THE HOOPING HOPPER

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Intro to Engineering, IDEAS 170, Spring 2020

ROADMAP

1. Assignment
2. Materials
3. Personal Design Goal
4. First Sketches / Original Design Plan
5. What Changed?
6. First Iteration
7. Second Iteration
8. Final Design

ASSIGNMENT

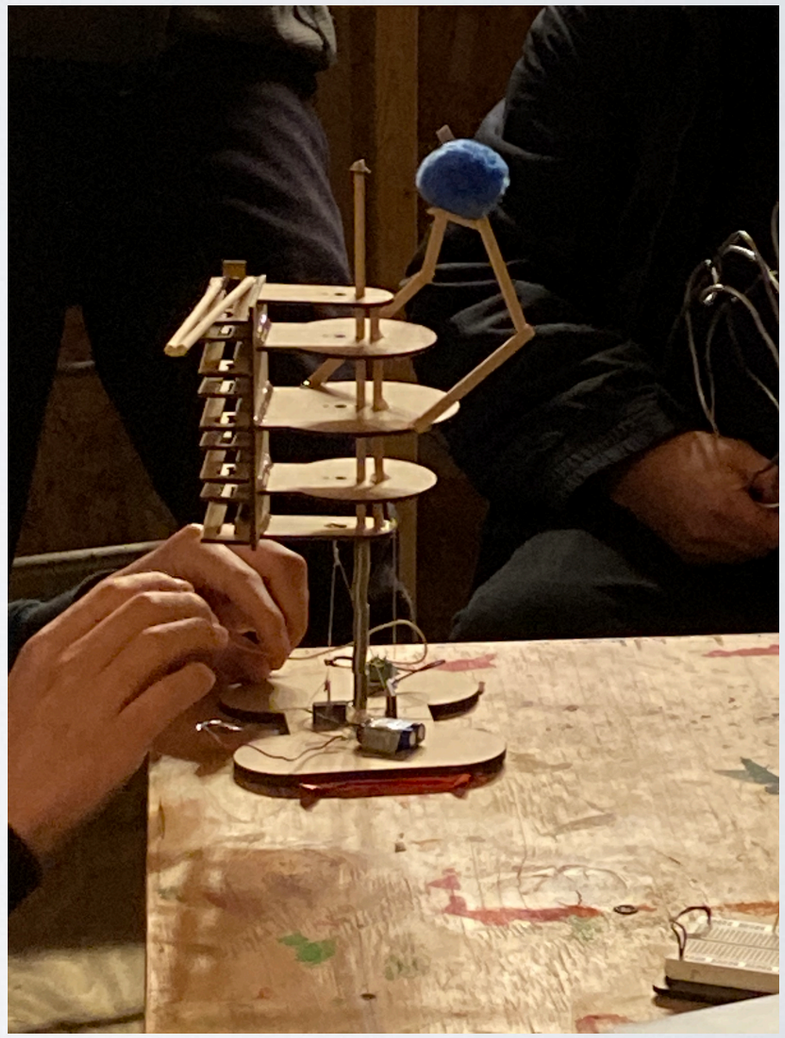
Create a hopping piece that has a timed wait of at least 8 seconds, at most 60 seconds, before hopping. All parts of the hopper must jump. All designs must adhere to your design goal.

IDEA170 Introduction to Design and Engineering

Hopper Design Challenge Parameters

You are to design a biologically-inspired hopper that will be composed of the items found in your kit (+ supercapacitors/rocket igniter and/or 3D printed part). The intent of this project is to evaluate and employ a means of potential energy release to defy gravity and send your hopper into air!

- The biologically-inspired design should hop in its entirety. In other words, you may not build a launcher or hopper that separates from a stationary base. You may, however, use liquid (that can be left behind) for timing or propulsion needs.
- Within the constraints of the design, you should develop a mechanical timer/trigger to allow actuation of the hop after 8 seconds and before 60 seconds without any intervention after time zero.
- As part of your design process, you should define a Personal Design Goal (PDG), of your choosing, and subject to the verbal approval of the instructor, that you should try to adhere to throughout the project life cycle. You are allowed to modify/change the PDG once between the First and Second Hopper Design Reviews without penalty, but further changes during the late stages of the Hopper Project will affect your scores.
    - Examples of a personal design goal may be:
        - hops more than 2 feet high, lands on its feet, does a flip, hits the ceiling, hops multiple times without manual reset, closely adheres to the theoretical calculations of the hop (i.e., max efficiency), has an animal-like aesthetic, uses no glue, uses a specific type of trigger, includes a 3D printed part, uses all kit items, etc.



Final Hopper

MATERIALS

Spring 2020 Hopper Kit Items

The items below provide the maximum quantities/sizes of materials that can be used for the construction of your final hopper design.

