Design and Fabrication of a Dynamic System.

Important Dates (no extensions for any reason).

February 25: Submit group members. You should email your group members name and student numbers to Sina via email (ssalari@sfu.ca). Sina will attend tutorial on February 25th to answer project-related question. You can submit the members to him then too.
March 3: Preliminary system design. You should use MSE 222 assignment box located on 4th floor. It should be no more than 2 pages. The design should be submitted again with the final project report and will be checked if they are the same (or very similar), or not.
March 31: In class testing of finished dynamic systems and marking them.
April 1: Testing MATLAB codes. Sina and Soheil will announce morning and afternoon times. You should meet them in their office and run the code for them.
April 5: Final report due by 11:59 pm.

Group composition:

Project groups should be composed of 4 students. Project group members must be submitted to Sina by email before end of Feb 25 tutorial time. Students without groups at that time will be assigned groups. Groups cannot be changed once they are formed.

Project Description

Design, analyze, simulate and fabricate/test a dynamic system that transports a ball from one corner of a 12×12 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 have the ball stop at the end position 4 seconds after it leaves the start position. The dynamic system must include at least one of each of the following: a rotating element, a spring, a curved path, two changes in direction (one from right to left and one from down to up) and an impact. 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 a spring (like a pinball plunger). The ball must come to a full stop at the end position.

PART I: Analysis of Each Component of your System

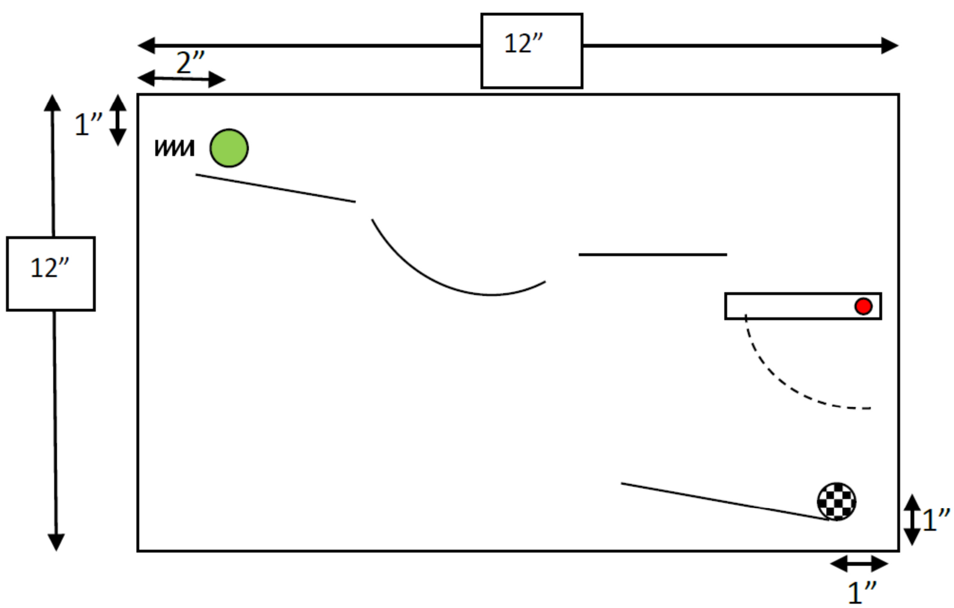
Steps:

Given an initial position, velocity

- Analyze the position of the ball center of gravity as it interacts with each element of your dynamic system (parameterize any assumptions such as spring stiffness, friction, coefficient of restitution so they can be updated after testing).
- Analyze the velocity (angular and linear) of any moving elements in your dynamic system.
- Analyze the acceleration (angular and linear) of any moving elements in your dynamic system.
- Find the forces of the ball acting on each element.

Note: Write these coded elements as functions in MATLAB. You can call the same function several times with different parameters to save yourself duplicate coding. Using separate functions also allows you to debug your code more easily.

Output: No output required for this stage.



PART II: Design, Simulate and Study Your Dynamic System

Assemble all the components of your dynamic system in a single simulation. The ball must be started from rest (not held by the user) using a spring to provide an initial force and acceleration on the ball. 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 component parameters (e.g. coefficient of friction, moment of inertia, spring stiffness and coefficient of restitution) by $\pm$ 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 chosen design will be evaluated for accuracy.

Output: 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.

Plots required:

- **Plot the position of the ball cg w.r.t. time, expressed in terms of the assigned global coordinate system.**
- **Plot the velocity and acceleration of the ball cg as it travels through your dynamic system w.r.t. time, expressed in the global coordinate system.**
- **Plot the angular velocity and angular acceleration of the rotating part w.r.t time.**

Note: Design your simulations in a way that the sizes and assumed parameters can be changed (also comment those lines in your codes), so that your code can be easily tested.

PART III: Component Sourcing and Characterization

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 recycle from existing devices including the 12” x 12” 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.

Having sourced components with unknown parameters (spring stiffness, impact properties etc) you must characterize the parameters of each component through testing. Each component must be characterized at least 3 times to determine a mean and standard deviation of the parameter value.

Output: Tabulate the results of the experimental characterization of each component. Comment on sources of potential error and propose methods for obtaining more accurate results.

Report and fabrication

Once your designs are ready and your MATLAB codes are working, you are required to draft your complete dynamic system with exact dimensions using Solidworks. The Solidworks drawing should demonstrate the initial position of your system.

Groups will be expected to source all materials for their project as outlined above in Part III Component Sourcing. 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. Please see Mr. Taha Al-khudairi (office across from the lego lab) for access to the shop. 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 submission must include:

1. A report containing your designs, all calculations, a parts list and environmental impact assessment (as described in Part III), and **all plots and output requested in each part of the project description**. The report should have all the element of a complete report, such as Cover, Introduction, Procedure, results, Discussions, Conclusions, References, Appendix, …
2. A working (commented) Matlab code (to be tested by TAs to give you a full grade)
3. A working prototype to be tested in class on March 31st.
4. Observations, conclusions and recommendations based on the performance of your system during in the class testing.