Zecar
P4-1985

INSTRUCTIONAL GUIDE

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Background

The Zecar may be used to demonstrate rotational inertia and efficiency. All matter possesses a property known as inertia. Because of inertia, objects continue doing what they are already doing. An object at rest will remain at rest. Similarly, an object in motion will continue in straight-line motion with constant speed until an unbalanced force acts upon it.

The rotational analog of inertia is rotational inertia. A stationary object will not start spinning spontaneously nor will a rotating object stop all by itself. Either change requires a force-like action known as a torque. Torque is found by multiplying the applied force by the distance between the point of application and the axis about which an object rotates.

The rotational inertia of an object not only depends on mass but also on how the mass is distributed. The effect of mass distribution on the moment of inertia of a system can be demonstrated quite easily with a meter stick and two masses.

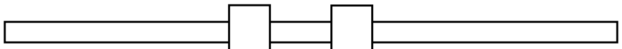

Figure 1

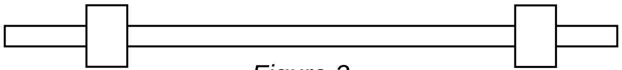

Figure 2

Rotational Inertia Activity

First attach the masses near the center of the meter stick as illustrated in **Figure 1** (unless the masses are slotted, you will have to use masking tape to keep the masses on the meter stick). A student holding the meter stick at its center will have little difficulty twisting the meter stick and masses back and forth. However, when the masses are moved further away from the center, as shown in **Figure 2**, the student will find it considerably more difficult to start and stop the assembly.

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Background on Flywheels

A flywheel, such as the one found in the Zecar, is a cylindrical mass rotating about an axis. Like the two masses on a meter stick, once in motion the flywheel will continue moving until something stops it. Flywheels may therefore be used to store energy. The amount of energy stored in a rotating flywheel depends on the wheel's rate of rotation as well as its rotational inertia.

In the early 1950's, a Swiss engineering company introduced the "Gyro-bus," a bus for 35 passengers that ran on electric power generated by a spinning flywheel. The flywheel was periodically brought up to speed by an electric motor which, in turn, got its energy from overhead wires. The Gyro-buses were introduced in 1953 and remained in service for 10 years.

Researchers are once again turning to the flywheel as a means of storing energy. Because of their high efficiency, flywheels may one day replace conventional batteries as energy storage systems for a variety of applications, including automobiles, buses, economical rural electrification systems, and remote power units commonly used in the telecommunications industry.

Activity

The Zecar may be used to demonstrate rotational inertia, the transfer and storage of energy, and efficiency. Students might begin their study of these concepts simply by "exploring" with the Zecar. You might guide their inquiry by asking them the following questions:

1. Do you feel "resistance" to your efforts to set the flywheel in motion? If so, why?
2. What becomes of the work done by you while setting the flywheel in motion?
3. What is the maximum range of the car on a level surface such as the floor? Does the range of the car depend on the nature of the surface?
4. Is the speed of the car constant from the time of release until it comes to rest? Why or why not?

A rough estimate of the energy stored in the flywheel may be made by asking students to see how far up a ramp the car will travel. A portion of the energy stored in the flywheel becomes gravitational potential energy as the car ascends the ramp. Frictional losses account for the remainder of the energy.

The Zecar's maximum gravitational potential energy will be attained at the top of the ramp. This potential energy is equal to $m \cdot g \cdot h$, where m is the mass of the Zecar in kilograms, $g = 9.8\ m/s^2$, and h is the vertical distance from the floor to the top of the ramp in meters. The value calculated using this approach sets the lower limit to the energy stored in the flywheel.

You may wish to ask students what they would have to know in order to calculate the efficiency of the Zecar. You may also have them suggest a procedure for gathering this information.

Related Products

Rotational Inertia Demonstrator (P3-3545) A Beautiful and engaging investigation of angular motion!

Variable Inertia Set (96-1060) The Variable Inertia Set is simple to set up and a fun activity to study rotational inertia. Students investigate how varying the distribution of mass (steel balls) inside a compartmentalized plastic disc effects how the disc rolls down an inclined plane.

Constant Velocity Car (44-1090) This simple but powerful toy provides a visible source of uniform speed. Students can easily quantify and graph their results, starting them on the road to a conceptual understanding of motion.

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