Item	Name	Quantity	Description
1	Safety glasses	1	self-explanatory…use them!
2	Wooden dowel	4, total	12in long Birch dowel rod with diameters (in) of 1/8, 3/16, 1/4
3	Craft stick	4	1/4in wide by 6in long by 1/16in thick craft stick
4	Fence wire	1	6in length of 14ga multipurpose
5	HDPE sheet	1	1in x 2in x 1/8in sheet of HDPE
6	PTFE rod	1	1/4in diameter x 1in solid PTFE (Teflon) rod
7	Aluminum foil	1	6in x 6in square of heavy duty aluminum foil
8	Machine screw	10, total	4-40 thread pan head phillips machine screw with lengths (in) of ½, ¾
9	Hex nut or locknut	10, total	4-40 thread nut or nylon-insert locknut
10	Retaining ring	6	3/16in shaft diameter external self-locking retaining ring
11	Compression spring	3	3.0in long, 5/16in outer diameter, stainless steel compression spring
12	Torsion spring	2, total	90° torsion spring, one left hand, one right hand
13	Rubber tubing	1	1 ft length of 1/4in outer diameter by 1/8in inner diameter latex rubber tubing
14	Rubber band	2	#64 rubber band
15	Plastic tubing	1	6in length, 4mm outer diameter, black or white polyurethane plastic tubing
16	Steel ball bearing	2, total	stainless steel ball bearing with diameters (in) of ½ and 5/16
17	Electrical wire	1	1ft length of insulated solid 22AWG hook-up wire
18	Heat shrink tubing	1	6in length of .09in inner diameter black heat shrink tubing
19	Magnet	2	neodymium cylindrical 1/8in outer diameter x 1/8in height
20	Safety pin	1	basting pin, size 2 - 1.5in
21	Cable tie	6, total	black Nylon cable tie with lengths (in) of 4, 8
22	Clear line	1	3ft length, 0.022in diameter, 30lb load limit, clear monofilament nylon line
23	Suction cups	2	3/4in diameter, 3/8in depth, suction cups with hook clips
24	Balloon (large)	1	12in diameter deep tone
25	Balloon (small)	2	5in diameter
26	Balloon (long)	1	long, twisty balloon
27	Pencil	1	#2 wooden pencil with eraser
28	Golf ball	1	yellow recycled golf ball
29	Golf tee	2	2 1/8in long golf tee
30	Pull back car	1	party favor
31	Binder clip	1	mini binder clip
32	Clothespin	2	ultramini clothespin
33	Sandwich baggie	1	foldover sandwich baggie

