega_0 = +5.0$ rad/s

$\omega_f = -1.5$ rad/s

$\Delta\theta = +4.5$ rad

$\alpha = ?$

$\omega_{average} = ?$

$t = ?$

We have taken counterclockwise as the positive direction and that the signs are explicitly stated. To find the angular acceleration, we find the kinematics equation that contains α and the given quantities. Examining our equations we see that we can use $2\alpha\Delta\theta = \omega_f^2 - \omega_0^2$. Rearranging this equation to find α yields

$$\alpha = \frac{\omega_f^2 - \omega_0^2}{2\Delta\theta} = \frac{(-1.5)^2 - (5)^2}{2 \cdot 4.5} = -2.53\ \mathrm{rad/s^2}.$$

Notice that the acceleration is negative. This means that the acceleration points clockwise. It means that an object's rotation will slow, stop, and reverse direction.

The average velocity is defined

$$\omega_{average} = \frac{\omega_0 + \omega_f}{2} = \frac{5 - 1.5}{2} = 1.75\ \mathrm{rad/s}$$

To find the time, we find the kinematics equation that contains and t and the given quantities. Examining our equations we see that we can use

$$\Delta\theta = \frac{\omega_0 + \omega_f}{2} t$$

Rearranging this equation to find t yields

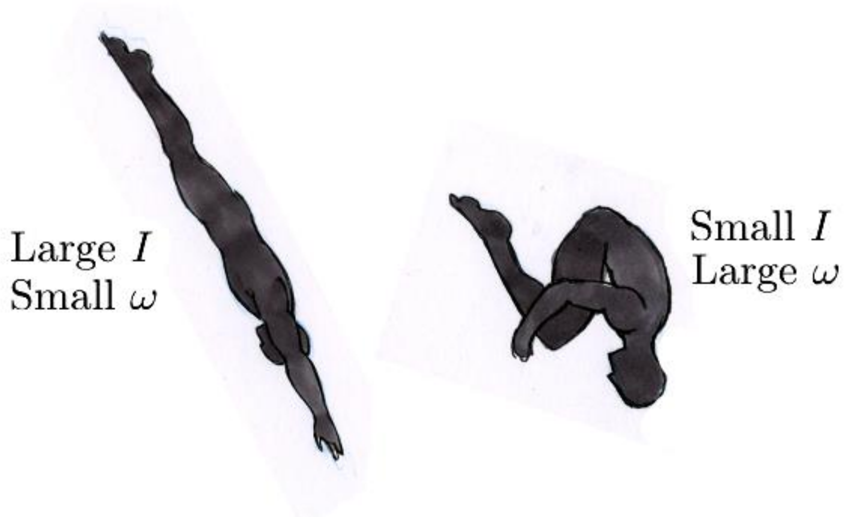
$$t = \frac{2\Delta\theta}{\omega_0 + \omega_f} = \frac{2 \cdot 4.5}{5 - 1.5} = 2.57\ \mathrm{s}.$$

**Answer.** a) $\alpha = -2.53\ \mathrm{rad/s^2}$, $\omega_{average} = 1.75\ \mathrm{rad/s}$, $t = 2.57\ \mathrm{s}$.

b) The diver starts to fall, the angular momentum remains essentially constant. Her angular momentum is the product of her moment of inertia $I$ and her angular speed ω:

$$L = I \cdot \omega \quad .$$

The angular velocity is a measure of how fast the object is spinning. The moment of inertia depends not only on the mass but also the location of the mass relative to the point of rotation. The further the mass is from the rotation point, the greater the moment of inertia.




When she pulls herself into a "tuck" position, this makes her moment of inertia -- her "rotational mass" -- small. To keep the angular momentum constant the angular speed increases.

When she comes out of the "tuck" position and extends her body, this makes her moment of inertia large and her angular speed decreases to keep her angular momentum constant.