Centripetal Force Simulator

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Interview

Client Interview - Ideas

Physics Simulator to explore and gain a deeper understanding of centripetal force

Which of the following should be made adjustable?

- [x] Mass
- [x] Centripetal Force
- [x] Centripetal Acceleration
- [x] Radius
- [x] Other: Period of Rotation, Coefficient of Friction, Position of objects

Does the data need to be saved for later use (i.e written to a file)

- ( ) Yes
- (•) No

Is there a need for a grid based system to track position?

- (•) Yes
- ( ) No
- ( ) Maybe

What colour palette should the UI use?

B&W

Should there be outside forces acting on the object?

- (•) Yes
- ( ) No

What graphs should be produced?

No

How important is the design of the program?

	1	2	3	4	5	
Unimportant	○	○	◉	○	○	Critical

What other data should the program display?

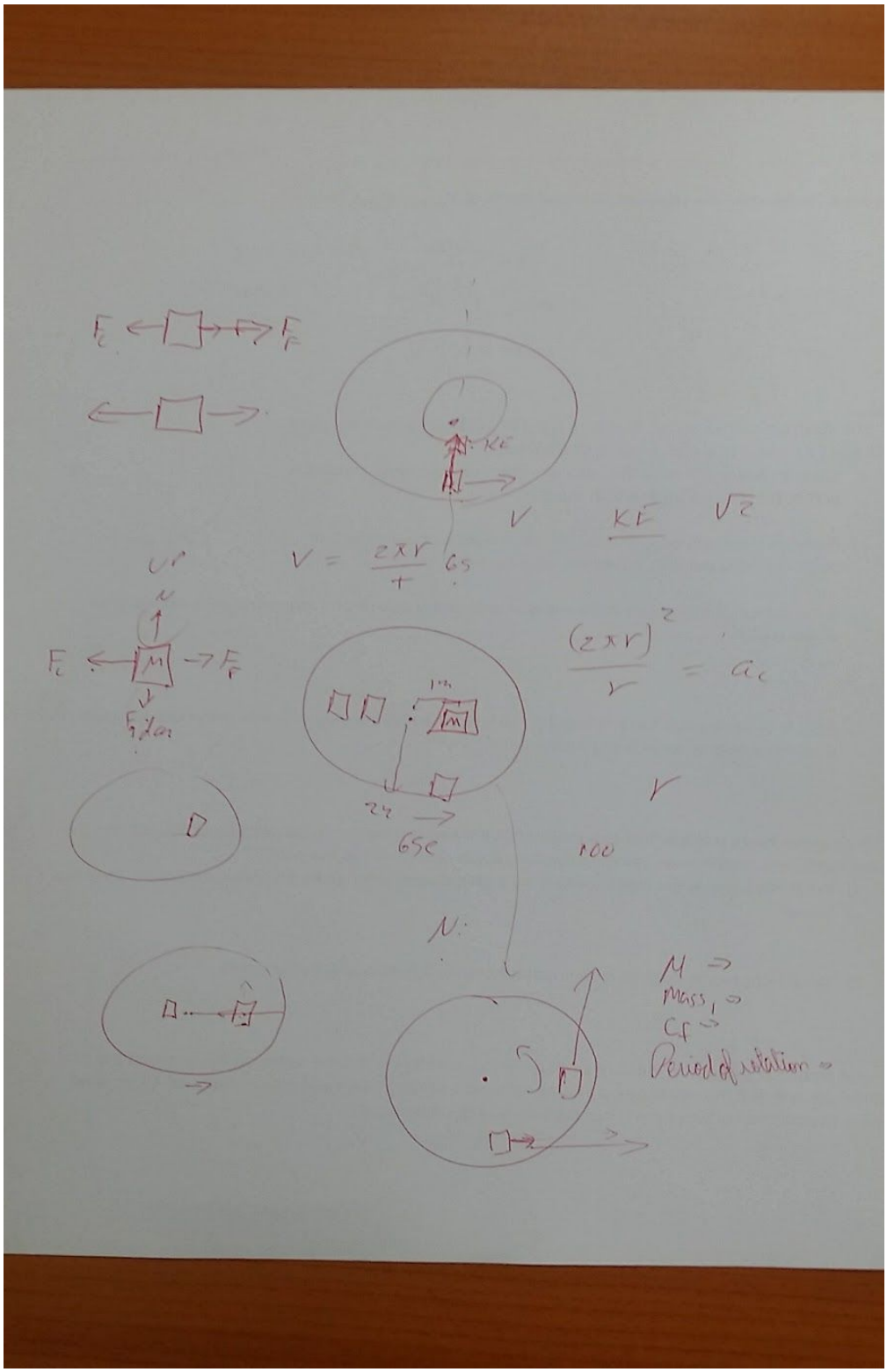
- [ ] Kinetic Energy
- [ ] Momentum
- [x] Free Body Diagram
- [ ] Other:

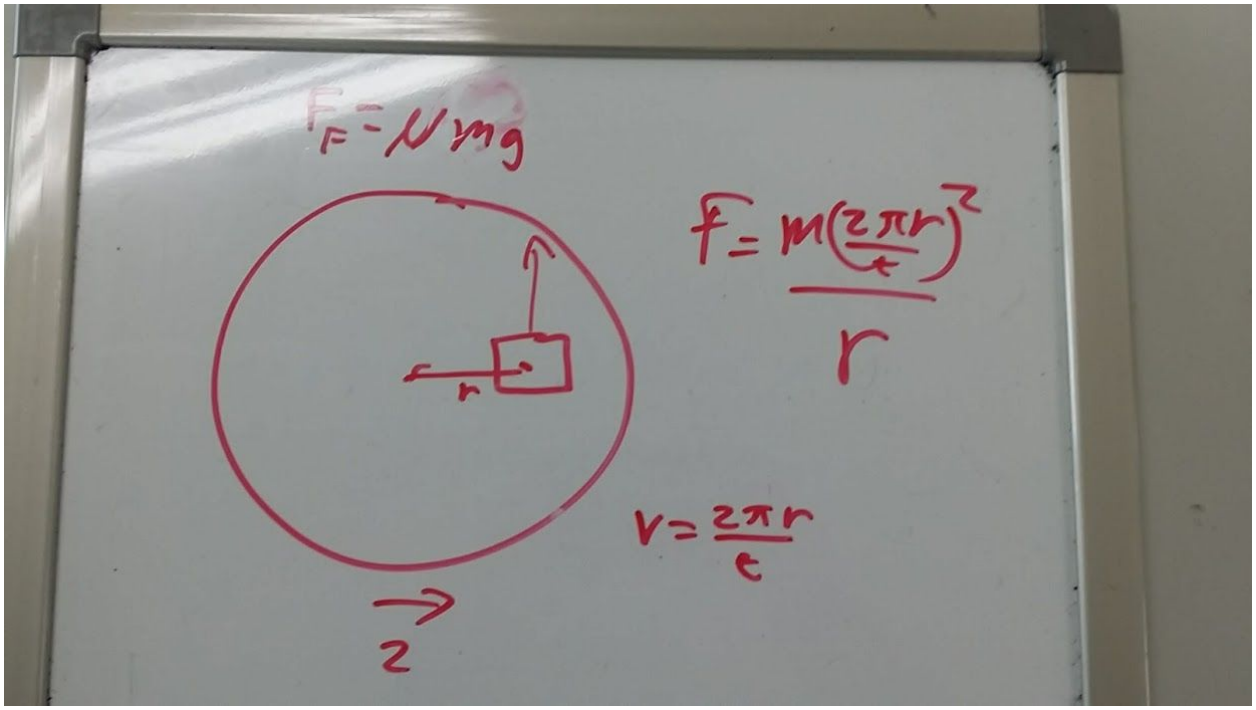
Should it allow solving for variables (i.e the user enters radius and force, and the program calculates the acceleration and draws it)?