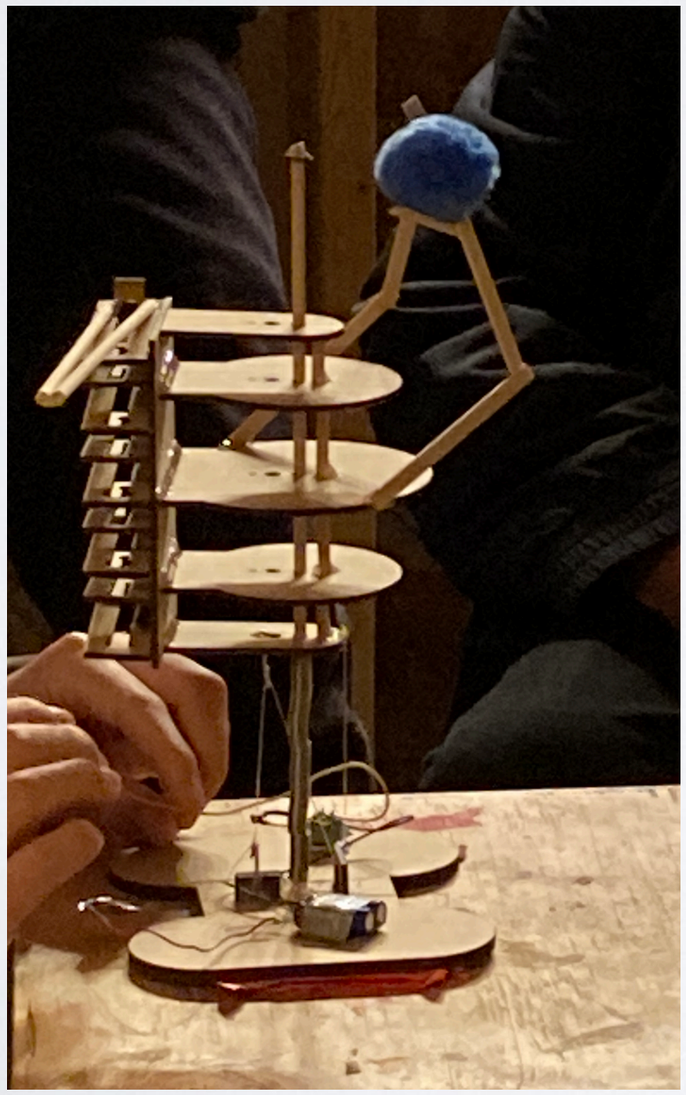
ADDITIONAL MATERIALS

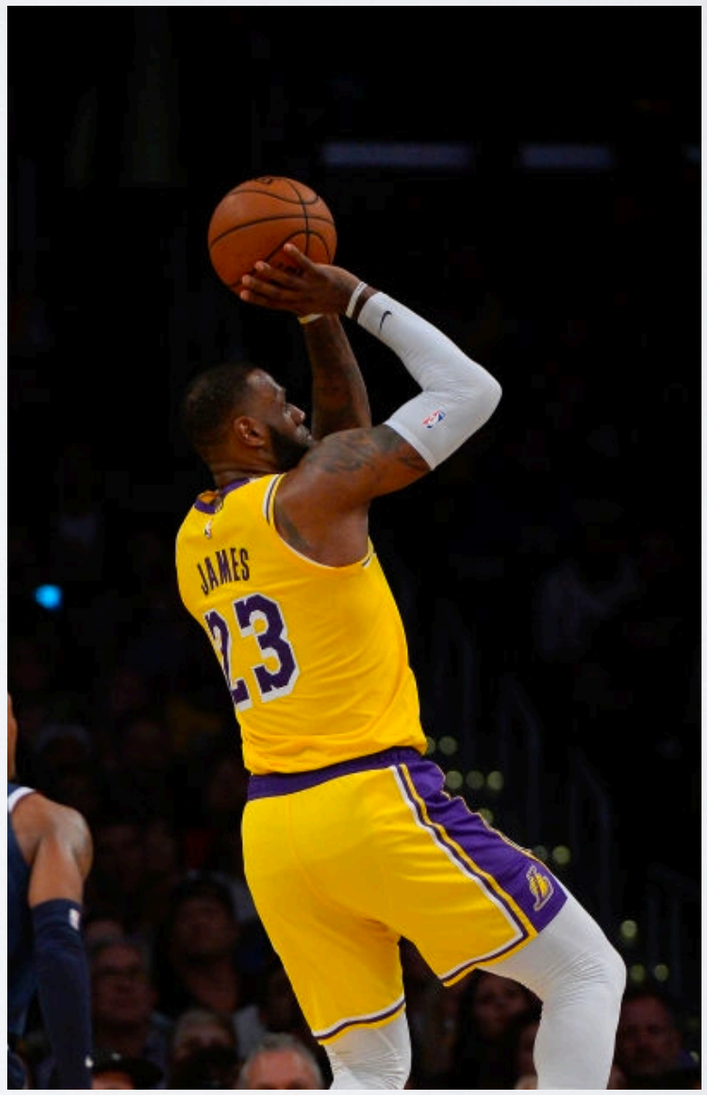
ITEMS BELOW ARE NOT PHYSICALLY IN KIT, BUT ARE AVAILABLE FOR USE

34	Fiberboard sheet	1, total	24 by 16 inch area, 1/8in or 1/4in thick, smooth Medium Density Fiberboard (MDF)
35	Super capacitor†	2	10F, 2.7V, 34mOhm equivalent series resistance, super capacitor
36	Rocket igniter† /resistance wire	1	Estes solar model rocket starters, or custom resistance wire
37	Water	1	100ml, tap water
38	Solder	-	0.031in diameter lead free solder with flux for joint making as needed
39	Hot glue	-	Gorilla hot glue sticks
40	Wood glue	-	Titebond III water-proof wood glue for joint making as needed
41	Epoxy	-	two-part epoxy, 5 minute
42	3D printed part‡	<=3 parts, 6in^3	No more than 3 printed parts, total volume on SolidWorks < 6 cubic inches

Personal Design Goal:

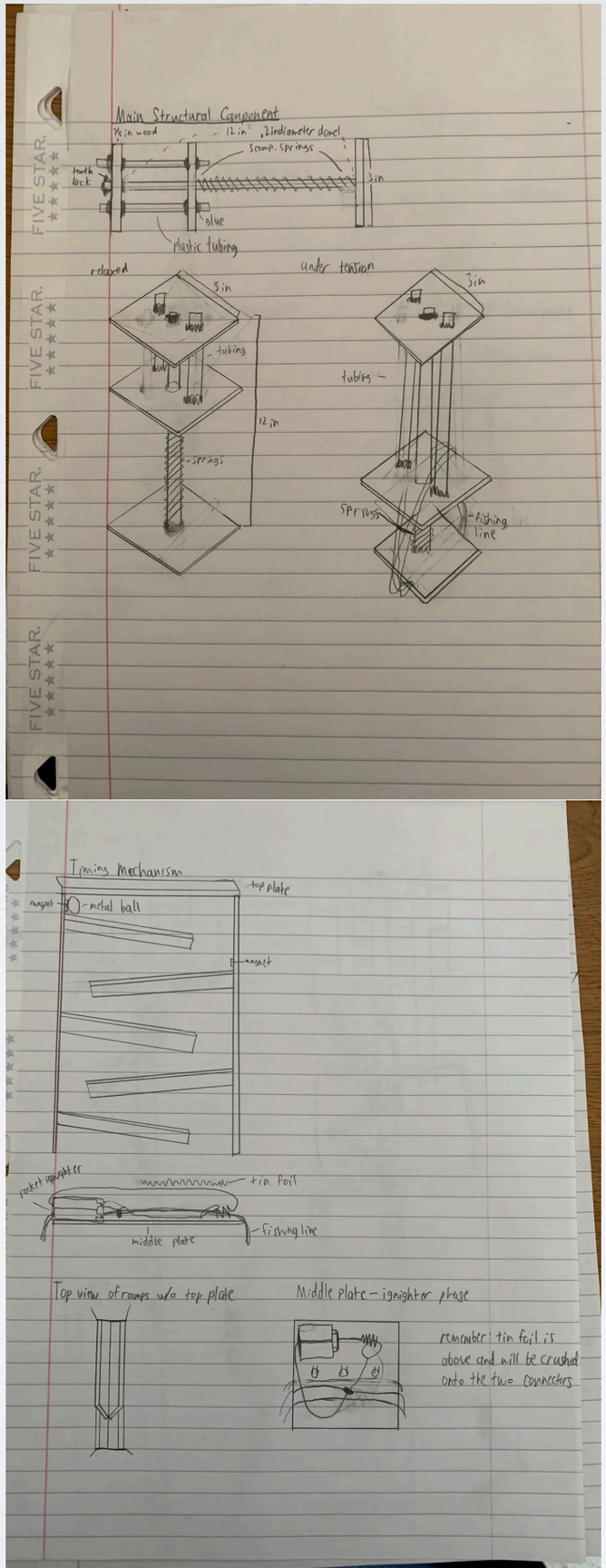
MAKE THE HOPPER LOOK LIKE A BASKETBALL PLAYER

