Bio-Inspired Mechanism

Creating an Undulating Machine

Tatiana Titov

Step 1.

Preparatory Research

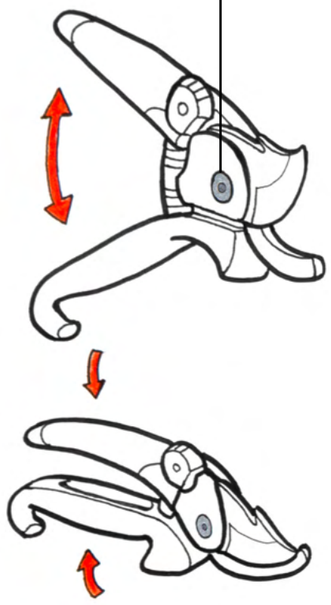
A) Discover the Mechanisms Found in Object Design

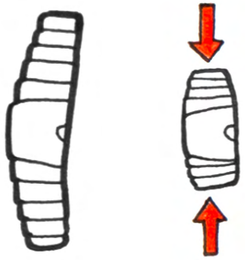
Pruning Shears - Mechanisms

Tatiana Titov

Fulcrum

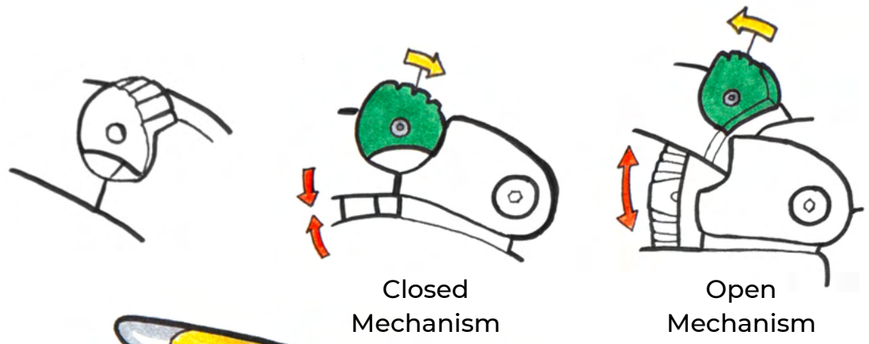
The fulcrum (the pivot point of the lever) is made with a screw, which facilitates the rotation of the handles of the pruning shears to perform the cutting movement.





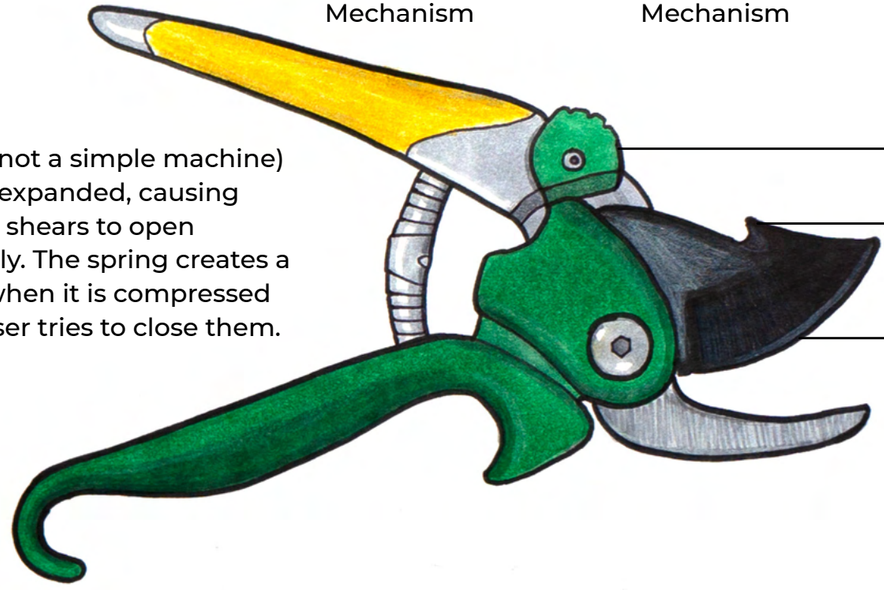
Lever

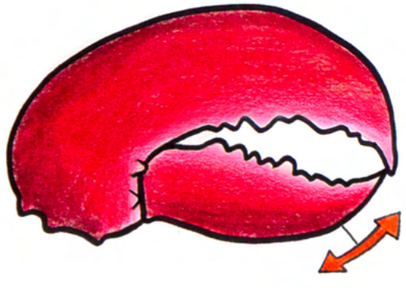
The pruning shears are a first class lever because the fulcrum is placed between the effort (the input force on the handles) and the load (the output force on the blades). Since the fulcrum is closer to the load than the effort, the user applies a small force on the handles to have a greater force on the blades, which makes the cutting movement more effective.



