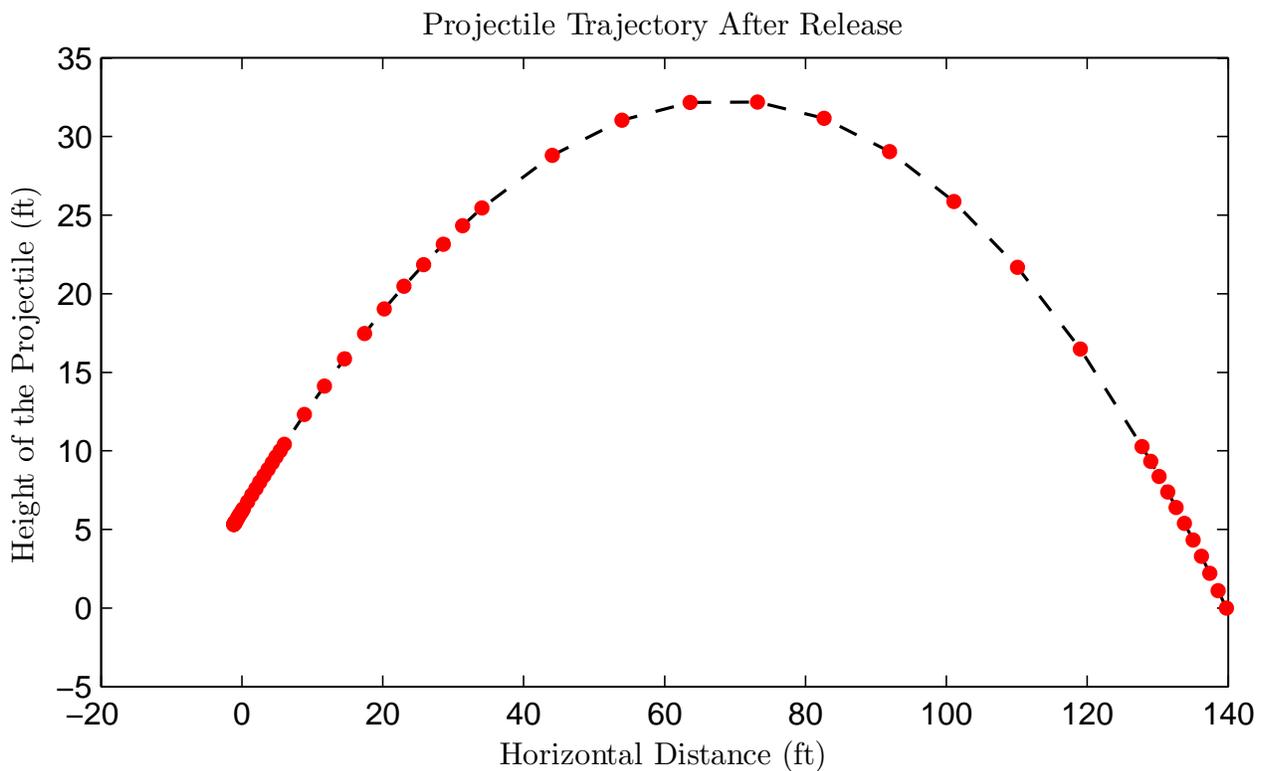# Trebuchet Physics Modeling Lab Instructions

GE100 Introduction to ISE

October 15, 2014

Your task today is to use the SimMechanics™ trebuchet model to find a design that improves range, evaluate the importance of each of the four variables, and to plan out your experiments for the second launch day.

After watching the model demonstration at the beginning of this lab session, please complete the following tasks with your group. Turn in just one set of documents for your whole group. Please read all instructions before getting started.

