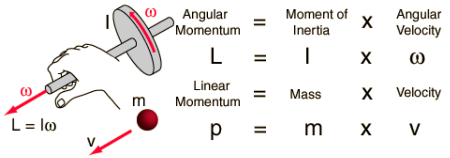
Angular Momentum

Definitions

The angular momentum of a rigid object is defined as the product of the moment of inertia and the angular velocity. Similar to linear momentum - angular momentum is conserved if there is no external torque on the object. Angular momentum is a vector quantity. (Unit is kg^2s^{-1})



Note – the equation to the right links linear momentum with angular momentum.

$$L = mvr$$

Equations

$L = I\omega$	Angular momentum	L	Kg $m^2 s^{-1}$
	Moment of inertia	I	Kg m^2
	Angular velocity	ω	rad s^{-1}
$L = mvr$	Angular momentum	L	Kg $m^2 s^{-1}$
	mass	m	kg
	velocity	v	m s^{-1}
	Radius of arc/circle	r	m

Questions

DIVING OFF THE HIGH BOARD (2006;3)

Hopi performs a dive from the high board. After leaving the board at A, he travels up in the air to B, tucking his body into a ball. At the end of his dive, he straightens his body and enters the water head first at C. When Hopi's body is in the tucked position during the rotations, his rotational inertia is 3.73 kg m^2. Hopi's mass is 76 kg.

(a) When Hopi's body is in the tucked position, his shape can be modelled by a solid sphere of rotational inertia $I = \frac{2}{5}mr^2$. Calculate the radius of the sphere that models Hopi's shape.

(b) Explain why Hopi must tuck his body if the rotations are to be completed before he enters the water.

(c) While his body is in the tucked position, Hopi's angular speed is a constant 9.82 rad s^{-1}. He does two complete rotations in this tucked position. Show that his angular momentum, while he is rotating in the tucked position, is 36.6 kg $m^2 s^{-1}$.

(d) At the end of the tucked rotations, Hopi straightens his body for the entry into the water. What physics principle applies while Hopi is straightening his body?

Terms

Tips

$I = \Sigma m r^2$	Moment of inertia	I	Kg m^2
	mass	m	kg
	Radius from pivot	r	m

Answers

(a) $I = 2/5\ m r^2 \Longrightarrow 5 \times 3.73 = 2 \times 76 \times r^2 \Longrightarrow r^2 = 0.122698 \Rightarrow r = 0.35$ m.

(b) When Hopi tucks his body, his mass becomes concentrated closer to his axis of rotation, so reducing his rotational inertia. Angular momentum will be conserved and so his angular speed will increase. As the time Hopi has to execute the dive is fixed, rotating at a faster speed enables him to complete all the rotations.

(c) $L = I\,\omega = 3.73 \times 9.82 = 36.6286$

(d) Conservation of angular momentum