Spring

The spring (not a simple machine) tends to be expanded, causing the pruning shears to open automatically. The spring creates a resistance when it is compressed when the user tries to close them.





Lobster Claws

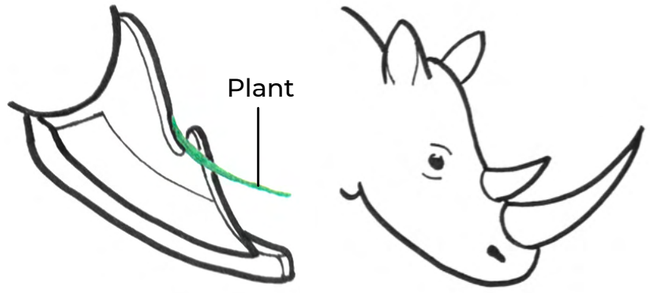
The functionality of the pruning shears and the way they use the wedge simple machine are similar to lobster claws. The claws also use rotation to be able to use the wedge machine. Lobsters use their claws as weapons and as a grip.

Wheel and Axle

This part of the pruning shears allows the blades to be securely locked when they are not in use. When the wheel is rotated counterclockwise, it unlocks the pruning shears and releases the spring that opens them.

Hook

The hook (not a simple machine) uses the system of a lever to be able to grip plants. In nature, rhinoceros use a similar system with their horns to dig soil and move objects.



Wedge

The blade uses the wedge simple machine because it has a thinner part to be sharp. It cuts vegetation by piercing it.

Sources

"Lobster Lingo: Get to Know the Parts of a Lobster." *LobsterAnywhere.com*, 24 Oct. 2013, https://lobsteranywhere.com/seafood-savvy/lobster-lingo/. Accessed 10 Mar. 2021.
"Simple Machine." *Encyclopedia Britannica*, https://www.britannica.com/technology/simple-machine. Accessed 10 Mar. 2021.
"Simple Machines - Levers." *Let's Talk Science*, https://letstalkscience.ca/educational-resources/backgrounders/simple-machines-levers. Accessed 10 Mar. 2021.
"What Do Rhinos Use Their Horns For?" *Sciencing*, https://sciencing.com/do-rhinos-use-horns-8069360.html. Accessed 10 Mar. 2021.

