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Rotational Motion 2

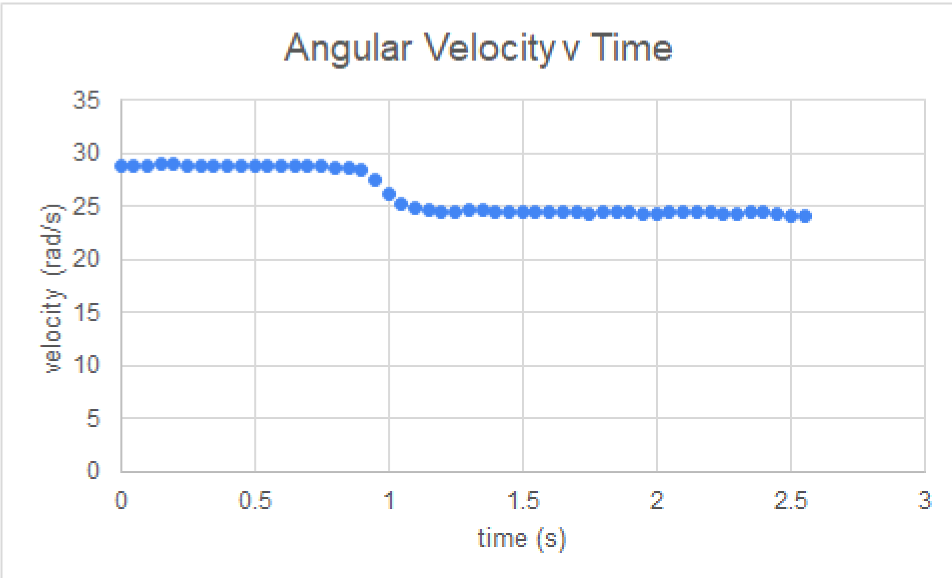
Objective

The first goal is to test the conservation of both angular momentum and kinetic energy in an inelastic rotational collision experiment. The second goal is to qualitatively observe some of the effects of the conservation of angular momentum.

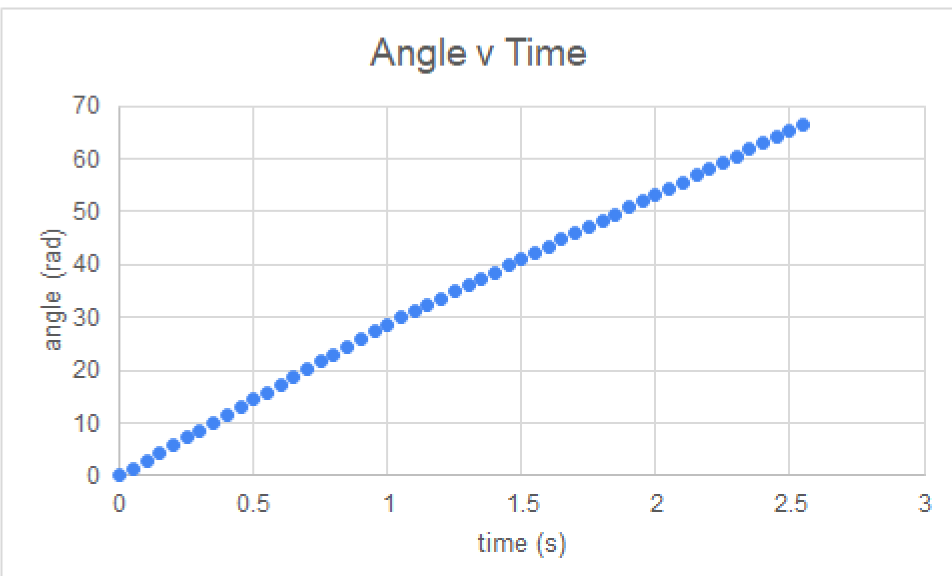
Approach/Method

To set up, a ring was attached to a free disk mounted on a stand to the table. Through a Vernier lab interface, the system was connected to the computer so the data (including time, angle, and angular velocity) could be recorded in LoggerPro and transferred to Excel for manipulation. A trial involved spinning the disk then dropping a cylinder into the ring. Five trials were executed and measurements of the masses and radii of the disk, ring, and cylinder were calculated and recorded for the purpose of calculating the moment of inertia. With the data, graphs of angular velocity versus time and angle versus time were created.

