PHY151H1F – Practical 10: Motion in a Circle, Torque

Don't forget:

- List the NAMES of all participants on the first page of each day's write-up. Note if any participants arrived late or left early.
- Put the DATE (including year!) at the top of every page in your notebook.
- NUMBER the pages in your notebook, in case you need to refer back to previous work.

Today's Textbook Reference to review before Practical:
"Principles & Practice of Physics" 1st Edition by Eric Mazur ©2015
Chapters 11 and 12

Note that the activities below have numbers which refer to numbers in the Mechanics Modules at http://faraday.physics.utoronto.ca/Practicals/ .

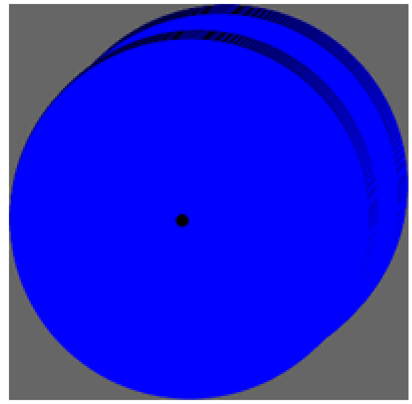
Mechanics Module 3, Activity 17

Attach one end of a string to the pig and the other end to the hook in the middle of the top bar. Pressing the "on" button on the side of the pig will get its wings moving. Now take the pig and give it a push in a circular direction in order for it to start performing uniform circular motion. After a few seconds, its motion should be stabilized. Then you may begin your measurements.

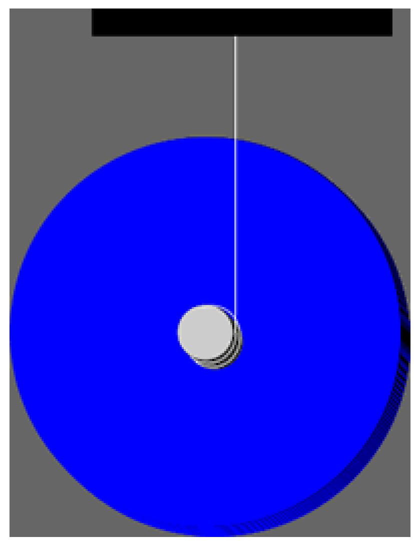
A. Determine the period of the pig's motion by finding the average time needed to complete 10 revolutions, using the stopwatch provided. Do 3 or 4 trials and take an average to get a good measurement of period.
B. Using the tape measure provided please measure the radius of the circle the pig is traveling. Determine a way to measure the pig's angle relative to the vertical.
C. Using data from part A and B calculate the centripetal acceleration of the pig.
D. Draw a free-body diagram for the pig (Do not include "engine force" and air resistance on this free-body diagram. They cancel out anyway.).
E. Use your free-body diagram and Newton's second law in the vertical direction to find the tension in the string.
F. Use your free-body diagram and the tension above to solve for the net force in the radial direction.
G. Compare the net force in part F to ma_c (using a_c from part C). How should these two values compare? How do your two values compare?
H. Briefly discuss why the "engine force" and air resistance did not enter into the calculations.

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.



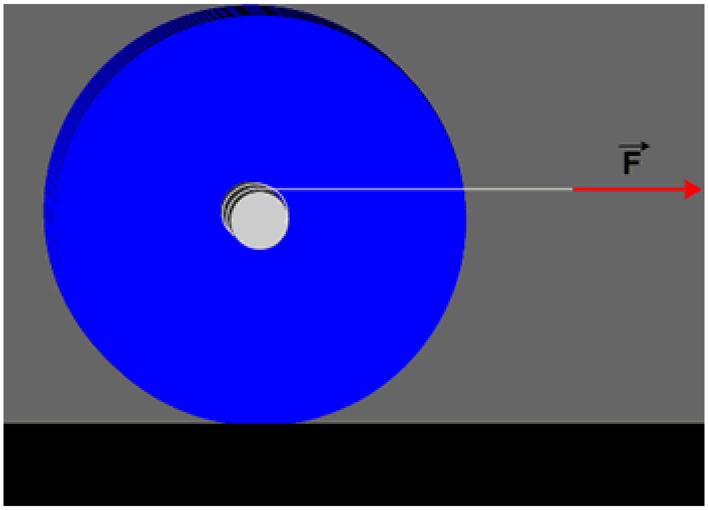
C. If both yoyos are released at the same time from the same height do they both fall at the same rate? Which moves fastest? Confirm your prediction by dropping the yoyo with and without you holding the string; catch the yoyo of Part A so it doesn't get damaged by colliding with the floor or tabletop.

