Angular Momentum

TOPICS AND FILES

Mechanics Topics

Rotational motion; position, velocity, acceleration

Rotational motion; velocity versus time

Capstone Files

39 Rotational Motion.cap

40 Rotational Inertia.cap

EQUIPMENT LIST

Qty	Items	Part Numbers
1	PASCO Interface (for one sensor)	
1	Rotary Motion Sensor	CI-6538
1	Mini Rotational Accessory (with disk and ring)	CI-6691
1	Rod, 45 cm	ME-8736
1	Large Rod Base	ME-8735
1	Mass and Hanger Set	ME-9348
1 m	Thread	
1	Balance	SE-8723
1	Base and Support Rod	ME-9355
1	Ruler	

INTRODUCTION

This lab has two parts.

The purpose of Experiment 1 is to measure the angular position and velocity of a rotating body. Use a rotary motion sensor to measure the rotation of a disk as the disk undergoes a constant angular acceleration. Use *Capstone* to record and display the data. Plot the angular position and angular velocity and analyze them. Compare the plots of angular position and angular velocity for the accelerating disk to plots of position and velocity for an accelerating fan cart.

The purpose of Experiment 2 is to measure the initial and final angular speed of a system consisting of a non-rotating ring that is dropped onto a rotating disk and to verify the conservation of the angular momentum of the system. Use *Capstone* to record and display the linear speed before and after the torque-free collision.

BACKGROUND

For each kinematic quantity (i.e. displacement, velocity, etc.) there is an analogous quantity in rotational kinematics. The rotational version of position (x) is the "angular position" that is given by the Greek letter theta. The rotational version of velocity (v) is "angular velocity" that is given by the Greek letter omega. All translational (linear) quantities have rotational counterparts.

The equations of kinematics for constant linear acceleration can be used for solving problems involving linear motion in one and two dimensions. For example, the motion of a fan cart accelerating on a flat track can be described by the equations of translational kinematics.

$$v = v_0 + at \tag{1}$$

$$x = \frac{1}{2}(v_0 + v)t \tag{2}$$

$$x = v_0 t + \frac{1}{2}at^2 \tag{3}$$

$$v^2 = v_0^2 + 2ax \tag{4}$$

The ideas of angular displacement, angular velocity, and angular acceleration can be brought together to produce a set of equations called the equations of kinematics for constant angular acceleration.

$$\omega = \omega_0 + \alpha t \tag{5}$$

$$\theta = \frac{1}{2}(\omega_0 + \omega)t \tag{6}$$

$$\theta = \omega_0 t + \frac{1}{2}\alpha t^2 \tag{7}$$

$$\omega^2 = \omega_0^2 + 2\alpha\theta \tag{8}$$

The equations of kinematics for constant angular acceleration can be used for solving problems involving rotational motion. For example, the motion of the blades on a fan cart as they start to rotate faster and faster can be described by the equations of rotational kinematics.

For rotational motion we defined the torque as analogous quantity to force in translational motion.

$$\tau = I\alpha \tag{9}$$

Torque is defined relative to the axis of rotation.

$$\vec{\tau} = \vec{R} \times \vec{F} \tag{10}$$

When a net torque τ is applied to an object that is free to rotate, there is a change in the angular momentum (ΔL) of the object.

$$\vec{\tau} = \frac{\Delta \vec{L}}{\Delta t} \tag{11}$$

When a non-rotating disk is dropped on a rotating disk, there is no net torque on the system since the torque on the non-rotating is equal and opposite to the torque on the rotating disk. If there is no change in angular momentum the angular momentum is conserved.

$$\vec{L} = I_i \vec{\omega}_i = I_f \vec{\omega}_f \tag{12}$$

where I_i and I_f are the initial and final rotational inertia of the system, with $\vec{\omega}_i$ and $\vec{\omega}_f$ being the initial and final rotational speed of the system. The initial rotational inertia is that of a disk and the final inertia is that of the disk and a ring.

The ring has a moment of inertia

$$I = \frac{1}{2} M \left(R_1^2 + R_2^2 \right) \tag{13}$$

where M is the mass of the ring, R_1 is its inner radius, and R_2 the outer radius.

The inertia of a solid disk of uniform density is given by

$$I = \frac{1}{2} M R^2 \tag{14}$$

where M is the mass of the disk and R is its radius.