- ○ Yes
- ◉ No
- ○ Other:

Other suggestions?

Sketches

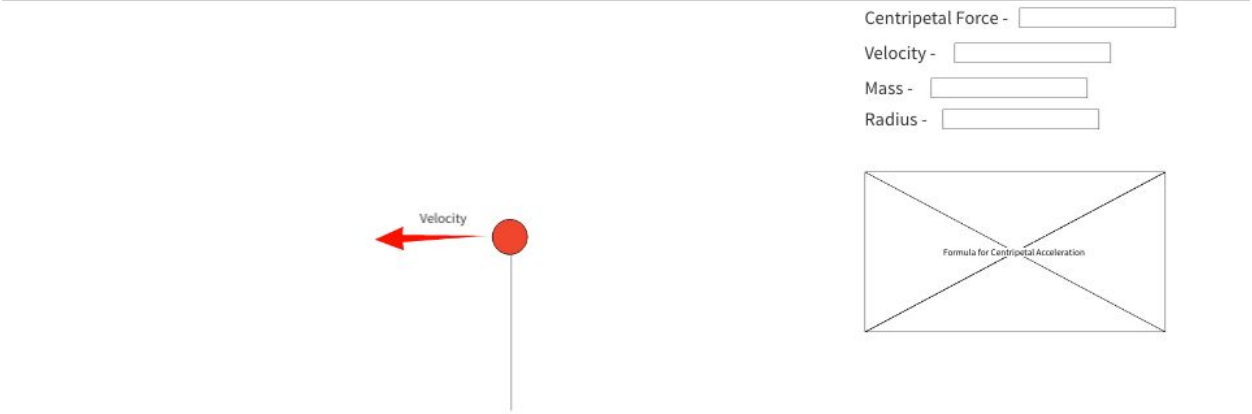




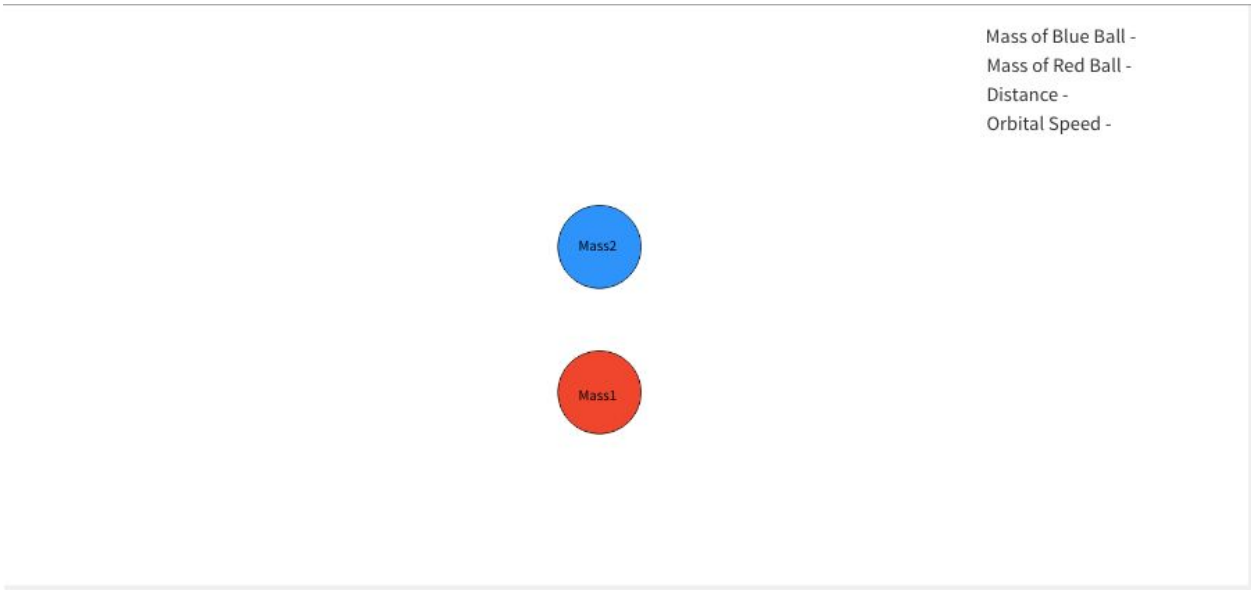
Specifications

- Incorporate static friction
- The size of the object is dynamic with respect to its mass
- Allows the placement of multiple objects on the platform
- Generates a free body diagram for each object
- Simulates the movement of the object depending on friction and centripetal force
- Allow the development of lab activities based around the software
- The speed of rotation is adjustable