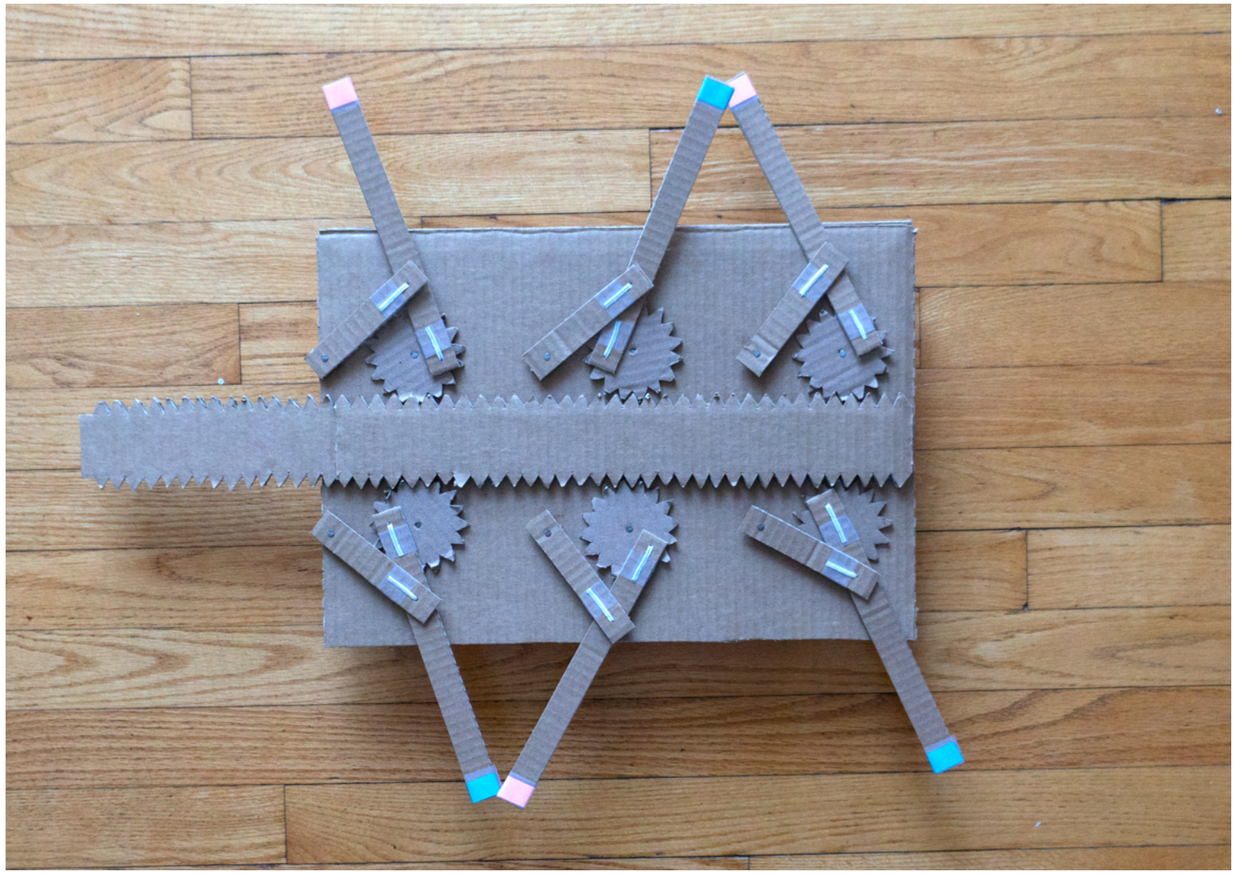
What I learned

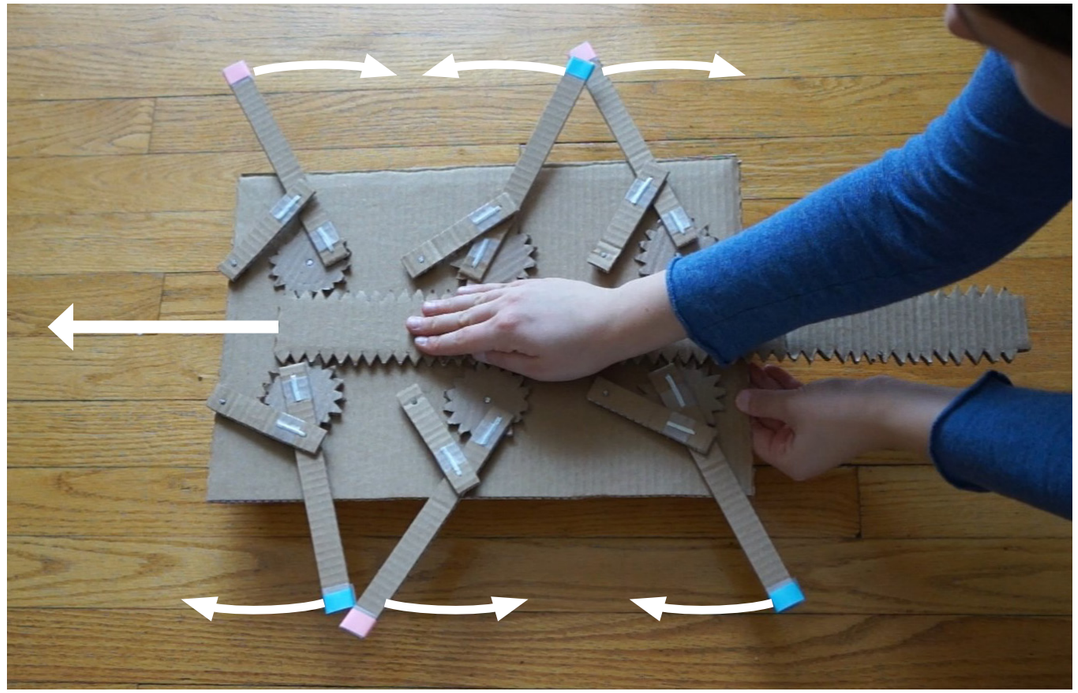
- I rediscovered simple machines.
- I understood the wheel and axle simple machine, which was useful for my final construction.
- I discovered how objects that seem simple can in fact be complex.

