Loop-da-Loop Acceleration

Or How I Learned "Simple" Physics

Isn't Always Simple

Adam J. Archibald

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Warning!

This talk has been rated PG:13

PG: Physics = Good

13: No one past the age of 13 will find these jokes clever or funny.
Background/Motivation

- Spring 2009: Micro-course in microcontrollers
- Summer 2010: AAPT Workshop
- Fall 2011: Advanced Lab
The Question of the Day:

How do we find the acceleration of an object moving about a track?

2 Methods:
- Theory
- Experiment
Experiment!
Why Arduino?

- Cheap!
  - Starting at less than $20
- Size
  - Tiny (see picture)
  - Less than 2 grams for the Pro Mini
- Low power
  - Run as low as 3.3V
- Easy(-ish) to Use
- Very Versatile
Prototype

Major components:

- Arduino Pro Mini (5V, 16MHz)
- MMA7260 2-axis accelerometer
- μSD Card Breakout Board
“Production” Models

#1 Created by C. Evans

#2 Created by A. Archibald

#3 C. Evans (surface mounting)

#4 Rebuild of prototype featuring ADXL 320J
Prototype Remix
Circular Motion

204A:

$$A_r = \frac{V^2}{R}$$

How simple is that?
Conservation of Energy

- $m \ g \ h_0 = m \ g \ h + \left( \frac{1}{2} \right) m \ v^2$

  On the Loop: $h = R \{1 - \cos \Theta \}$

- $v^2 = 2 \ g \ (h_0 - R \{1 - \cos \Theta \})$

- $A_r = 2g \ (h_0 / R - 1 + \cos \Theta )$

But the Arduino datalogger we built doesn't record theta, only acceleration and time!
Uhg! Dimensions!

\[ A_r = 2g\left(\frac{h_0}{R} - 1 + \cos \Theta \right) \]

Remember \( A_r = \omega^2 R \)

Let's call \( \sqrt{\frac{R}{g}} = \tau \)
\( \frac{h_0}{R} = h \) and \( \frac{t}{\tau} = t' \)

Now we have:
\( (\omega \tau)^2 = 2(h - 1 + \cos \Theta) \)
Finding a function of $\Theta(t')$

Recall: $\omega = \frac{d\Theta}{dt}$

So $(\omega t)^2 = 2(h - 1 + \cos \Theta)$

becomes

$\frac{d\Theta}{dt'} = \sqrt{2(h - 1 + \cos \Theta)}$

A separable ODE right?
So let's do it!

What do you mean you can't do that in your head?

To Mathematica!
Next steps:

Get current prototype to work and create a working soldered product

Or

K. Scully and A. Skeffington's work with Wiimotes
(see paper posted in hallway)

Or

Android App (R. Belli) and Duct Tape
Special thanks to:

Christopher Evans

for all his work over the summer, and during advanced lab.*

Also that one time... with the shirts. You know what I'm talking about
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