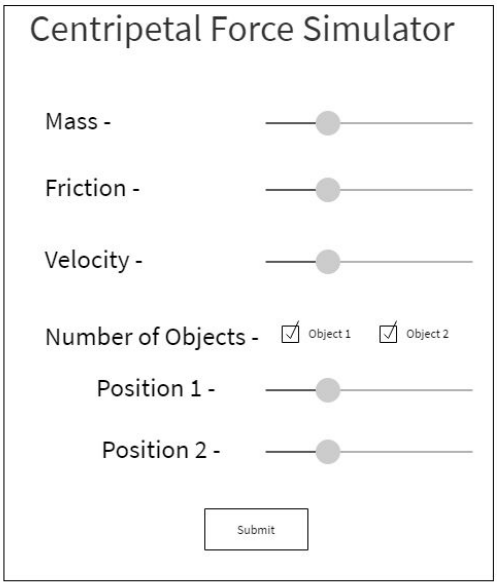
Designs

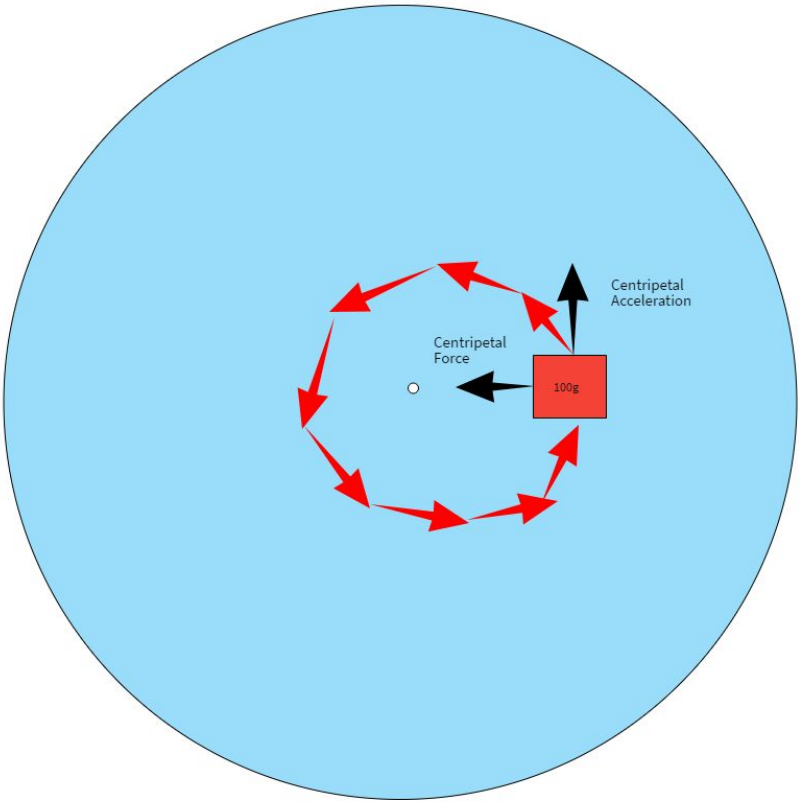


The user enters in three of the datafields at the top right, and the program calculates the last one. In order to prevent the user from entering bizarre information, the program never allows the user from entering all four data fields at once by automatically calculating the last one. Using this information, the ball that is attached to the string spins. This can be done by using a canvas and having the program calculate the position of the ball on the canvas. In order to make it move in a circular path, the program calculates all possible positions of the ball given the current radius. As it spins, a dynamic free body diagram is generated for the ball in order to demonstrate the forces acting (such as centripetal force and velocity). The image contains the formula for centripetal force.



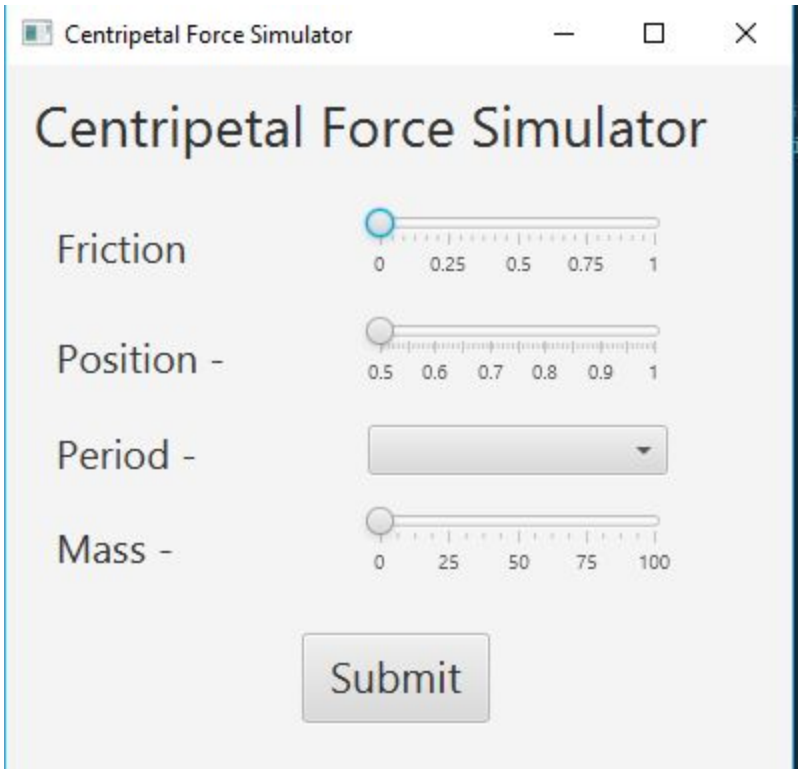
The user enters in at least three of the datafields at the top left, and the program calculates the rest. Using the mass of the two balls, the program determines the force of gravity for both balls. Depending on the gravity and set velocity, the balls move in relation to each other. For example, if the red ball is very large and blue ball is very small and is moving fast, the blue ball orbits the red ball. If the velocities are high enough, the two balls should be able to collide. In order to prevent the user from entering physics-breaking data, the data will be validated to make sure that is not breaking any laws of physics.

