To: Maxin, Lab Instructor
From: Nick Dolan, Student
Date: April 10th, 2007
Subject: Lab 5 Experiment 1 Tech Memo

The purpose of this experiment was to find the linear velocity of an object at a constant angular speed, and relate this, to the distance from the axis of rotation (R), and determine how the linear velocity changes as the distance from the axis of rotation varies. Using a rotating beam, and video analysis equipment, we obtained data on the rotation of an object by importing the videos of the rotation of the beam into Logger Pro and assigning data points over time intervals. Through this method, we calculated linear velocity of points of varying distances on the beam, and the time it took for one complete revolution of the beam.

Prediction and Method Questions

To determine how the linear velocity varies with respect to distance from the axis of rotation (R), assuming constant angular velocity, one can use the formula V=R*ω where ω is ((Number of Revolutions)*(2*π))/(Time). To obtain this equation, it is necessary to paramaterize a point on the beam into x and y components (with respect to t). Doing this, x becomes R*cos(ω*t) and y becomes R*sin(ω*t). Once these points are calculated, you can take the derivative of these expressions with respect to t to calculate the x and y components of velocity. After this is done, one simply takes the square root of the sum of the squares of these two components to achieve the desired equation, V=R*ω. One can derive a formula for the accleration of a point on the rotating beam by calculating the anti-derivative of the velocity components to get the acceleration components, and taking the square root of the sum of the squares of these components to get the formula for centripetal acceleration, $A=V^2/R$. Assuming V is R*ω as we established, this can simplify to $A=R*\omega^2$.

All graphs are presented on the pages attached to the back of the memo.

Data, Results, and Analysis Questions

Our lab group used a setup that involved a rotating beam which was free to rotate about its central axis. We gave the beam an initial push, and filmed a few rotations of the beam, with points marked on the beam at varying distances from the axis of rotation(5 cm, 10 cm, 15 cm, and 20 cm). Using Logger Pro we determined that the time it took for one revolution of the beam, was 1.17 seconds. With this information, calculating ω was easy: ((Number of Revolutions)*(2*π))/(time). Our value for ω calculated this way was 5.37 rad/s. Once our angular velocity was discovered, we could use ω in the equation V=R*ω and provide an answer to the original problem, 'How does the linear velocity of a point on a rotating beam change with respect to it's radius from the axis of rotation assuming constant angular velocity?' This relationship is demonstrated in the following table.

Centripetal Acceleration	Linear Velocity	Radius	Angular Velocity
1.4418 m/s^2	.2685 m/s	.05m	5.37 rad/s
2.8837 m/s^2	.537 m/s	.10m	5.37 rad/s
4.3255 m/s^2	.8055 m/s	.15m	5.37 rad/s
5.7674 m/s^2	1.074 m/s	.20m	5.37 rad/s

The values we calculated for linear velocity based on rotation time and the dervied formula, were compared with the linear velocity values that Logger Pro reported, and were found to be congruent, and the velocity vector was always in the expected direction. This chart clearly demonstrates the linear relationship between the radius of a point on a rotating beam of constant velocity, and it's linear velocity. This same linear relationship is seen with centripetal acceleration compared to the radius (as the angular velocity, a constant, is getting squared, the relationship remains linear). Linear velocity, and centripetal accleration, both increas as the distance from the axis of rotation increases (this makes immediate sense if one considers a record; the distance travelled by a point on the outside of a record, is much greater than the distance travelled by a point near the rim of the record, and this distance is covered in the same amount of time). Although the timing of the rotation of the beam is not exact, and the calculated values for linear velocity are not exactly the same as the values reported by Logger Pro (I do however believe the two to be acceptably close), there is not much uncertainty in this experiment, as this is a very simple and easily observable relationship.

All graphs are presented on the pages attached to the back of the memo.

Conclusion

In conclusion, we found that linear velocity can be given by $V=R*\omega$, and centripetal acceleration by $A=V^2/R$ or $A=R*\omega^2$. The values Logger Pro reported for linear acceleration were fairly close to the values calculated through just using the time for one rotation of the beam, and application of the derived formulas.