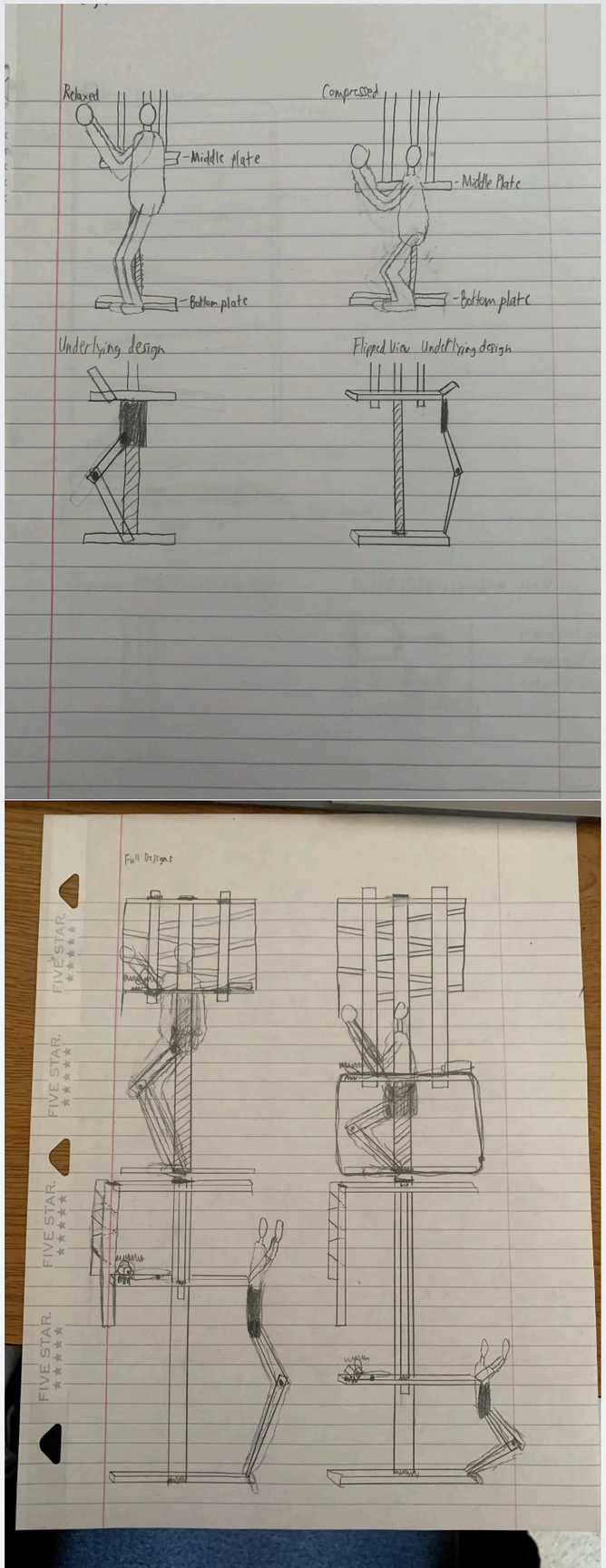




Sketches / Original Design Plan

The original design was inspired by previously created hoppers. It consisted of one plate moving between two static plates. Propulsion was to be created utilizing two springs and the rubber tubing. Every design and iteration included multiple ramp, where the metal ball would be traveling down the track and finally compress the two connectives attached to the rocket igniter. In the first design, the string would be wrapped around the entire moving plate, secured under the hopper.





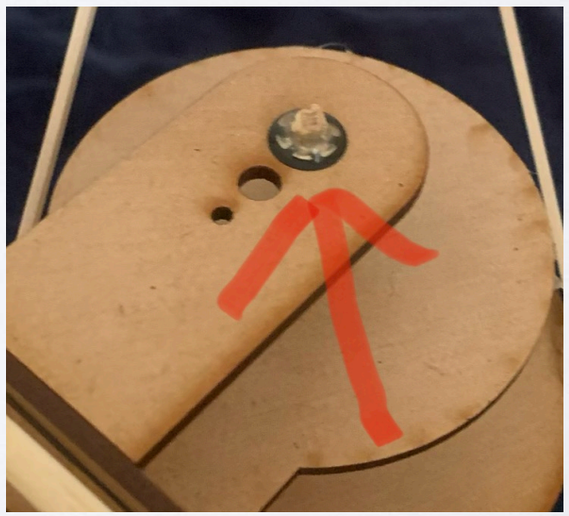
The original idea had the basketball player design offset from the ramp to provide balance. Originally, you can see the ramp protruding down from the top level, not connected to the moving plate with the player design. The first sketches also included 'legs' that would compress with the loading of the hopper and expand when the fishing line was cut.

SO WHAT CHANGED?

- I removed the top plate so that the moving part simply hits one of the retaining rings.

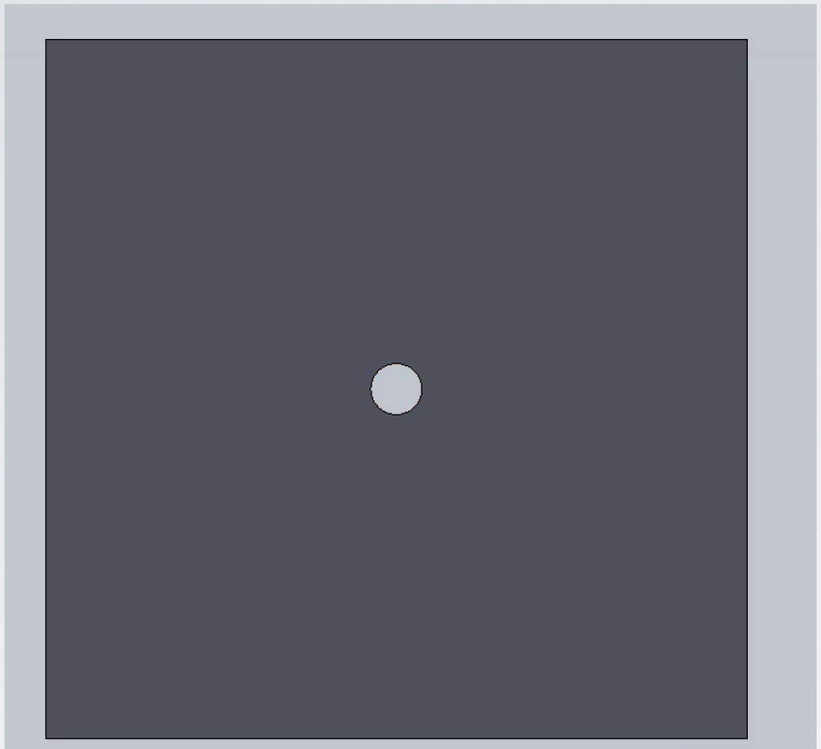
- I replaced the moving plate with a tiered design resembling a body.

