Specifications for Graphs and Tracks rewrite, July 2016

[Phase One specifications in black; Phase Two specifications in blue]

# Technologies for implementation

Uses JavaScript, D3, SVG, HTML and CSS. Other technologies acceptable upon consultation.

# Runtime requirements

This is a web app that runs in browsers IE9, Edge, Chrome, Firefox

Runs on Android, iOS and Windows phones and tablets, and on Macintosh, Linux and Windows PCs

The layout scales upon window resizing. Minimum width and height is 640px X 480px (comparable to legacy version). On phones and tablets, program runs in landscape mode.

# User input

Press and release, press and hold, press and drag

# Window layout

Upon startup, a Title Page is displayed. Clicking anywhere, pressing Return or right-arrow advances to Main Window.

Main Window is divided into four panels: Instructions panel, Graphs panel, Tracks panel, Feedback panel. The aspect ratios of the panels can change depending upon current window dimensions.

Graphs panel displays graph axes with tick marks and numbers, units labels ‘(x (cm)’, ‘v (cm/s)’, ‘a (cm/s2)’, ‘t (s)’) graph title and curves for challenge motion (dashed or dotted) and trial motion (solid line).

Graph title has responsive triangle icons on either side to enable switching between graph types. For instance, if the current view is velocity, then clicking on the triangle to the left changes the display to position; clicking on the right changes the display to acceleration. When position is displayed, triangle on left is grayed out; when acceleration is displayed, triangle on right is grayed out.

Instructions panel shows instructions to the user. Styled text required.

Feedback panel shows help and evaluations of success. Styled text required.

Tracks panel displays posts and ramps with ball. Scales of initial position and initial velocity are displayed directly beneath the ramps.

# Data structure for trial motions

Ball rolling trials are defined by an array of 8 integers (initial position (s0), initial velocity (v0), 6 post heights), [x0, v0, h1, h2, h3, h4, h5, h6]

Range of x0: 0 to 500 in increments of 50

Range of v0: -60 to 60 in increments of 10

Post heights: 0 to 10 in increments of 1

Note: by limiting trial motions to these limited values, providing help and evaluating correct arrangements is simplified.

Initial challenge example is: [50, -30, 6, 5, 4, 3, 2, 1]

Second challenge example is [400, 30, 0, 0, 0, 2, 4, 6]

# Animation and Graph plotting

There are two “modes” of animation: (1) The selected graph (position, velocity or acceleration) is plotted simultaneously as the ball moves [used in all trial motions]., (2) The selected graph is plotted without any ball motion [used for challenge motions].

Accelerations along the ramps are taken as an = hn-1 - hn where n is the ramp number (1 to 5) and hn is the height of the post at the right-hand end of ramp n (hn-1  is the height of the post at the left-hand end of ramp n). This uses a small-angle approximation—that the angles of inclination of the ramps are negligible.

The ball position, x and velocity, v are updated at each time interval DT, as provided by a clock. Acceleration values depend upon the slope of the current ramp (fixed during a given trial motion). New values for x, v and t are calculated by,

x = x + v\*DT + a\*DT\*DT/2

v = v + a\*DT

t = t + DT

The x-position of the ball is calculated according to the formulae above and the motion is considered one-dimensional. The y-position of the ball is determined by where it needs to appear on the ramp given its x-position.

# User interaction with Tracks panel

User can click and drag top of post to adjust its height; uses rubberbanding to display new ramp angle.

Cllicking above each post or above the ramp at the midpoint places the ball there and updates the indicator on the initial position scale. Ball can also be dragged from its current position to a new position (0 to 500 in increments of 50, only)

Clicking on points along the initial position scale updates the indicator to the nearest 50cm position; ball position along tracks is updated.

Clicking on the initial velocity scale updates the indicator to the nearest 10 cm/s point.

On the left side of the Tracks panel are a Roll Button and labels for Initial position and Initial velocity.

# Menu items

Menu bar has items Options, Graph, Examples, Help

Options

Title page

Instructions

Free exploration

Quit

Examples

Next

Previous

Pick an example

Save current experiment

Help

Give help once

Leave help on

About

Title screen

# Step by step instructions for first-time users

Guided instructions for viewing different graph types (position, velocity, acceleration), setting initial position and initial velocity values, adjusting post heights.

# Provide specific feedback on trial motions.

Implement highlighting of initial position and velocity scales and ramps (labeled A, B, C, D, E) specific to help being provided. Note: multiple feedback messages may be available for a particular trial motion.

# Ability to save arbitrary configurations in data file

Save student track arrangements locally. Eventually, this may evolve into sharing challenge motions via the Web.

# User interface enhancements

In Problem Examples mode and Free Exploration mode, display post heights as integers immediately below each post.

Implement right-click and drag to raise or lower entire track at once.

Implement right-click on Roll button to roll ball in segments, one ramp at a time.