# Optimizing the design of a ball track using calculations and experiments.

### Important Dates (no extensions for any reason).

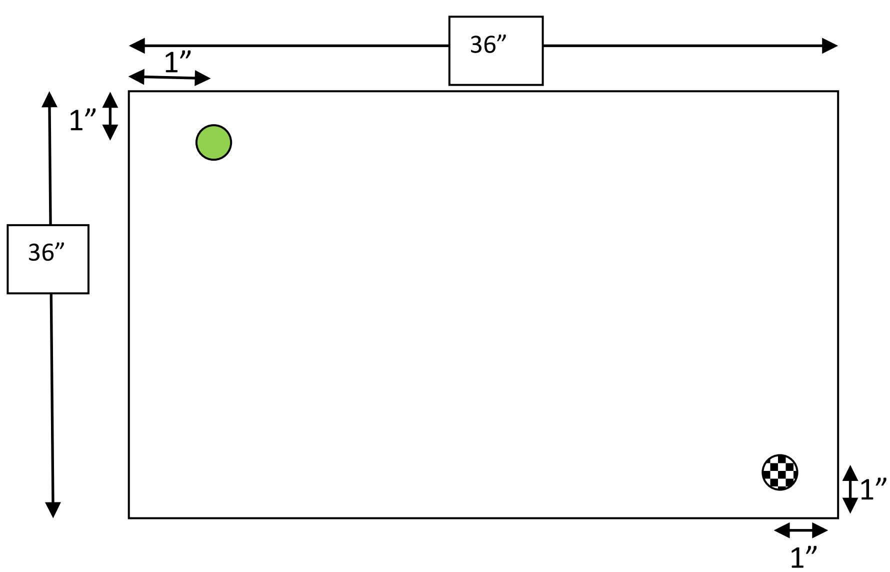
February 21: Sign up group members on Canvas.
Apr 4: In class testing of finished dynamic systems.
April 4: Final report and matlab code uploaded to Canvas by 11:59pm

### Group composition:

Project groups should be composed of **<u>4 students</u>**. Project group members must be signed up on Canvas by February 21st at midnight. Any students not in a group at this time will be assigned a group.

## Project Description

Design, simulate and fabricate/test a dynamic system that transports a ball from one corner of a 36 x 36 $in^2$ **vertical slab** to the other using the start and end positions as shown on the figure below. The objective of your design is to move the ball as quickly as possible from the start to the end. The dynamic system must be constructed of sloped, flat and curved fixed paths only (one of each). The ball must experience at least two changes in direction (one from right to left and one from down to up). The dynamic system must be passive (no electronics or batteries) and operate without user intervention once the ball is released from the start position. The ball must start from rest and start using gravity by releasing the ball.



## PART I: Design, Simulate and Study Your Dynamic System (60%)

Assemble all the components of your dynamic system in a Matlab model. Your ball must be started from rest (not held by the user) using gravity to provide initial movement after a barrier/gate is removed. Using the relationships that you derived in PART I, simulate and plot the motion of the ball through your dynamic system.

Vary the assumed value of each of your parameters (e.g. coefficient of friction, moment of inertia, curvature) by +/- 10%. Determine the mean and standard deviation for the total ball travel time with these variations included.

Designs will be evaluated for creativity, complexity and ability to meet the prescribed system constraints. The simulation of the final design will be evaluated for accuracy.

**Outputs:**

1) **The results of your sensitivity study including tabulated values of all tested parameters and the resulting mean and standard deviation for the total ball travel time. Comment on the value of sensitivity studies in your design analyses and the limitations of the study you conducted.**

2) **Plots required (overlay your chosen system and the mean and slowest variants of the system):**

- **Plot the position of the ball cg in fixed time increments (e.g. one data point every 0.1s), expressed in terms of the global coordinate system.**
- **Plot the magnitude of the linear velocity and acceleration of the ball cg as it travels through your dynamic system w.r.t. time.**
- **Plot the magnitude of the angular velocity and acceleration of the ball as it travels through your dynamic system w.r.t. time.**

3) **Submit your working matlab code for testing.**

## PART II: Component Sourcing and Characterization (10%)

As engineers we must be concerned with the source of each component we use in our designs and the impact of our choices on the environment. Therefore each component included in your system must be reused or recycled from existing devices including the 36” x 36” support frame. The source of each component, approximate duration of prior usage and disposal of each component after use in this project must be documented in your report. This is a simplified version of a life cycle analysis.

**Outputs:**

1) **Describe the source and disposal plan for each component of your designed system.**

## Report and fabrication (25%)

Once your designs are ready and your MATLAB codes are working, you are required to draft your complete dynamic system with dimensions using Solidworks.

Hand tools are available in the 4th floor machine shop (e.g. drills, hand saws, jig saws). Access to the shop is only for students who have completed the department safety training. Components should be selected that require minimal additional machining. You are welcome to use any additional tools that you may have access to outside of the SFU machining facilities.

Your final report submission must include:

1. Your designs, a parts list and environmental impact assessment (as described in Part II), and **all plots and output requested in part I of the project description**.
2. A working prototype to be tested in class on April 4th.
3. Observations, conclusions and recommendations based on the performance of your system during in class testing.

You must also submit your working matlab code as a separate .m file (do not copy the text of your code into your final report!)

### Performance (5%)

The performance of your system will be tested in class on April 4th. The performance grade for your system will be weighed based on the fastest and slowest systems in the competition.