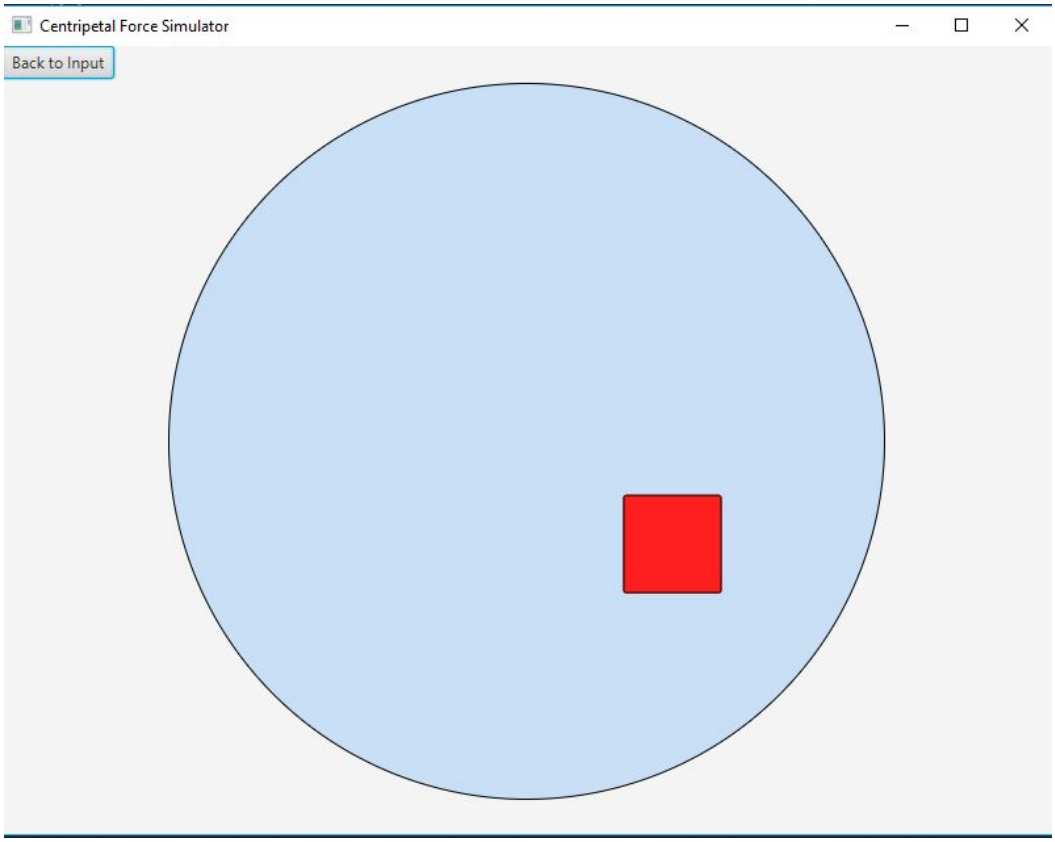


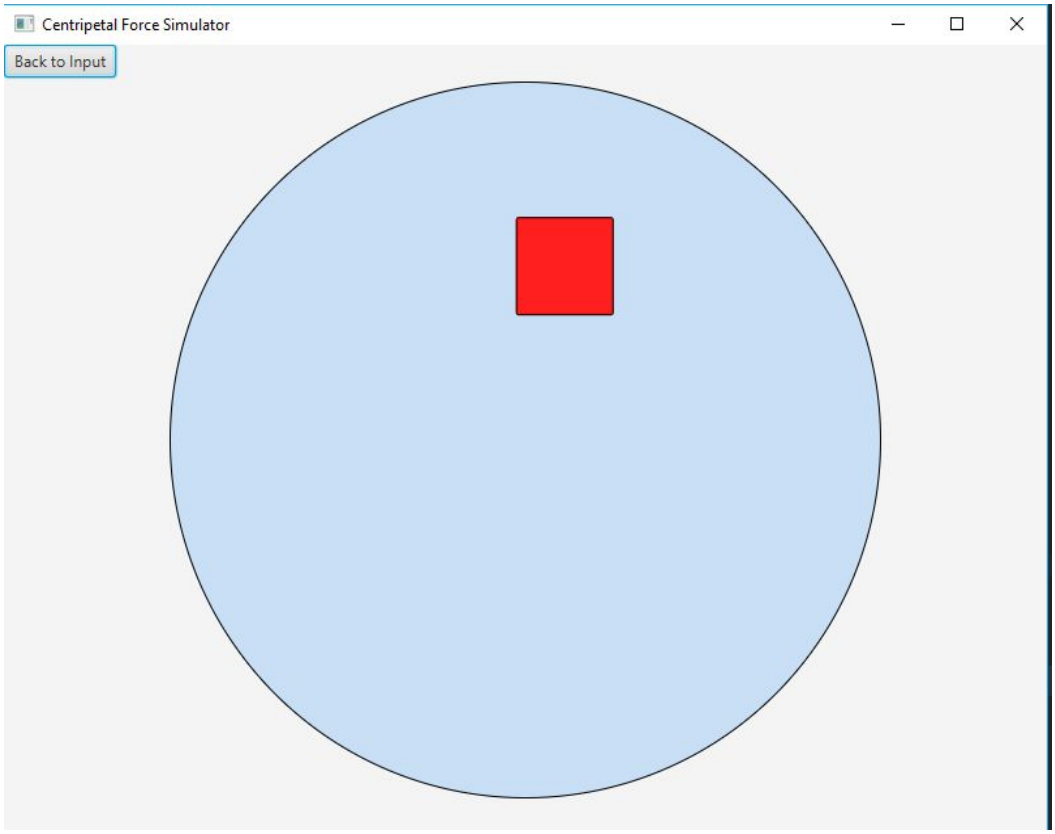


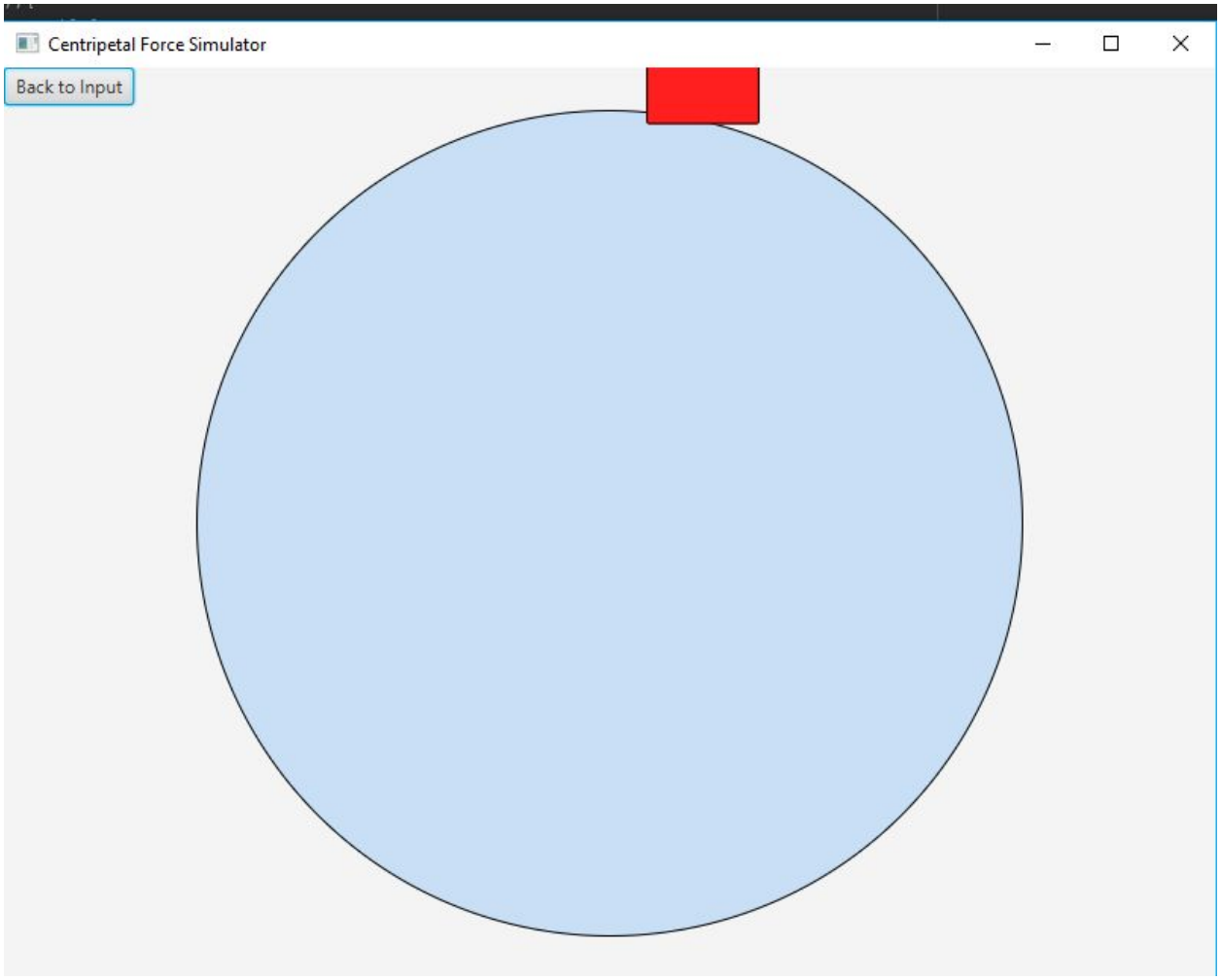
The user needs to enter all the data in the input screen as specified in the first screenshot. Once the user clicks on submit, the program will retrieve all the data as it was entered. Based on the set friction level, position and period, the program will calculate the static friction force and the centripetal force. If the force of friction is greater than the centripetal force, the object needs to follow a curved path off screen. Otherwise, the object needs to travel in a circular path around the centre with the velocity depending on the period that the user selected. The purpose to demonstrate the relationship between friction force and centripetal force.