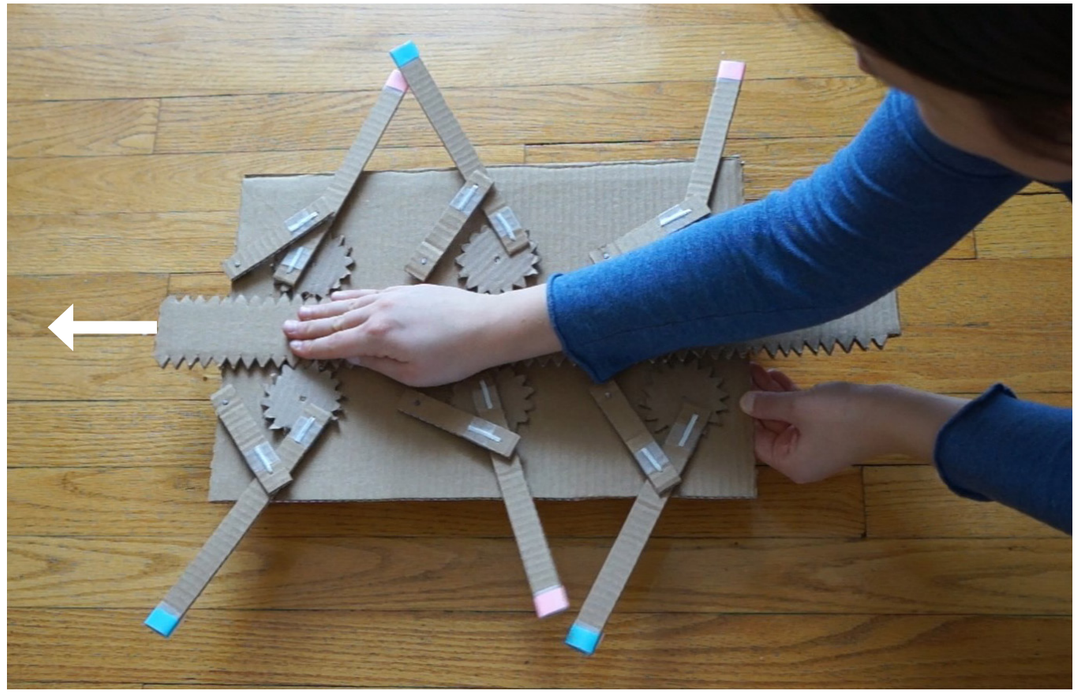
Step 1.

Preparatory Research

B) Discover the Anatomy of the Movements Found in the Body of Humans/Animals/Insects







Study of the Tripod-Walking Gait of Insects

This walking technique allows insects to be stable. In this movement, 3 legs always do the same movement and the other 3 do the opposite.

I built this machine using cardboard.

I learned...

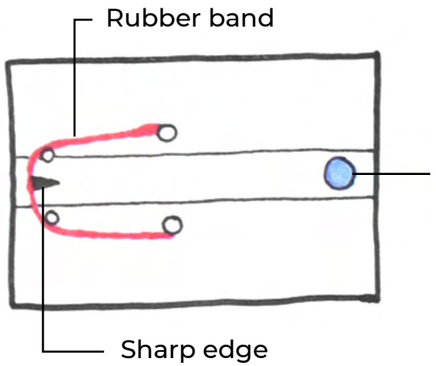
- How to use gears.
- How to create work inspired by Theo Jansen.
- About the complexity of the movement of legs, whether the creature has 2, 4, 6 or 8 legs.

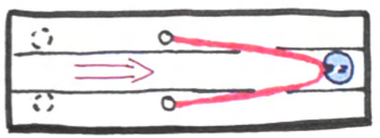
Step 2.