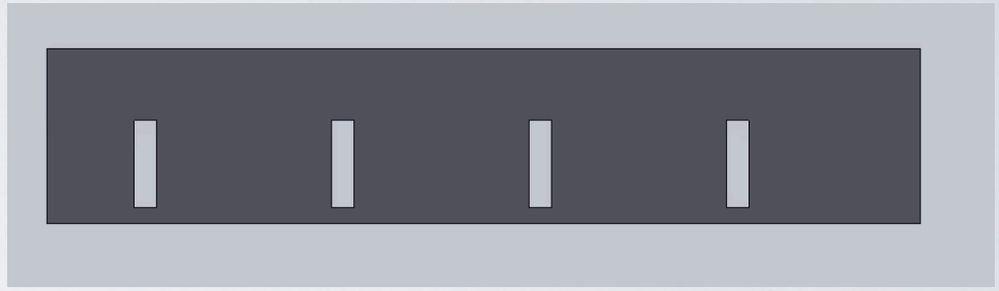
- I placed the ramps on the back of the body design.



FIRST ITERATION

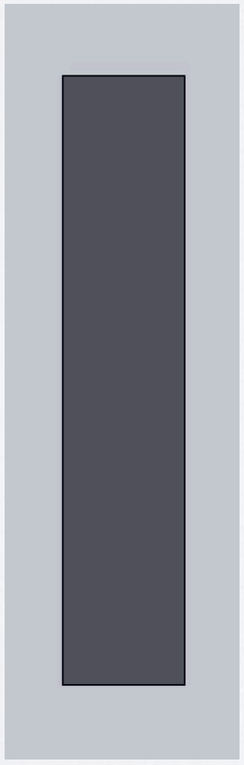
This was my first Solidworks design of my base. It was simply a 3/16th inch hole in a 5 inch block. A 1 foot, 3/16th inch dowel stuck out of the hole.

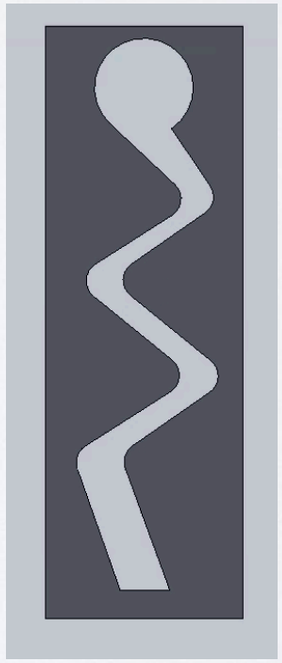




Originally, I had a side brace that the tracks would fit in. I eventually went against this because it added too much weigh for a single dowel.

This was my first design of the ramp. The ball flew down this version extremely fast, so I had to change direction.



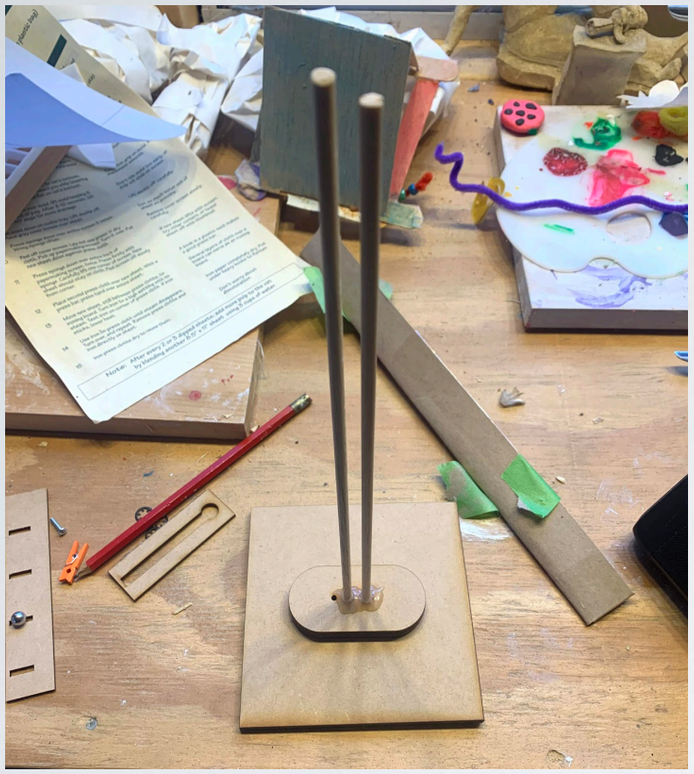


Here is my second design of the track. The idea was to increase the time that the ball would be on each track. I eventually scrapped this idea because the ball was never actually able to roll down this track.