Protoype 1


Centripetal Force Simulator
Centripetal Force Simulator
Friction
0 0.25 0.5 0.75 1
Position -
0.5 0.6 0.7 0.8 0.9 1
Period -
Mass -
0 25 50 75 100
Submit


Centripetal Force Simulator
Back to Input


Centripetal Force Simulator
Back to Input


Centripetal Force Simulator
Back to Input

Testing

Survey

Prototype 1 - Feedback

What are some design modifications that you think are necessary?

Display the data from the input screen on the animation screen,

Should the platform itself rotate?

- (●) Yes
- ( ) No

How is the movement of the box off the screen simulated?

Have it move in a curved path off the platform

Should the mass and the centre point be indicated on the screen?

- (●) Yes
- ( ) No

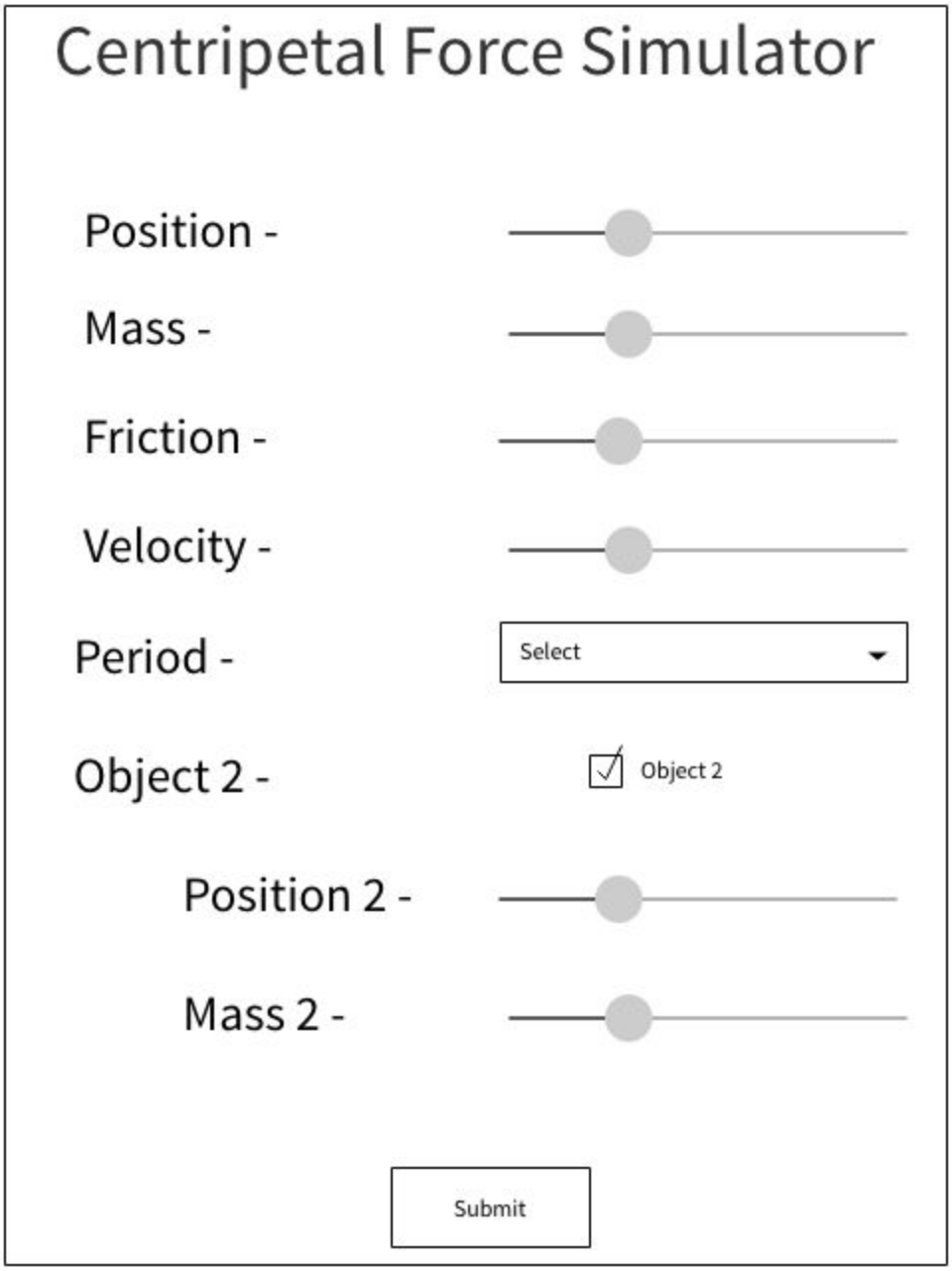
Suggestions?

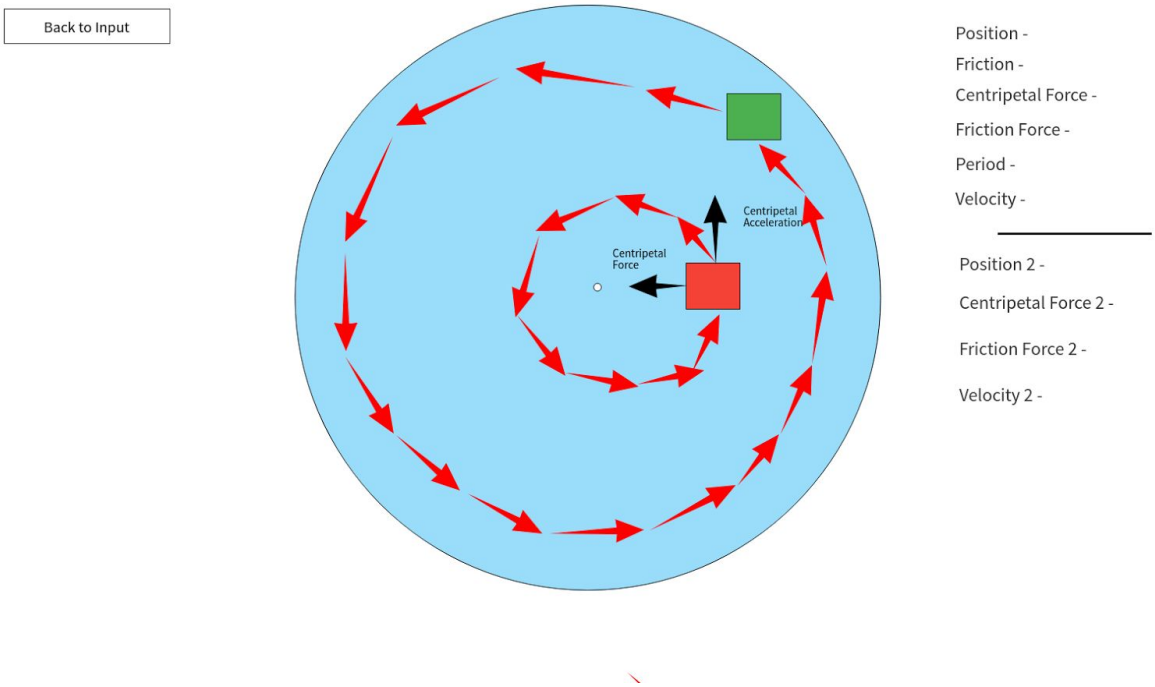
Determine min, max for each type of force and set it to overlap, use arbitrary values if necessary, Show free body diagrams

Testing Report

The client was generally pleased with the progress shown in prototype 1, but had some important critiques. The client detailed that he wanted the data that the student enters to be displayed on the animation screen in order to clearly show what was entered. The client also mentioned that he would prefer the sliders to snap to key values instead of being completely smooth. In the event that the client that the box needs to slide off the platform, the client detailed that he would like the object to follow a valid curved path off the platform rather than simply have it move off screen. He also expressed concerns that the parameters necessary to make the friction force exceed centripetal force was too stringent, and advised that using arbitrary values are still valid as long as they are used consistently.