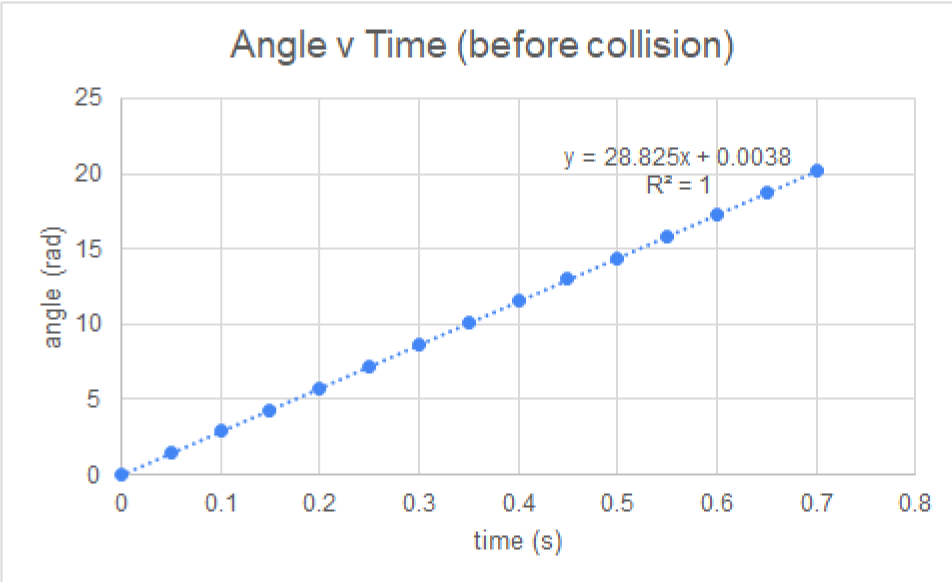
Data & Analysis



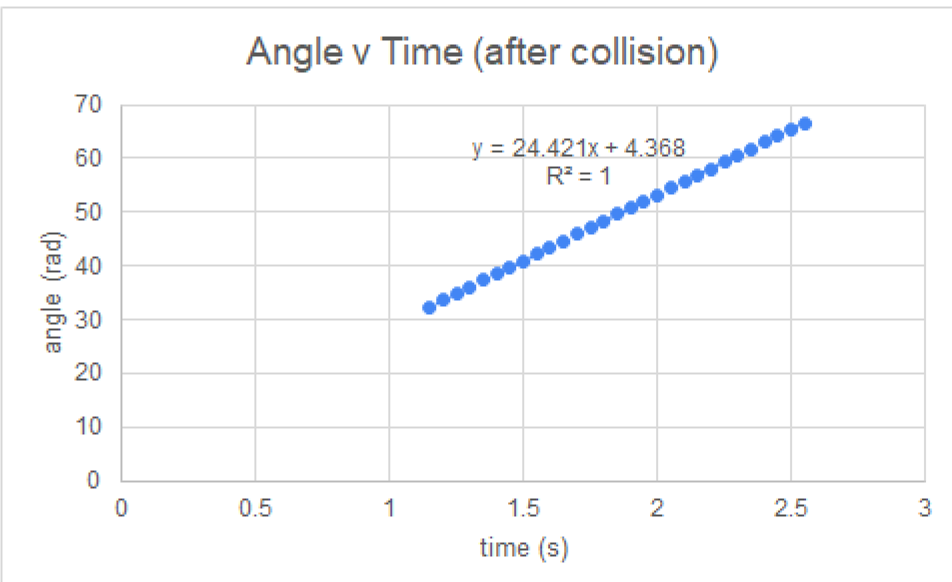
Graph 1 shows how the angular velocity (a relative constant) changed after the collision



Graph 2 shows how the linearly increasing angle changed slightly after the collision



Graph 3 shows the perfect linear trend of the changing angle before the collision



Graph 4 shows the new perfect linear trend of the changing angle after the collision

Table 1 below displays the velocity, angular momentum, and kinetic energy both before and after the collision for each of the five trials.

v = velocity

L = angular momentum

KE = kinetic energy

	initial v	final v	initial L	final L	initial KE	final KE
T1	28.8	24.6	0.017654	0.017766	241.9891	282.3071
T2	13.7	11.5	0.008398	0.008305	54.75856	61.69463
T3	25.4	21.8	0.01557	0.015744	188.2254	221.6995
T4	12	10	0.007356	0.007222	42.012	46.65
T5	23.7	20.1	0.014528	0.014516	163.8731	188.4707

Table 1

There was not much room for error in this experiment. The frictional force within the system and due to the air contributed to imperfect conservation, and dropping the cylinder into the ring made it easy to accidentally nudge the system thus introducing torque, though these would most likely be considered negligible.

Sample Calculations

Moment of inertia (disk): $I = 0.5(m)(r^2) = 0.5(0.121)(0.048^2) = 0.000139$

ring: $I = m(r^2)$

cylinder: $I = 0.5(m)(r^2)$

Angular momentum: $L = I\omega = (I_{disk}+I_{ring})\omega = 0.000613(28.8) = 0.017654$

The following are observations made during demonstrative experiments with regard to seated rotation, a gyroscope, and a wheel:

When sitting on a spinning stool with outstretched arms, as you pull them in your angular velocity increases. If you were to be holding weights while your arms were out, spinning with the same initial velocity, as you bring your arms in, you will spin faster than you would without the weights. When you sit on a stool at rest and hold a bicycle wheel spinning towards you, as you tilt the wheel right, you move to the left and vice versa.

When a gyroscope is at rest and you apply a force on the tip of the axis, it rotates in the direction of the force. If you stop applying the force, it nonetheless continues to rotate. With the gyroscope now spinning with the disk moving clockwise relative to you, if you push it up, it moves right. If you push it down, right, and left, it will move left, down, and up, respectively. When applying a force to the right of the near side of the axis, the axis rotates clockwise. If you stop applying the force, it continues to rotate clockwise.

If you hold a spinning bicycle wheel and try to change the direction of the angular momentum, you will feel a resistive force. If you hold it with the wheel spinning towards you and try tilting it to the right, it tries to go back to the axis it was initially spinning on by way of a circular motion.

Finally, when the wheel is spinning and you hold up one end of the axis using a rope, it spins with the axis being somewhat parallel to the ground. The precession speed is slower as the wheel is spinning faster.

Results & Conclusions

Through the experiment, the measurements almost perfectly confirmed the conservation of angular momentum, with an average ratio of final L to initial L being approximately 0.998. However, the kinetic energy did not prove to be very conserved, if at all with an average ratio of final KE to initial KE being approximately 1.15.