FIRST DESIGN BODY

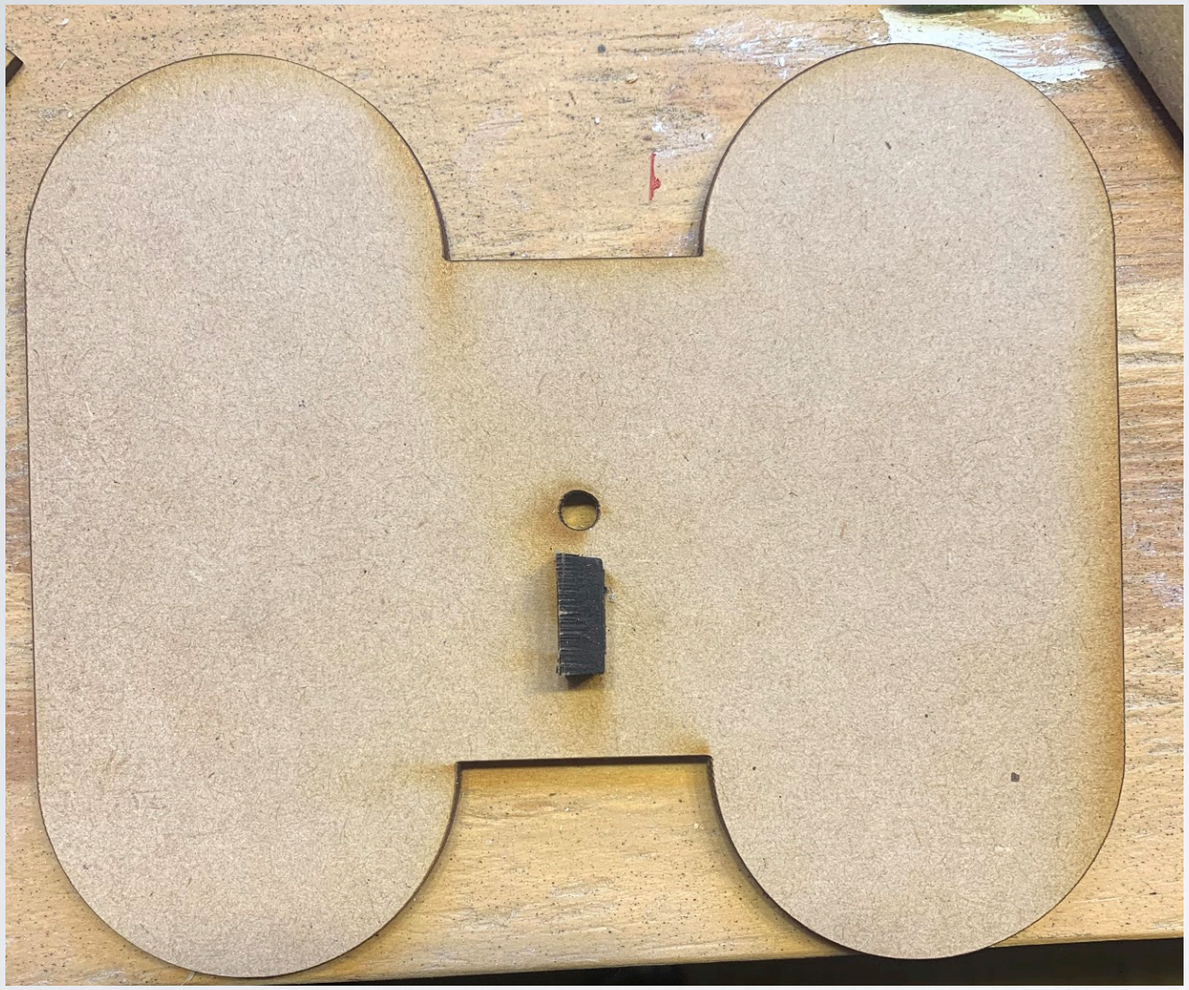
This body design was the one I decided to go with for the whole project. Unfortunately, there were two major problems with this iteration. First, the new track only lasted for 6.5 seconds, which was much too little. I needed to guarantee that the track would last for at least 7.5 seconds, with 8 being ideal. Second, having only one dowel seemed too weak for the whole design (in this iteration).

SECOND ITERATION



I then created a body and base that supported two dowels and would use more springs. This way, the entire structure would be much more stable. However, the new base was much too heavy. I had to rethink the entire base. I printed one, and left for spring break. Then, quarantine hit, and I no longer had the machine shop to make changes.