Design 2

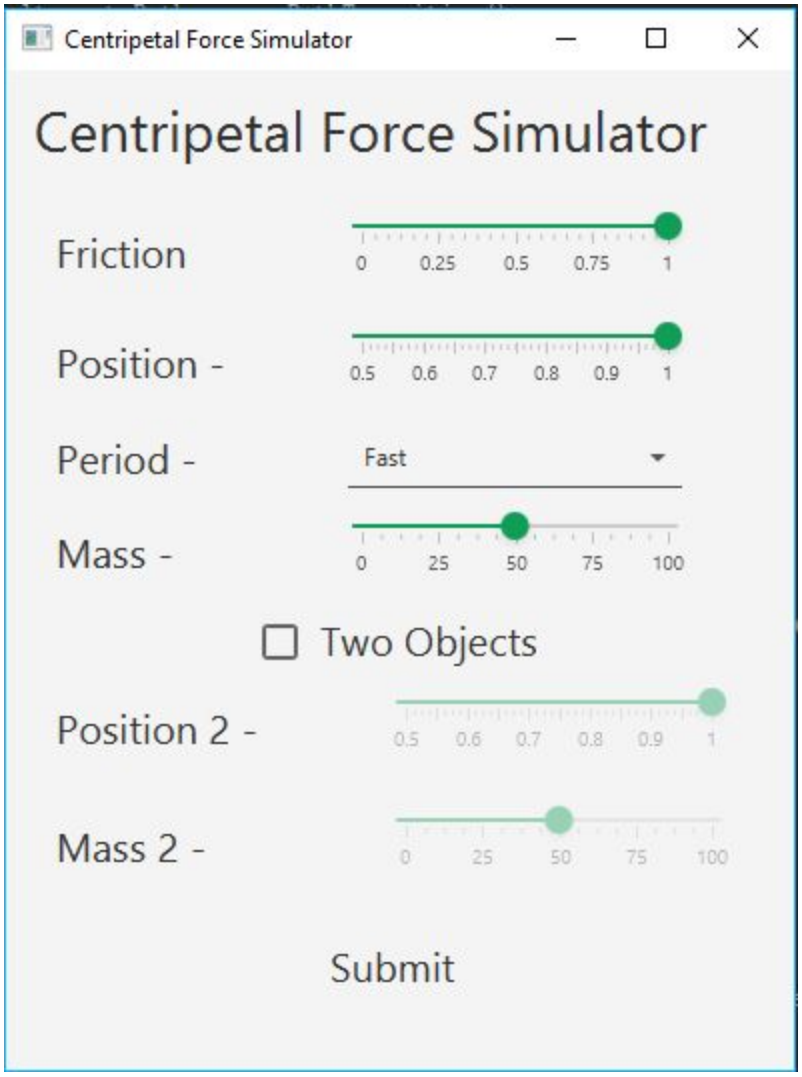

Centripetal Force Simulator
Position -
Mass -
Friction -
Velocity -
Period -
Select
Object 2 -
Object 2
Position 2 -
Mass 2 -
Submit