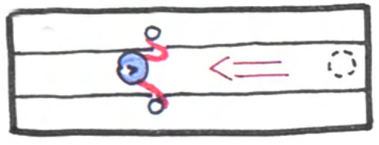
Brainstorming and Concept Development

Step 2 - Brainstorming

Tatiana Titov





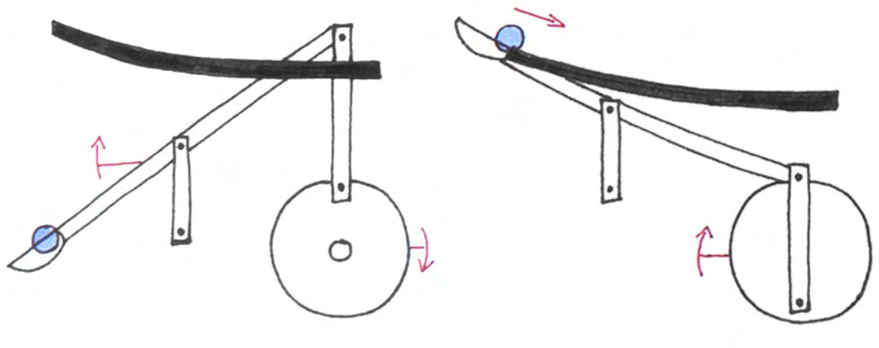


Chameleon's Tongue

This mechanism mimics the way chameleons catch their prey with their tongue. The machine uses a rubber band with a sharp edge to pierce the ball when it is released. The surface is approximately 15 inches wide. Screws hold the rubber band. The structure is made of cardboard.

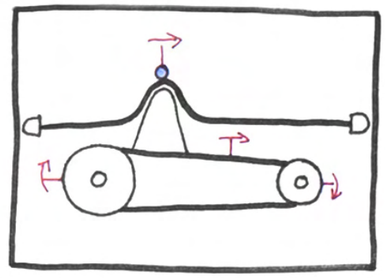
Object Lifting

This machine mimics how predators such as pelicans, after catching their prey, lift their head to swallow it more easily. The main stick in the machine is about 10 inches long.

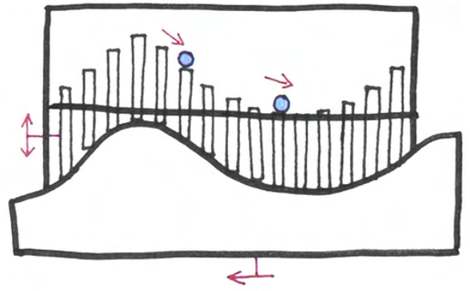


Snake Locomotion (Lateral Undulation)

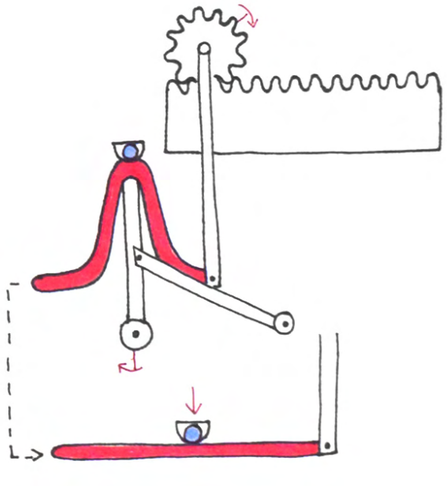
These machines imitate the movement of a snake. They create a sine wave to move a ball.



Here, a system of pulleys is used and the ball is moved with a magnet on top of the "mountain". The ball is placed on thick fabric.

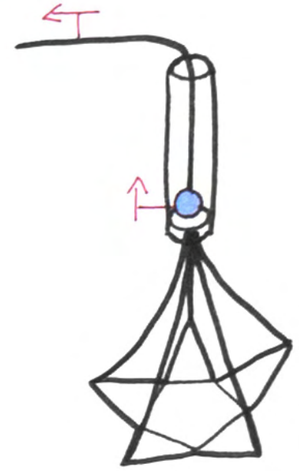


Here, the sine wave is created with a cardboard wave that is moved from right to left to move sticks that hold the ball.



Inchworm

This machine uses a system of cardboard gears that move the red structure up and down, causing the ball to move also. It mimics the movement of inchworms.