1. Sign In (All Group Members)

Group Number: _____

Name:_____ NetID:_____

Name:_____ NetID:_____

Name:_____ NetID:_____

Name:_____ NetID:_____

Name:_____ NetID:_____

2. How to Use this Document

- Red underlines in the digital PDF are hyperlinks to locations in the PDF or website. You can link these to jump to the hyperlinked location. The example here goes to the figure on the first page: Click Me

3. Using the Computer Model

Using the SimMechanics™ model, explore a number of trebuchet designs. Make sure the Matlab®[1] working directory is set to the folder containing the model files:
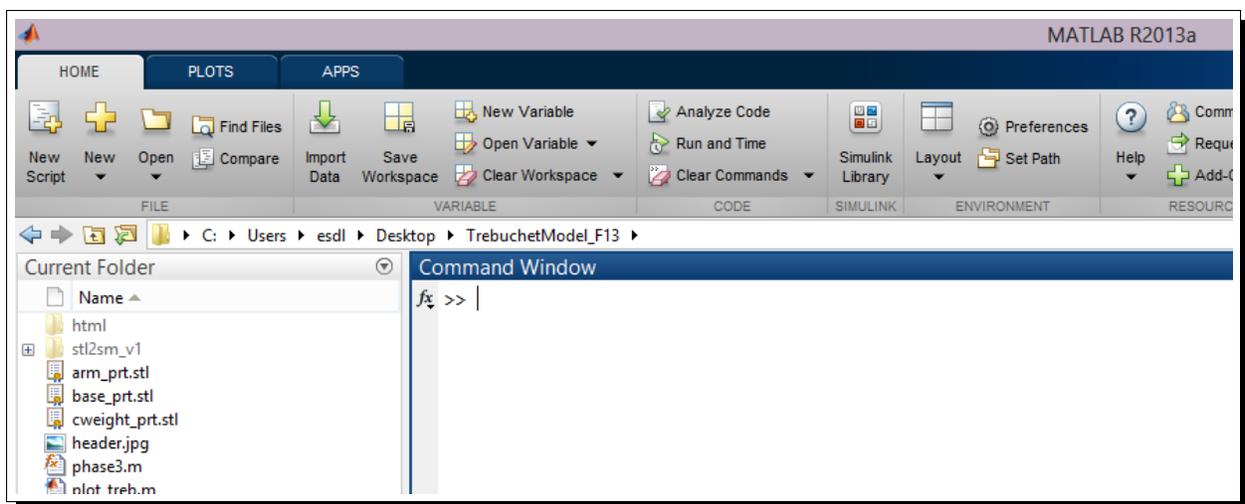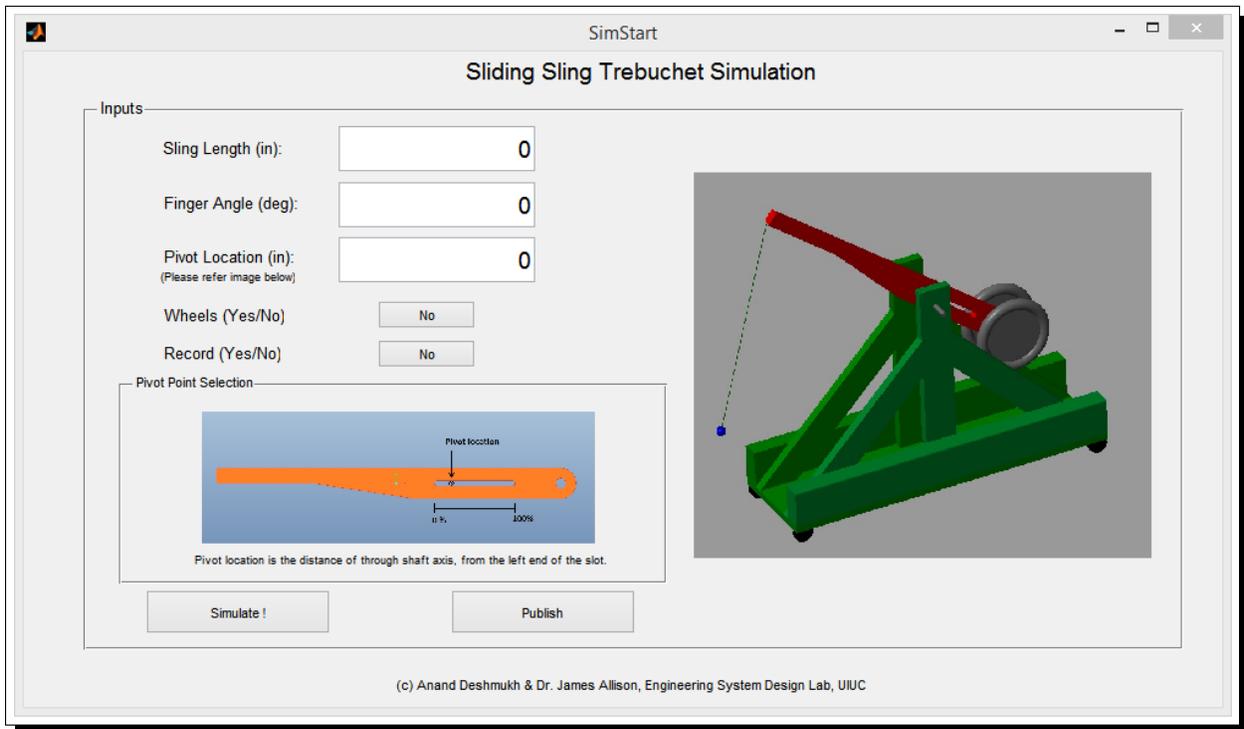

