Miles Modeste

IDEA 170 | Fall, 2021 | Professor Moller

Kangaroo

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1. Assignment

In short, the task at hand was to design a contraption that hops after a seven second delay. Along side that, our hoppers were supposed to be biologically inspired using the limited source of materials we were given at the start. This means that our hoppers needed to be able to:1) store energy, and 2) have a trigger mechanism.

Final iteration of hopper

2. Materials/Constraints

Fall 2021 Hopper Kit Items

The items below provide the maximum quantities/sizes of materials that may be used for the construction of your final hopper design. You may replenish your supplies as needed during your iterative design process.

Item	Name	Quantity	Description
1	Safety glasses	1	self-explanatory…use them!
2	Wooden dowel (small diameter)	5, total	12in long Birch dowel rod with diameters (in) of 1/8, 3/16, 1/4
3	Wooden dowel (large diameter)	1	6in long Birch dowel rod with a diameter of 3/4in
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	3, total	1in length of solid PTFE (Teflon) rod with diameters (in) of ⅛, 3⁄16, ¼
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, 1.25
9	Hex nut or locknut	10, total	4-40 thread nut or nylon-insert locknut
10	Craft stick	6, total	1/4in wide by 6in long by 1/16in thick craft stick, or mini popsicle
11	Ear plug	1	orange noise-reduction foam ear plug
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 3/8 and 1/2
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	Binder clip	1	mini binder clip
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	Aluminum rod	1	solid aluminum rod of 1/8in diameter x 2in length
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	Sandwich baggie	1	foldover sandwich baggie
31	IDEAS ruler	1	6in lasercut ruler

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

Notes:

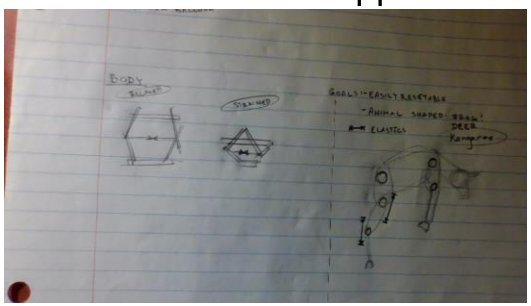
†The super capacitors and rocket igniters are not placed in your kit. If you wish to use these items, please speak to your instructor to be trained on their proper preparation and use.

‡You may create up to three 3D printed parts of your own design, based on your needs.

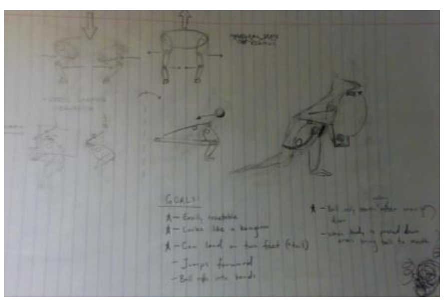
You may also use wood glue, two-part epoxy, solder and hot glue for fastening purposes. *Superglue is not allowed.*

3. Sketches

One of my preliminary design goal was to create a deer like hopper.



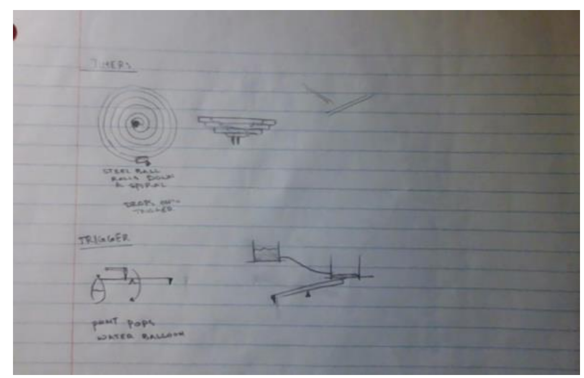
Specifically, I wanted to experiment with storing energy and releasing it through multiple joints. However, in order to simplify trying to coordinate



two points of rotation across four legs, I switched from a four-legged deer to a two-legged kangaroo.

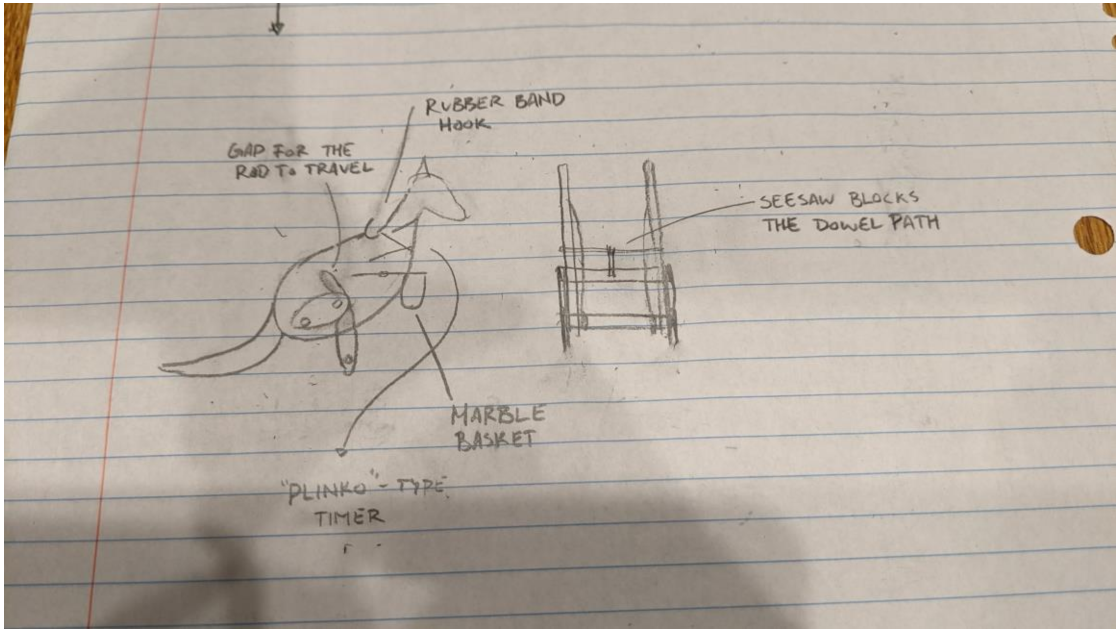
Alongside prototyping the motion and energy storage I also considered various timer mechanisms. One being spiral track for a ball to slowly run to a trigger.