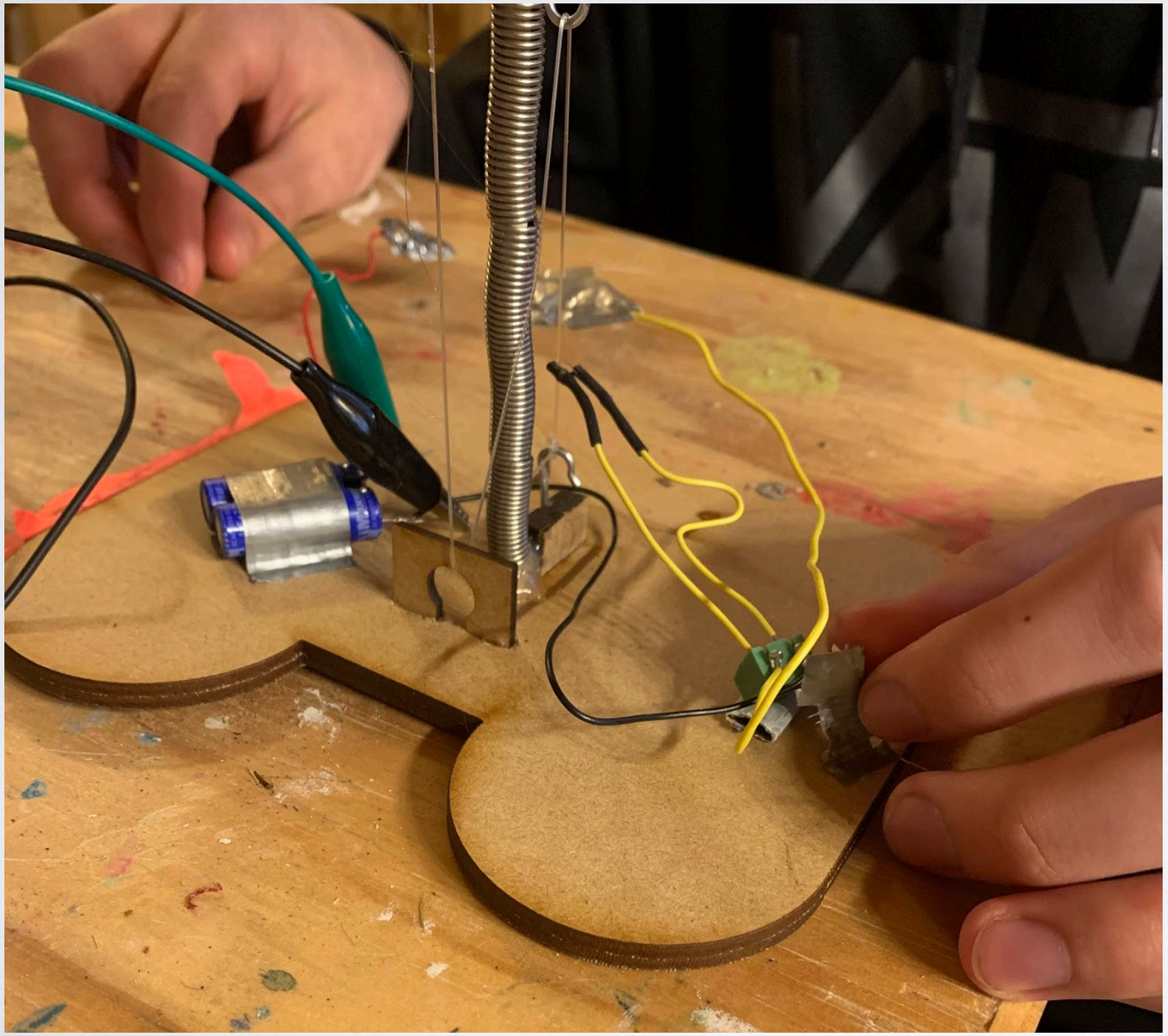
FINAL DESIGN - BIG PICTURE



Now working in quarantine, I had to adapt my plans. For the final player body, I decided to use the double-dowel design, even though I knew that the final would only use one dowel. There were two reasons for this; first, post-quarantine I did not have the machine shop to create another single-dowel version. I also found that the second hook fit perfectly into the holes I had originally created for a second dowel. I added the extended ramp to ensure that the timer would hit 8 seconds.

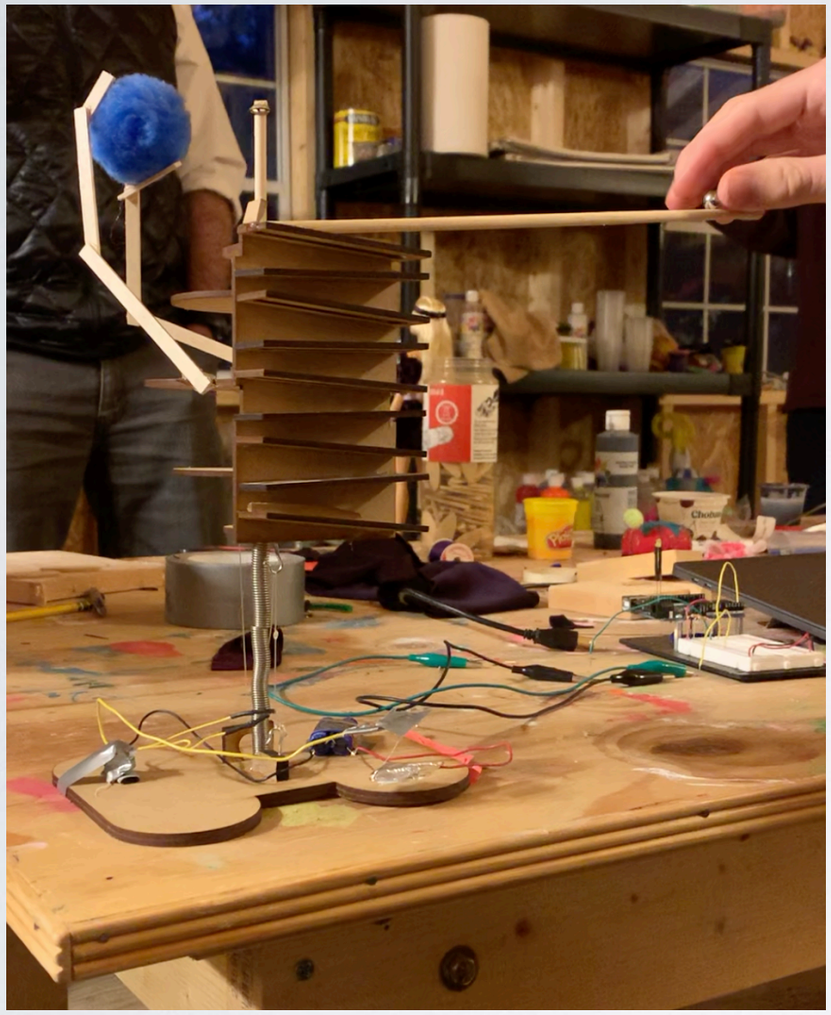
The final base that I created at school still worked in this new configuration. It was made to look like the player's feet. I introduced the large block protruding out of the base to attach one of the metal hooks for holding the fishing line.