Launch the model by typing SimStart at the Matlab® command prompt:

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[1]Matlab® is a high-level language and interactive environment for numerical computation, visualization, and programming. You will learn how to use the software in CS 101–Intro Computing: Engrg & Sci
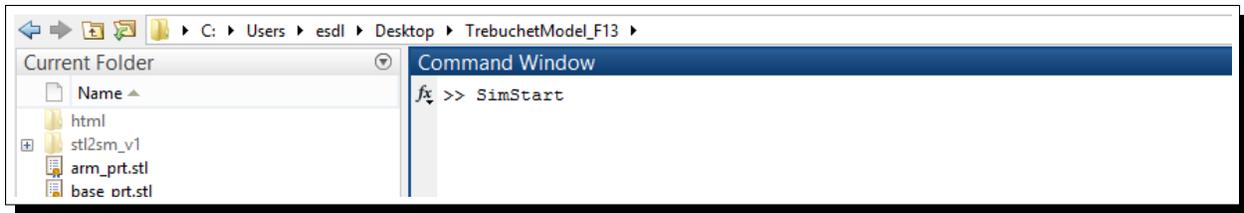
This will bring up a GUI (graphical user interface) where you can enter in design variable values:

Click the record button to begin recording what designs you try and the resulting range. Enter in the design variable values you want to test, and then click Simulate!. Several new windows will pop up to tell you the range, show you the projectile path, and allow you to animate the trebuchet motion.

After you are done with your tests, click the Publish button. This will generate to PDF files. Data.pdf will have a table showing all of your tests with design variable values and ranges. Plot.pdf will show using a plot how the range of your trebuchet designs changed during your design iterations.

Print out these two files, and submit them with this worksheet.

4. Exploring the Design Space

Test #	Sling Length (in)	Finger Angle (deg)	Pivot Location (in)	Wheels	Distance
1	26	-50.0	4	Y	_____
2	26	-37.5	4	Y	_____
3	26	70.0	4	Y	_____

What is a good finger angle when sling length is 26 in and the pivot location is 4 in? Why?

_____

_____

_____

_____

5. Rank the Design Variables

This will be done according to what you predict their influence on projectile range is. You did this during the design of experiments (DOE[2]) activity. Now that you have experience both with the physical trebuchet and experience exploring a large number of design using the model, see if your importance ranking changes. Variable #1 is what you consider to be the most important variable. When you are doing your tests during Step 2 you should be trying to assess what variables are most important in addition to working to maximize range.