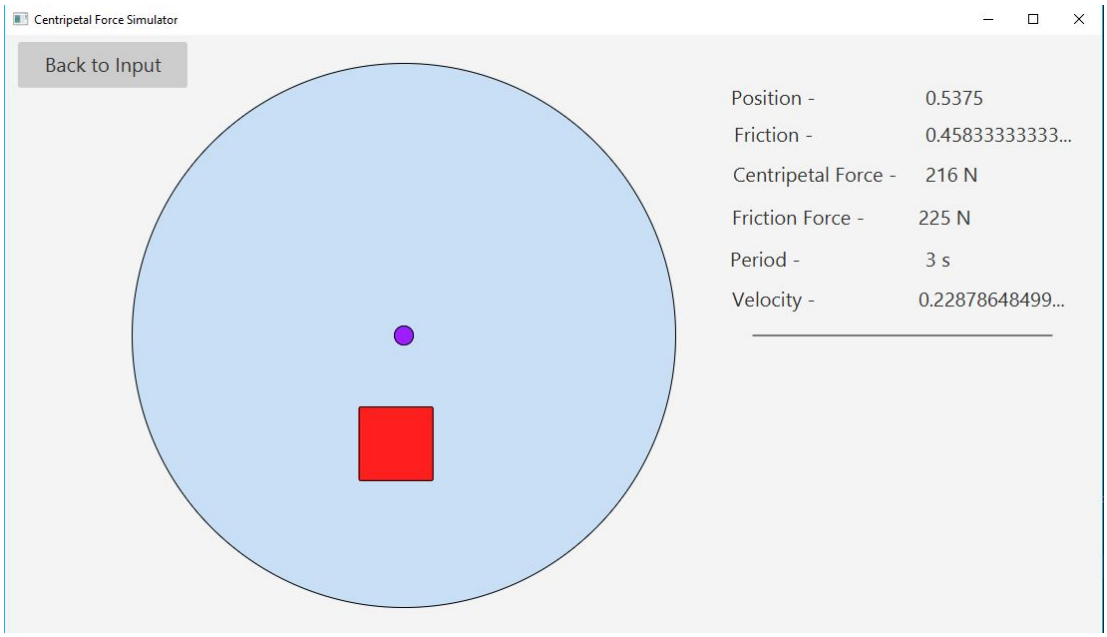


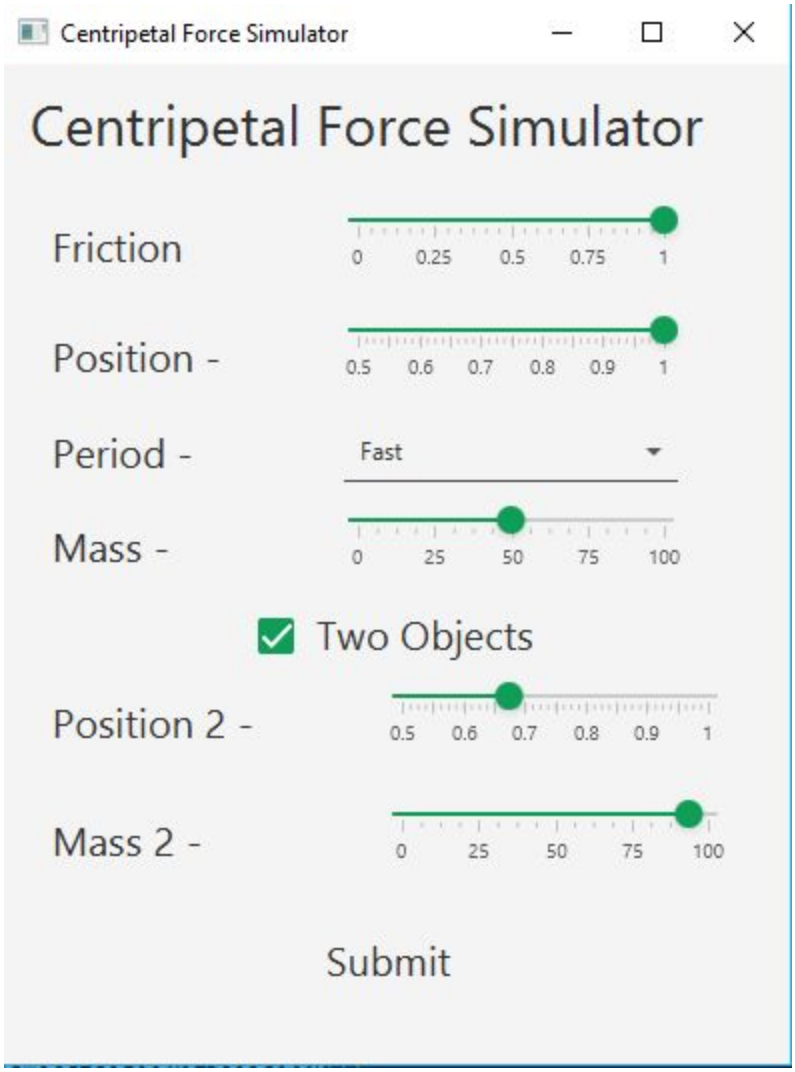
The input screen allows the user to enter the necessary information required to run the simulation. Initially, the object 2 checkbox is unticked and the sliders pertaining to that are disabled. Once the user enables object 2, the sliders are activated and the user is allowed to access them.

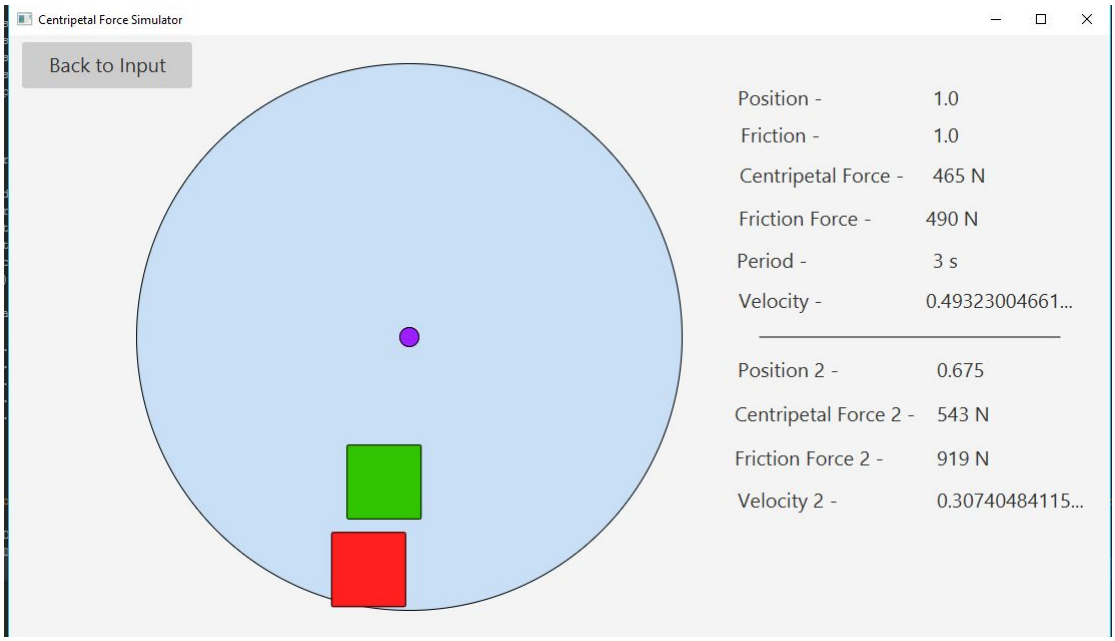
The simulation screen is mostly unchanged from design 1. Some additions include the information being presented on the right hand side of the screen. This is to allow the user to view the exact data that is being used to run the simulation. The second object is simulated in much the same way as the first object. A button is added to the top left that allows the user to stop the simulation and return to the input screen in order to change the data.

Protoype 2


Centripetal Force Simulator
Centripetal Force Simulator
Friction
0 0.25 0.5 0.75 1
Position -
0.5 0.6 0.7 0.8 0.9 1
Period -
Fast
Mass -
0 25 50 75 100
Two Objects
Position 2 -
0.5 0.6 0.7 0.8 0.9 1
Mass 2 -
0 25 50 75 100
Submit

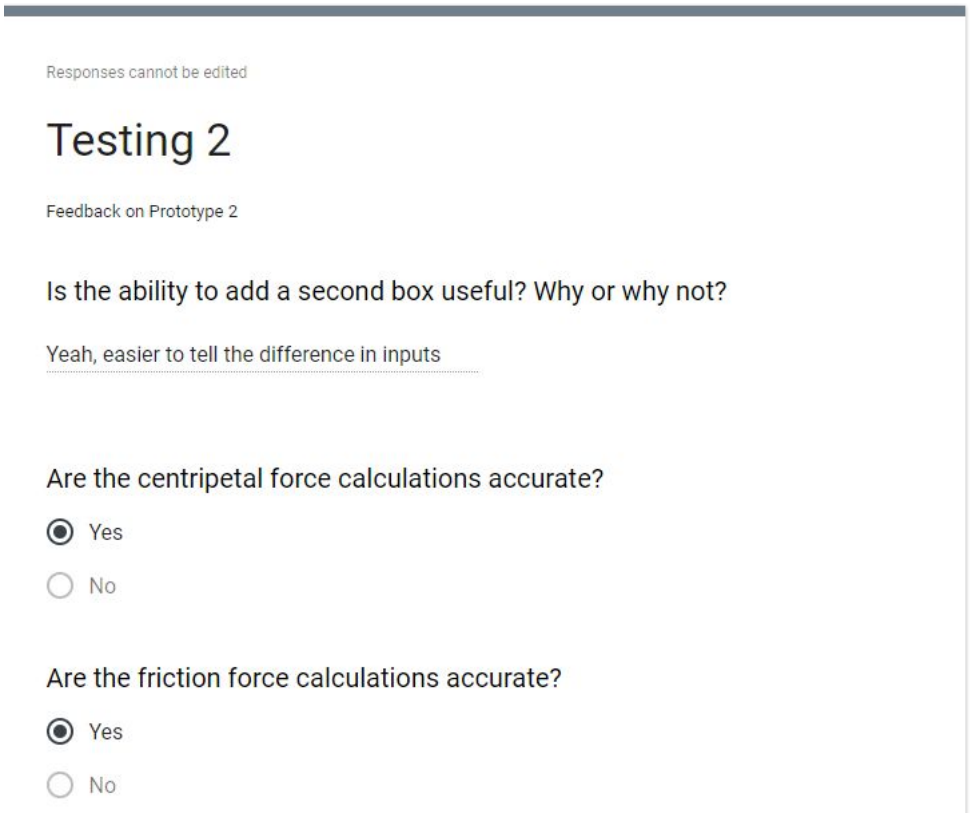

Centripetal Force Simulator
Back to Input
Position - 0.5375
Friction - 0.45833333333...
Centripetal Force - 216 N
Friction Force - 225 N
Period - 3 s
Velocity - 0.22878648499...


