Lab 4: Newtonian Mechanics

Lab objectives

In this lab you will construct a simple system which nevertheless exhibits fairly complex behavior. You will analyze its behavior theoretically, and try to use that analysis to implement that system in the real world.

The system is a seesaw with a rolling wheel on top. As the see saw is tilted the wheel rolls from side to side. To keep the wheel rolling back and forth, the tilt of the seesaw must be changed periodically. The system has one source of feedback, an optical sensor at the balance point, that is capable of sensing the wheel as it passes.

For this lab, we will introduce a bit of friendly competition. How many back and forth rolls of the wheel can each group get their seesaw to make? Can you get the seesaw to work using the plastic ball, and how many cycles can you make the ball do?

IMPORTANT NOTE – your marks will be mainly given based on your analysis and approach to the problem. So long as you get the system to work reasonably well, you will get a good mark. The competitive aspect is for your learning and enjoyment – your marks will NOT be based on how well you compete with your peers. On the other hand, good analysis will probably lead to good results with your seesaw.

IMPORTANT NOTE – for this lab, you will have to demonstrate to a TA your *finished* system. You must be able to reliably and repeatably cause the wheel to roll back and forth at least 10 times, and the ball to roll back and forth 3 times to get the demonstration mark.

Step by Step

1. Analyze the motion of a rolling object on an incline using basic physics. Suggest an algorithm for balancing the rolling wheel. In particular consider how to start it, and estimate values for any time constants.
2. Construct the seesaw as shown in seesaw.pdf. It operates by turning the motor through a 180 degree turn, lowering or raising the bar. Compute (show all assumptions and work) when the bar should be tilted.
3. The program seesaw1.nxc is a very simplistic controller for the seesaw, that usually manages to get it to tilt back and forth a few times, but does not succeed in getting the system to stabilize for long (see video http://video.google.ca/videoplay?docid=8824106065221026886&pr=goog-sl). Use your analysis from question1, plus your experience in the lab so far to identify problems with this system. Design a better solution to balance the wheel. So long as you don't block the wheel, all aspects of the design can be changed, both mechanical and programmatic. You are being marked on your design process – give analytical reasons WHY you are making the changes you make.
4. If, instead of the rolling wheel, the seesaw was to balance one of the plastic balls from your kit how would the design have to be changed, and why? (The program given to you works even worse on this problem, see video http://video.google.ca/videoplay?docid=-1543861148117658742&pr=goog-sl) Can you create a stable system to balance the plastic ball? Again, so long as you do not block the ball, all aspects of the design can be changed. You are being marked on your design process – give analytical reasons WHY you are making the changes you make.

To hand in (10 marks each, total 60 marks):

1. Analysis of the motion of a rolling object and proposed algorithm for the seesaw (10 marks)
2. Analysis of flaws in the system provided to you. (10 marks)
3. NBC program to operate the seesaw for the wheel (10 marks).
4. Analysis of differences between the case of the wheel, and the ball and new/changed design to balance the ball (10marks).
5. Demonstration of results (Demonstration – 10 marks each the wheel and the ball).

References

This lab was inspired from the Seesaw built by Phillippe Hurbain http://www.philohome.com/seesaw/seesaw.htm