Another idea was to have a water timer slowly fill up one side of a see saw. As fun as these timers seemed, I was limited by the space within the kangaroo.



4. Design Goals

My design goals were for the hopper to resemble a kangaroo first, and foremost. I also wanted for it to be a resettable creation. For my timer, I wanted to use the ball rolling down a track, and through small obstacles in the balls path it would hopefully delay for long enough eventually hitting a trigger to release the legs.



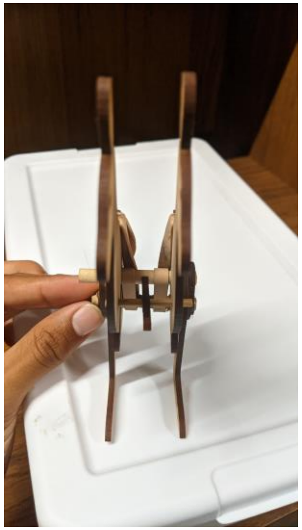
5. Design Process: 1st and 2nd prototype

I began with figuring out the hopping motion. As stated, the motion would include multiple limbs. My first prototype was an experiment. It had a simple ovular shape for the body with a dowel running through to act as the hip joint. The thighs were connected to the calves with another protruding dowel. The protrusion allowed me to wrap a rubber band from one side of the knees, run it under the thigh dowel, hook it around the back, where I repeated these steps on the other side. The elasticity of the rubber provided enough downward force to propel the body. I decided to create two arms that also serve to hook into the legs to store the energy

First prototype

2nd prototype

With the proof of concept working, for my next model I designed a kangaroo shape to fit the aesthetic of a kangaroo. I added slots to allow the dowel connecting the legs to move. A see-saw like piece held the dowel back, so when inevitably hit with a steel ball would rotate up, and the knee dowel could move down. However, having the calf and thigh as two separate joints created issues with stability



view of see-saw lock mechanism

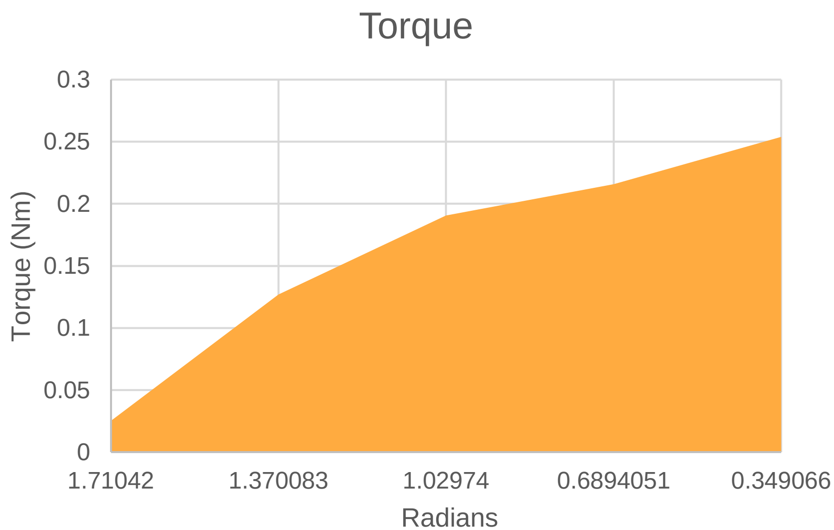
6. Design Process: 3rd to final model

My 3rd prototype eventually became my last. I added a tail piece that would act as extra stability, and I turned the legs into one piece. The dowel at the knee remained and I also added a track for the 3/8 ball to roll down onto the see-saw. With some minor tweaks to the overall shape the ball was able to consistently trigger. Furthermore, I had issues with

All that remained was a timer. The track that I had initially wanted to do did not provide enough delay, so I added arms that, unless all the way down prevented the ball from rolling. In order to delay the arms I had the arms hold one magnet and placed a magnet up by the mouth. In between the two magnets I stuck an earplug that would slowly separate the arms to where the magnets could not hold on anymore.

7. Data

Degrees °	Radians	Newtons	Torque (Nm)
98	1.71042	1	0.0254
78.5	1.370083	5	0.127
59	1.02974	7.5	0.1905
39.5	0.689405	8.5	0.2159
20	0.349066	10	0.254



Ustored=0.229082 J

I measured this hopper as a rotational hopper. Due to a dowel I added to have the rubber band pull in a certain direction this isn't an exact measurement.

The total mass of my hopper ended up being .048kg (48g). Assuming that U=.229 is accurate. My hopper would have an estimated peak height of **.48 meters**

the actual height of the jump was .1 meters giving my hopper an efficiency of ~20%

8. Iterations