

Physics Terms Involved in the Yo-Yo and How It Works

Friction is the force that acts between materials that touch as they move past each other.

Newton's First Law is also known as the law of inertia. It states that every object continues in a state of rest, or of motion in a straight line at constant speed, unless it is compelled to change that state by forces exerted upon it.

Kinetic Energy is the energy of movement.

Potential Energy is the energy of position.

Gravitational Potential Energy is the energy that is stored and held in readiness due to an elevated position.

Angular Momentum is the inertia of rotation. It is equal to the rotational inertia times the rotational velocity. The Law of conservation of angular momentum states that in no unbalanced external torque acts on a rotation system, the angular momentum of that system is constant.

Linear Momentum is momentum in a straight line.

Gyroscopic Stability is the property that once a mass is set in motion, it continues on that line until some other force acts on it.

How the Yo-Yo Works

When a yo-yo is released, gravity is acting on its center of mass. Because one end of the string is attached to the axle of the yo-yo, and the other end of the string is attached to the operator's finger, the yo-yo begins to rotate as it drops. If the yo-yo was unable to rotate, it would not be able to fall. As the yo-yo begins to drop, its potential energy changes into kinetic energy.

Due to the acceleration of gravity, the speed at which the yo-yo drops increases with time, and therefore, the rate of rotation also increases. The speed and rotation rate are greatest when the string is completely unwound. Once the yo-yo reaches the end of the string, the linear momentum is converted into angular momentum. The yo-yo will continue to spin at the bottom of the string because the string is loosely looped around the axle. This is gyroscopic stability. As Newton's First Law states, due to inertia, the yo-yo has a tendency to continue to spin at the end of the string until an outside force acts on it. If the yo-yo is left in this state, it will eventually stop spinning. Because the yo-yo cannot drop any farther, it cannot build up any more angular momentum; and due to the friction (the outside force) between the axle and the string, the yo-yo will come to rest.

Yet, if a short tug is exerted on the string, friction is created between the axle and the string. The axle can no longer easily spin inside the loop at the end of the string. When the axle encounters resistance, the angular momentum of the yo-yo causes the string to wind around the axle. This causes the yo-yo to climb back up the string until it reaches the hand of the operator.

As the yo-yo climbs up the string, the angular momentum of the yo-yo is reconverted into gravitational potential energy. Therefore, the speed and rotation rate of the yo-yo decrease as the yo-yo climbs back up.