Angular momentum

Because a rotating object has inertia, it also possesses momentum associated with its rotation. This momentum is called **angular momentum.** Angular momentum is defined by the following equation:

ANGULAR MOMENTUM

$$L = I\omega$$

angular momentum = moment of inertia × angular speed

The unit of angular momentum is $kg \bullet m^2/s$. When the net external torque acting on an object or objects is zero, the angular momentum of the object(s) does not change. This is the law of *conservation of angular momentum.* For example, assuming the friction between the skates and the ice is negligible, there is no torque acting on the skater in **Figure 2,** so his angular momentum is conserved. When he brings his hands and feet closer to his body, more of his mass, on average, is nearer to his axis of rotation. As a result, the moment of inertia of his body decreases. Because his angular momentum is constant, his angular speed increases to compensate for his smaller moment of inertia.

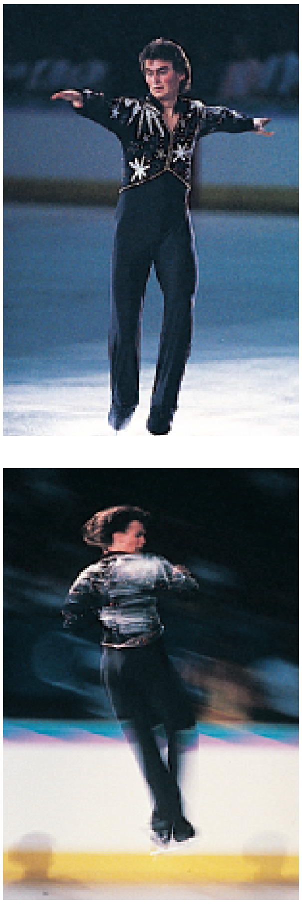

Figure 2
When this skater brings his hands and feet closer to his body, his moment of inertia decreases, and his angular speed increases to keep total angular momentum constant.

Angular kinetic energy

Rotating objects possess kinetic energy associated with their angular speed. This is called **rotational kinetic energy** and is expressed by the following equation:

ROTATIONAL KINETIC ENERGY

$$KE_{rot} = \frac{1}{2}I\omega^2$$

$$\textbf{rotational kinetic energy} = \frac{1}{2} \times \textbf{moment of inertia} \times (\textbf{angular speed})^2$$

As shown in **Table 1,** rotational kinetic energy is analogous to the translational kinetic energy of a particle, given by the expression $\frac{1}{2}mv^2$. The unit of rotational kinetic energy is the joule, the SI unit for energy.

Table 1 Comparing Translational and Rotational Motion

	Translational motion	Rotational motion
Equilibrium	$\Sigma F = 0$	$\Sigma \tau = 0$
Newton's second law	$\Sigma F = ma$	$\Sigma \tau = I\alpha$
Momentum	$p = mv$	$L = I\omega$
Kinetic Energy	$KE = \frac{1}{2}mv^2$	$KE = \frac{1}{2}I\omega^2$

extension

Practice Problems

Visit go.hrw.com to find sample and practice problems for rotational equilibrium, Newton's second law for rotation, conservation of angular momentum, and angular kinetic energy.

Keyword HF6APJX