    #1:_____

    #2:_____

    #3:_____

    #4:_____

Note: the fulcrum position and finger angle are measured as indicated in the figure below. When the fulcrum is as close as possible to the counterweight, it is in the 0 inch position,

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[2]For more information on DOE, you can take the elective course IE 400–Design & Anlys of Experiments

and when it is as close a possible to the finger it is in the 8 inch position. The finger angle is positive if the finger is pointed in the direction that the throwing arm rotates upon release, and the finger angle is negative if the finger is pointed opposite the direction that the throwing arm rotates upon release. The angle is measured from the dotted line shown in the figure.
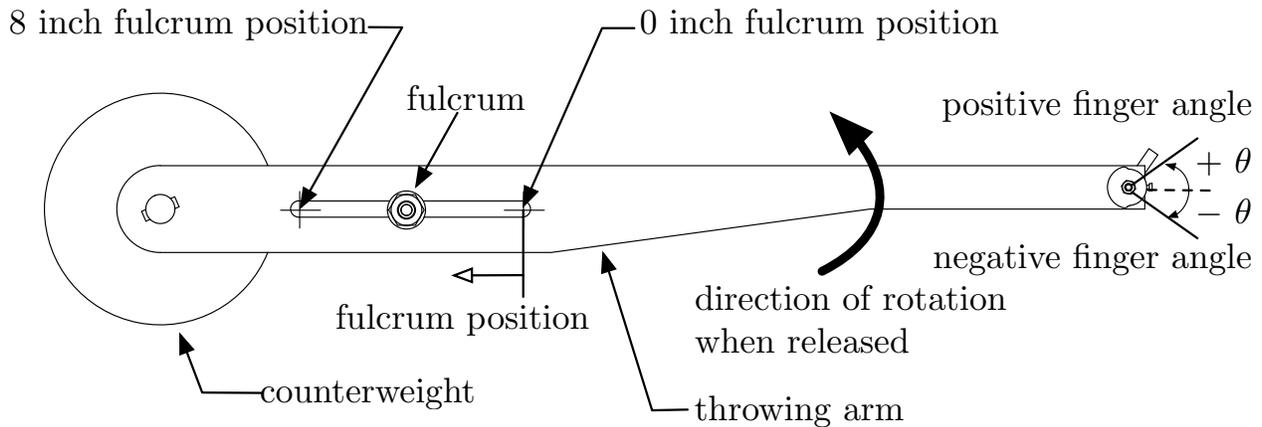
6. Plan for a Budget of Six Total Experiments

When you created your first DOE your objective was to explore a wide range of design possibilities (i.e., you used a space-filling DOE strategy). Now that you have used the model to identify an approximately optimal design, you need to use a very different strategy.

Your experimental result will not match your simulated result exactly due to inaccuracies in the model or uncertainties such as wind gusts. Your objective with these tests is to account for model inaccuracies and test not only your *optimal* design[3], but several similar designs to try and identify the best design for the actual physical system. Think of a dart board. Instead of scattering all of your tests evenly across the dart board, this time you will want to cluster your tests near the predicted optimal design.

Please record your experimental plan in the table below. These worksheets will be scanned and returned to you for the second launch day.

Optional: Test More Designs at Home

The model's files are in a compress zip folder that needs to be extracted hosted at:
`http://systemdesign.illinois.edu/GE100/TrebuchetModel.zip`

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[3]A number of department courses teach optimal design: GE 413–Engrg Design Optimization (this course is most relevant if you want to optimize the trebuchets), IE 310–Operations Research, IE 411–Optimization of Large Systems

Variable	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6
Fulcrum Position						
Finger Angle						
Sling Length						
Wheels						

The simplest way to run the model on your own machine is to use the Citrix Webapps. Navigate to the following website and login with your NetID and password. Then you might need to install the Citrix Online Plugin. Next you will arrive at a page of available applications to use. Select Matlab® (although many of other useful pieces of software are available).

`https://citrix.engr.illinois.edu`

`https://it.engineering.illinois.edu/ews/lab-information/remote-connections/connecting-citrix`

The other option is to install Matlab® on your personal computer. To do this you will need to login into the Illinois Webstore and order a free copy of Matlab®. Click Personal Purchases and then find MATLAB License & Download. A number of other free and deeply discounted software such as Windows and Microsoft Office can be downloaded from this website.

`https://webstore.illinois.edu/home/`

Matlab® among many other useful pieces of software are installed on a number of engineering workstation labs through campus. The following link listed the lab hours and locations for the EWS Engineering Workstations:

`http://it.engineering.illinois.edu/ews/lab-information/lab-hours-and-locations`