D. Explain the results of Part C qualitatively using Newton's Laws.

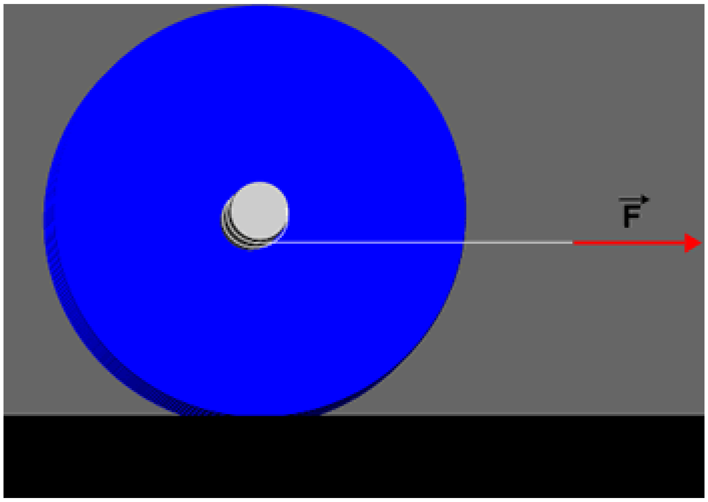
E. For the yoyo of Part B, can the force exerted on the yoyo by the string ever do work on it? Explain the result of Part C qualitatively using conservation of energy.

Mechanics Module 6, Activity 8

A. A yoyo sits on the tabletop, and is gently pulled to the right by the horizontal string, which is wound about the axel as shown in the cross-section view. The pull is gentle enough that the yoyo does not slip. Predict the motion of the yoyo. Using the supplied yoyo, confirm your prediction.



B. A yoyo sits on the tabletop, and is gently pulled to the right by the horizontal string, which is wound about the axel as shown in the cross-section view: note that now the string is attached to the bottom of the axel. The pull is gentle enough that the yoyo does not slip. Predict the motion of the yoyo. Using the supplied yoyo, confirm your prediction.



C. Explain the results of Parts A and B. Assume that the radius of the axel of the yoyo is r, and the radius of the yoyo itself is R. What are the total torques acting on the yoyo about its axis of rotation for Parts A and B?

D. Suppose that in the arrangement of Part B the string is not horizontal, but instead pulls the yoyo to the right and up. As the angle of the string is increased predict what will happen. Test your prediction. Can you explain?

If You Have Time (For a Bonus Point) – Practice Question from the Fall 2013 PHY151 Final Exam

Recently, my Aunt sent me a lovely ornament. It had a mass M_O; to display it, I built a shelf of mass M_S and length L and positioned the ornament at its centre, as shown in the figure. Unfortunately, I am a rotten carpenter, and the right hand support for the shelf soon disintegrated, so that the shelf fell down, pivoting about the left hand support as it did so. You may assume that the dimensions of the ornament are small, so that it may be treated as a point-like object. Express your answers in terms of M_O, M_S, L, g and μ_s, the coefficient of static friction between the ornament and the shelf.

(a) If moment of inertia of the shelf about its centre is $\frac{1}{12}M_S L^2$ and the ornament is not slipping along the shelf, find the total moment of inertia of the shelf plus the ornament about the pivot.

(b) Neglecting air resistance and assuming that static friction is holding the ornament fixed with respect to the shelf, find the angular velocity of the shelf about the pivot after it has fallen through an angle θ.

(c) Draw the free-body diagram for the ornament before it starts to slip off the shelf. What is the acceleration of the ornament?

(d) Show that the critical angle at which the ornament starts to slide down the shelf is given by:

$$\tan(\theta_{crit}) = \mu_s \left(\frac{4M_S + 3M_O}{10M_S + 9M_O} \right)$$