Centripetal Force Simulator
Centripetal Force Simulator
Friction
0 0.25 0.5 0.75 1
Position -
0.5 0.6 0.7 0.8 0.9 1
Period -
Fast
Mass -
0 25 50 75 100
Two Objects
Position 2 -
0.5 0.6 0.7 0.8 0.9 1
Mass 2 -
0 25 50 75 100
Submit


Centripetal Force Simulator
Back to Input
Position - 1.0
Friction - 1.0
Centripetal Force - 465 N
Friction Force - 490 N
Period - 3 s
Velocity - 0.49323004661...
Position 2 - 0.675
Centripetal Force 2 - 543 N
Friction Force 2 - 919 N
Velocity 2 - 0.30740484115...

Testing 2

Survey



Responses cannot be edited

Testing 2

Feedback on Prototype 2

Is the ability to add a second box useful? Why or why not?

Yeah, easier to tell the difference in inputs

Are the centripetal force calculations accurate?

- (●) Yes
- ( ) No

Are the friction force calculations accurate?

- (●) Yes
- ( ) No

Select the features that are not currently part of the program that you wish were.

- [ ] Free Body Diagrams
- [ ] Feedback to the user that the platform is rotating
- [ ] Showing the calculations for the forces
- [x] A tutorial screen
- [x] Other: Direct input

Rate your impression of the user interface since last prototype

	1	2	3	4	5	
No change	○	○	○	○	◉	Phenomenal

Would you use this program to teach students about this concept in physics?

Yes

Is dynamic sizing of the boxes important to understanding this concept

- ○ Yes
- ◉ No
- ○ Maybe

How would you prefer to distribute this program?

Schoology file as a file they can download and run. Or as a web service.

What other programs could be made to represent concepts in physics?

Centre of mass during collisions; two body interactions

Other additional thoughts?

Impressive!!!

Testing Report

The client was extremely impressed with the final state of the application given the time frame I had to work in. While he made some suggestions, overall he was satisfied with the capabilities of the simulator. The client was rather happy with the addition of new features such the second box, the centre indicator and the labels on the side. He was also very happy with the user interface of the program, which had been changed to look nicer than the standard javafx user interface. He would've preferred the inclusion of tutorial screens for students; they could refer back to it in the event they get lost during the lesson. He also found the sliders somewhat frustrating as it was hard to make precise adjustments and suggested that there be a method to directly input the value he wanted to test. While dynamic sizing was part of the original specification, it has been deemed unnecessary for the purposes of this program by the client. Finally, he made some suggestions for future projects such as building a simulator for two body interactions.

Evaluation

How useful was your initial interview? What information did you find that was useful? What extra question(s) would you ask next time? Was it useful? Was there any confusion with what your client asked for and what you understood?

The initial client interview proved to be extremely useful because my client was not present for the first week of the project. Since I couldn't contact him for details, I had to design the project without his input. However, when I presented my designs and ideas to him the next week, I realised the differences in how we understood the project. I had imagined a system where the box's have their velocities and radii set and then the computer simulates it. However, he wanted to demonstrate the effect of a moving platform on centripetal and friction force. We were able to clarify all these details during the initial interview.

I wish I had asked as to how exactly the physics behind the simulation worked during the initial interview, as I spent a considerable amount of time modifying the simulation to fit the parameters. For example, due to the way I had programmed it following the initial interview, the conditions required for the box to stay on the platform rather than fly off it was nearly impossible to do. I was able to redo the math behind the simulation at a later date in order to fix that issue, yet I wished I had asked about it during the initial interview. Regardless of this issue, following the initial interview I was able to understand exactly what my client wanted and was able to create the program.

For the design, did you complete it in as much detail as was required? Was it a useful task as part of the development process. If so, why? If not, why not?

While I did try to complete in as much detail as necessary, overall I found it to be quite useless as a part of the development process. The initial design had some purpose; the idea was to present three designs after the initial interview to the client and create the interface they liked. However, since my client was unavailable during the first week, I had to imagine three designs without having conducted the initial interview. This proved to be a huge waste of time as I was designing programs without having a single clue as to what the client wanted me to do. As a result, I was forced to throw out basically all my designs after I learnt what it was that the client wanted and design my program from scratch. Curiously enough when I did have to do that, I didn't bother recreating an imagined design on the paper and then creating it; I just made the program first and modified the design as necessary.

The second design step was pointless in both theory and practice. While I understand the purpose of this step if I were developing for a large development team and need to communicate with the designers, programmers, and testers, since I'm building the program by myself, it made no sense to create buttons and then describe them to myself. I already know what the buttons are going to do--I made them. Furthermore, my initial design was very close to what the client wanted anyway; the only changes were the order of inputs and the addition of labels on the side.

Specifications Check

<u>Incorporate static friction</u>

- Status → Completed
- It was completed by using a slider to adjust the coefficient of slider and combining that with the selected mass to calculate the friction force.

<u>The size of the object is dynamic with respect to its mass</u>

- Status → Incomplete
- While this wouldn't've been particularly challenging, since it was merely a graphical change and not necessary for the program's function it was pushed to the back of the development. Unfortunately, time ran out before I was able to design this section of the specifications. However, during testing 2 it was determined that the inclusion of this feature wouldn't have made much of a difference.

<u>Allows the placement of multiple objects on the platform</u>

- Status → Complete
- Completed using the option of adding a second box to the simulation. The details of the simulation was calculated using the same calculations as the first box.

<u>Generates a free body diagram for each object</u>

- Status → Incomplete
- This proved to be nigh on impossible because javafx has no arrow object as part of its library. While it's possible that some external library contained an arrow object, due to the severe time constraints I was unable to find a decent library and learn to use it before the deadline.

<u>Simulates the movement of the object depending on friction and centripetal force</u>

- Status → Complete

- This was the main portion of the program, and was necessary. It was done using PathTransition and physics calculations based on user input.

Allow the development of lab activities based around the software

- Status → Complete
- Since the program behaves in a particular way that is both consistent and true to physics, this program could be used to demonstrate to students the concepts of centripetal force and friction through the development of activities based around this program. While some modifications need to be made in order to simplify the user interface, overall this is a very feasible objective.

The speed of rotation is adjustable

- Status → Complete
- Another integral portion of the program, this was completed by allowing the user to select between two different speeds. This was necessary to show to students the impact that the speed of rotation has on centripetal force.

Did you complete the testing as well as you could have done? What good/useful questions did you ask? What other questions would you ask if you did it again?

Overall the testing was completed as necessary, with later questions being clarified separately throughout the development cycle of the program. All of the questions served some purpose or another; some clarified the designs, others the functions. The utility of the questions lay not with the inherent value of the response but rather the follow up questions and discussions it sparked. When he gave an answer to my question, I was able springboard other questions off of that response, which were greatly helpful through the development of the program.