Answer on Question #40128, Physics, Mechanics

a) A ball has an angular velocity of 1s 0.5 rad−1counterclockwise. Sometime later, after rotating through a total angle of 4.5 radians, the ball has an angular velocity of 1s 5.1 rad−1 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) Given

$\omega_0 = -0.5\frac{rad}{s}$.

$\omega_f = +5.1\frac{rad}{s}$.

$\Delta\theta = +4.5\,rad$.

$\alpha = ?$

$\omega_{average} = ?$

$t\ = ?$

I have taken clockwise 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. We see that we can use

$$2\alpha\Delta\theta = \omega_f^2 - \omega_0^2.$$

Rearranging this equation to find α yields

$$\alpha = \frac{\omega_f^2 - \omega_0^2}{2\Delta\theta} = \frac{\left(5.1\frac{rad}{s}\right)^2 - \left(-0.5\frac{rad}{s}\right)^2}{2\cdot 4.5\,rad} = 2.9.$$

Notice that the acceleration is positive. 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

$$\omega_{average} = \frac{\omega_f + \omega_0}{2} = \frac{5.1\frac{rad}{s} - 0.5\frac{rad}{s}}{2} = 2.3\frac{rad}{s}.$$

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

$$\Delta\theta = \omega_{average}\cdot t \to t = \frac{\Delta\theta}{\omega_{average}} = \frac{4.5\,rad}{2.3\frac{rad}{s}} = 2\,s.$$

b) Once off the board, the high diver has no torques on her so her angular momentum remains constant. Her angular momentum is the product of her moment of inertia and her angular speed. When she pulls herself into a "tuck" position, this makes her moment of inertia 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.