PHY131 Practicals Day 8 Student Guide

Summer 2009

Concepts of this week's Module

- Motion along a circular path
- Angular Momentum
- Rolling without slipping
- Rotational Motion

Mechanics Module 6, Activity 3

Whirl the ball on a string in a horizontal circle, being careful not to hit anybody with it. Try to maintain the ball at constant speed. You will find it useful to run the string through the supplied drinking straw and hold the straw in your hand, keeping the string taut with your other hand. If you make the axis of rotation directly over your head you will be much less likely to hit yourself in the head with the ball.

A. Was the linear momentum $\vec{p} = m\vec{v}$ of the ball conserved as the ball moved in uniform circular motion? Explain.
B. Was the kinetic energy $\frac{1}{2} mv^2$ of the ball conserved as the ball moved in uniform circular motion?
C. Was the angular momentum of the ball, $L = mvr = mr^2\omega$, conserved as the ball moved in uniform circular motion?
D. Whirl the ball again in a horizontal circle. Reduce the radius r of the circle to about $\frac{1}{2} r$ by pulling on the string hanging below your hand. What happened to the speed of the ball? Did you notice anything about the pull on your hand by the string? If yes, what?
E. Was the kinetic energy conserved as the radius of the circle was being reduced? Explain.
F. Was the angular momentum conserved as the radius of the circle was being reduced? Explain.
G. If the speed of the ball was v when the radius of the circle was r, what was the speed when the radius of the circle was $\frac{1}{2} r$? If the magnitude of the angular velocity of the ball was ω when the radius of the circle was r, what was its magnitude when the radius of the circle was $\frac{1}{2} r$?

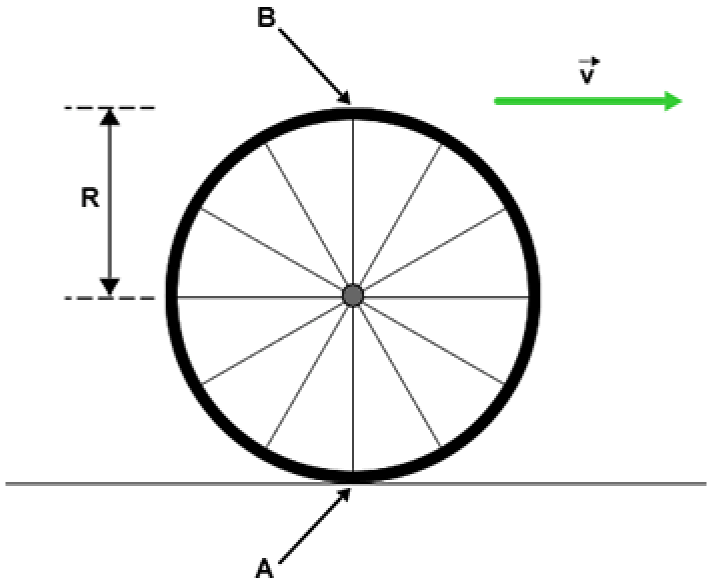
Course Concepts *Mechanics Module 6, Activity 4*

A Flash animation illustrating some of the points of this Activity and the next one is available at:

http://www.upscale.utoronto.ca/PVB/Harrison/Flash/ClassMechanics/RollingDisc/RollingDisc.html.

A full screen version which is easier for a group of people to see is at:

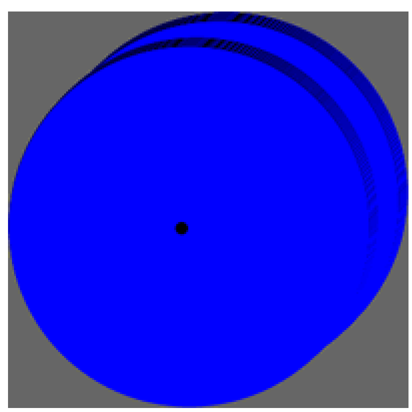
http://www.upscale.utoronto.ca/PVB/Harrison/Flash/ClassMechanics/RollingDisc/RollingDisc.swf



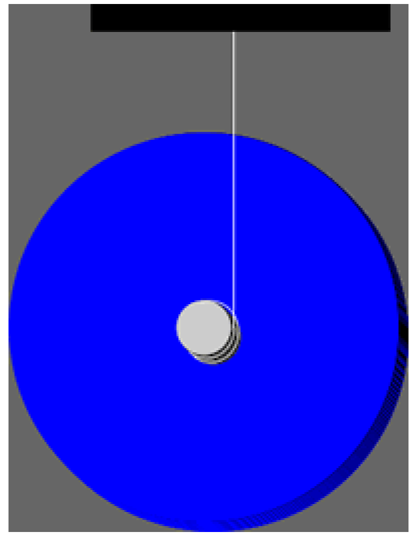
A bicycle wheel of radius **R** rolls to the right without slipping. The velocity of the axle of the wheel relative to an observer standing on the road is $\vec{v}$. At the moment shown in the figure Point **A** is in contact with the road, and Point **B** is at the top of the wheel.

A. At the moment shown what is the instantaneous velocity of Point **A** relative to an observer standing on the road?
B. For the person riding on the bicycle, about what point is the wheel rotating? What are the velocities of Points **A** and **B** and the axel at the moment shown in the figure? What is the angular velocity ω_B of the wheel?
C. For an observer standing on the road, about what point is the wheel rotating? For this observer what is the angular velocity ω_R of the wheel? What is the instantaneous velocity of Point **B** for this observer at the moment shown in the figure?

Course Concepts *If you have time: Mechanics Module 6, Activity 6*



A. Here is a figure of a yoyo that is in free fall: the string is not attached to anything and is not shown in the figure. Draw a free body diagram of the forces acting on the yoyo. Assume that air resistance in negligible.



B. Here is a cross section of a yoyo that is falling with the end of the string fixed to a support. In Part A, you could reasonably assume that the yoyo is a point particle. The free body diagram for this case must treat the yoyo as an extended body, and where the forces are exerted on it is important. Draw an *extended free body diagram* of the forces acting on the yoyo.
C. If both yoyos are released at the same time from the same height do they both fall at the same rate? Which moves fastest? Confirm your prediction by dropping the yoyo with and without you holding the string; catch the yoyo of Part A so it doesn't get damaged by colliding with the floor or tabletop.
D. Explain the results of Part C qualitatively using Newton's Laws.
E. For the yoyo of Part B, can the force exerted on the yoyo by the string ever do work on it? Explain the result of Part C qualitatively using conservation of energy.

Last revision to this write-up: June 8, 2009 by Jason Harlow.

The Mechanics Module 6 Student Guide was written in May 2008 by David M. Harrison, Dept. of Physics, Univ. of Toronto. Last revision: November 14, 2008.