FINAL DESIGN - SMALL DETAILS

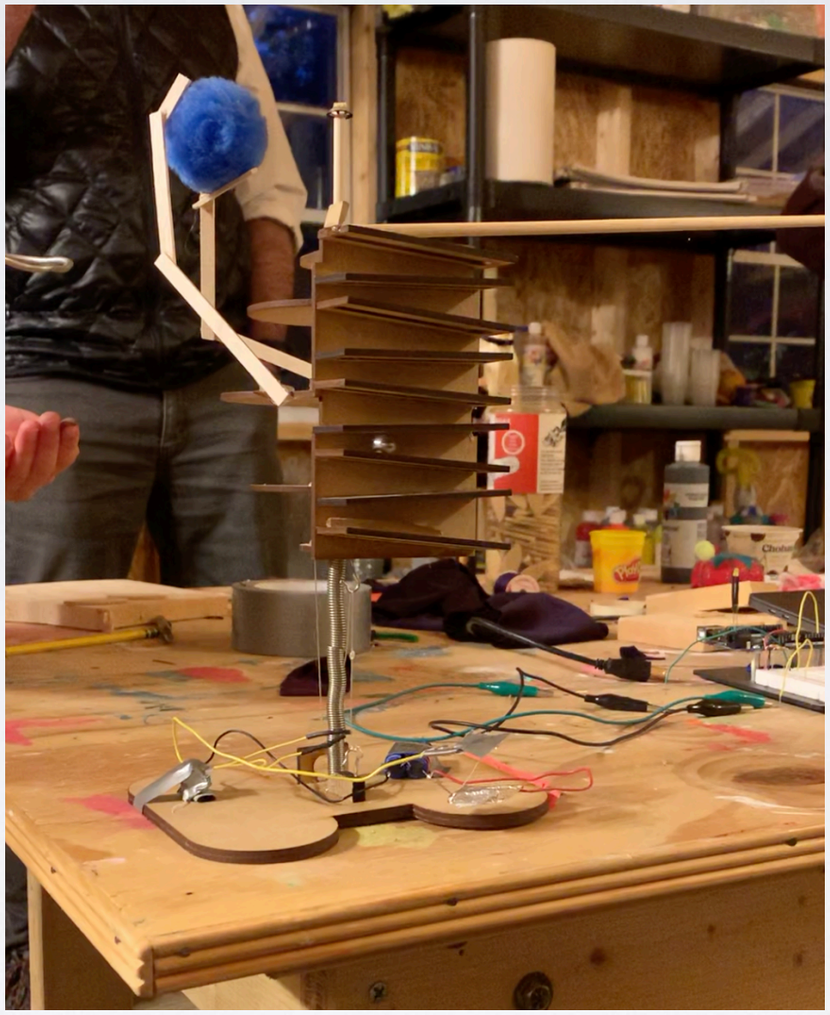


There were a few changes that were important to the success of the hopper. First, having only one string holding the hopper down caused it to lean to one side. To offset this problem, I introduced a bridge that held the other side of the hopper down with the same string. Second, there was a problem with ensuring that the positive and negative connectors on the rocket igniter would stay connected for long enough to cut the string. I added a magnet to one connective and a screw to the other, which served to keep the connectives together after the ball dropped.

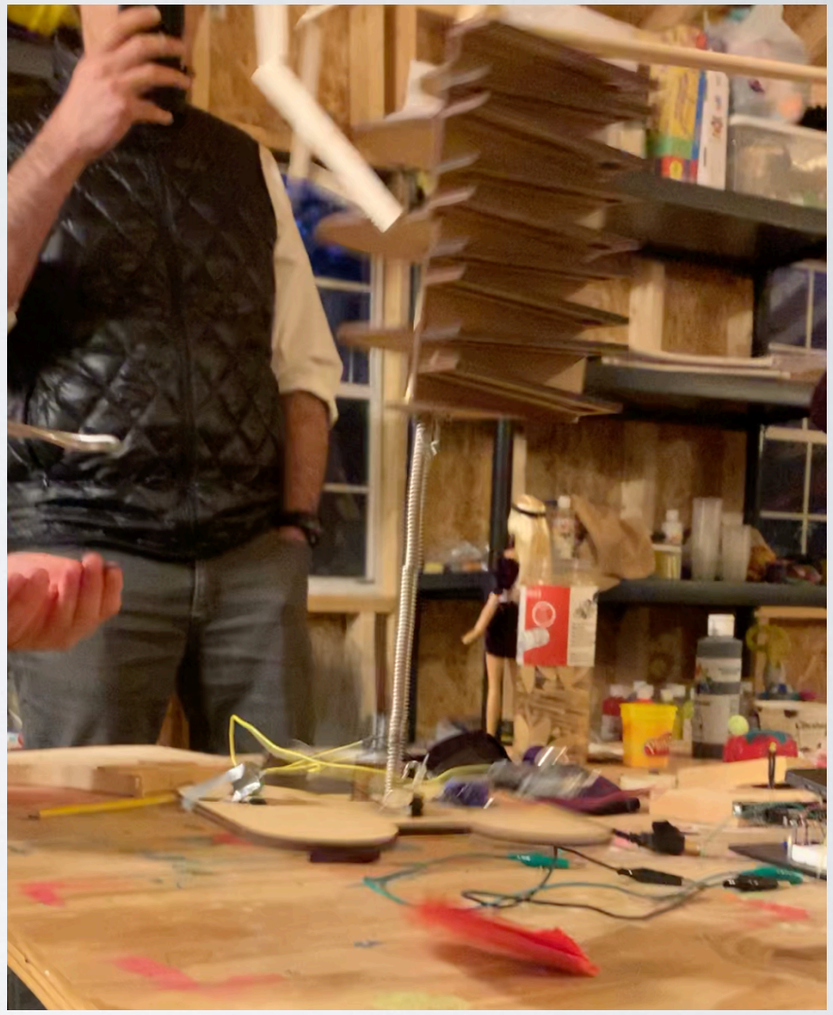
FINAL DESIGN - START, MIDDLE, HOP



Start



Middle
(8 second snapshot)



Hop