Mark McGuinness

Project
Swing High[1]

Due: Friday 15 October 2010.

You will work together in a group or in several groups on this project, but each of you must write an individual report.

The work is done together, and there will be lots of discussion and sharing of ideas. However, the final report must be your own work and words, representing your own understanding and explanation of the problem, and not a direct copy of any other report or material on the web or in publication already. Your report for this project will be used to help determine your grade for this course.

Please hand your report in to me (Co323), or leave in my mailbox at the School of Maths, Stats and OR, or email (preferably as a pdf file) to Mark.McGuinness@vuw.ac.nz, by or on Friday 15 October 2010.

[1]Note: this swing pumping problem was inspired by Prof. Colin Please (Southampton), and is also based on a problem posed by John Norbury (Oxford) for his Masters course.

Project Description:

How does a swing work?
How can a person on a swing make it go higher and higher?

You are asked to examine the action of a person on a swing, as they take it higher and higher without touching the ground and without being pushed. This is also called ”swing pumping”. You should model the swing with some mathematics, a nonlinear differential equation perhaps, but as simply as possible, and solve this model in some way. Then you should explain, mathematically and in words, how it is that the swing can be made to go higher and higher by an energetic person.

To make this project a little easier, you do not need to consider starting the swing from rest, but you may assume the swing is already moving a little. It will also help to consider what happens when a person is standing up on the seat of the swing, as in the following picture. You may find some of the work we have just completed in lectures useful in this project.

I also suggest you do a simple pendulum experiment with (long) string and a weight, to check if you have the right idea about what is happening. See if you can pump this pendulum by pulling the string, to make the pendulum longer and shorter, rhythmically.

Project Activities

The group work will be conducted during the remaining regular lecture times, when we will gather in the lecture room for informal discussions. These will be unstructured sessions, where I will be present. I will try to help, without telling you exactly what to do. The idea is that you work it out for yourselves, in a group effort, guided only a little bit by me. Please do ask me questions, if you need help.

In the group sessions, you will work together with pencil and paper, and/or perhaps using chalk on the blackboard. You may find it useful to visit the library to look at some books on mechanics and angular momentum and conservation of energy, at times. The internet is always a useful source of information, but watch out for incorrect or naive information. You can divide the work up according to your skills and interests in the group.

Each group will choose a **scribe**, who will record everything agreed upon in each session, and give copies to others in the group. You might change scribe each session, to spread the load. Each group will also choose a **reporter**, who will report back to the whole class, at the end of each week, what progress has been made so far by the group. This report should be no longer than 5 minutes long.

One of the first things we should do is to find a swing in a nearby playground, and then do some experiments to see how a person swings higher. I recommend that you bring digital cameras to take short movies to help visualise/slow down the action.

Suggested Report Format

This is how your report outline could look:

1. Problem title and description, and your name.
2. Physical background
3. Physical processes that might be important
4. Simplifications and assumptions made
5. Model derivation and definition of variables
6. Solution of model
   (a) numerical
   (b) analytical: phase plane, asymptotics, …
7. Interpretation of results and physical meaning
8. Comparison with experimental results