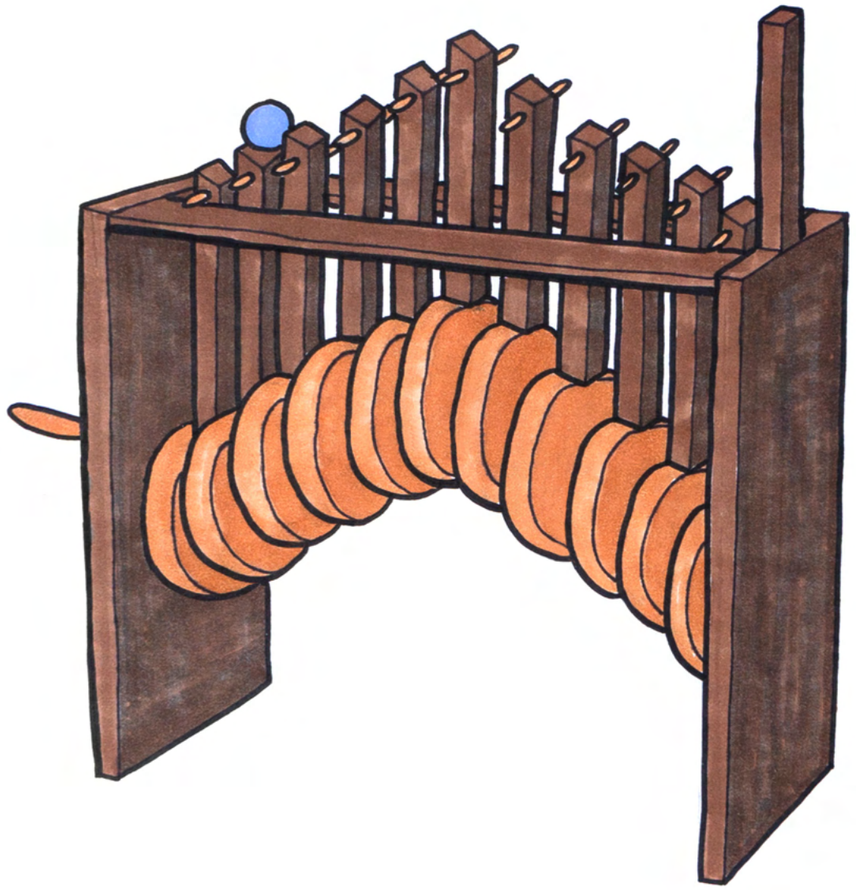


Flower

This machine is inspired by the ability of flowers to close and open. When the flower is open, the ball is located at the bottom of the transparent tube. When the thread is pulled, the flower closes and a platform moves the ball upwards.

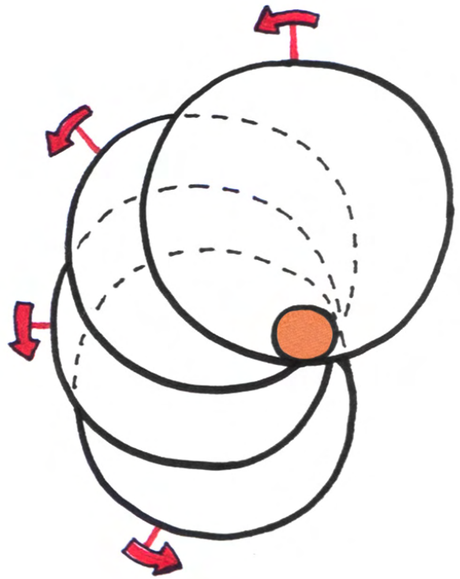
Step 2 - Concept Development

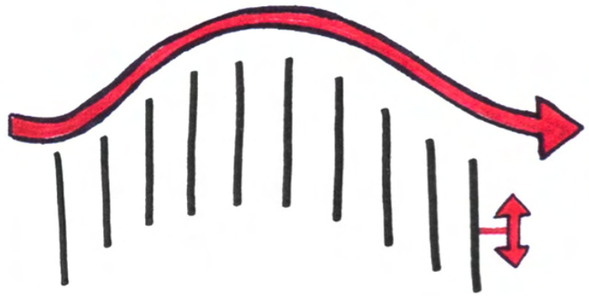
Tatiana Titov



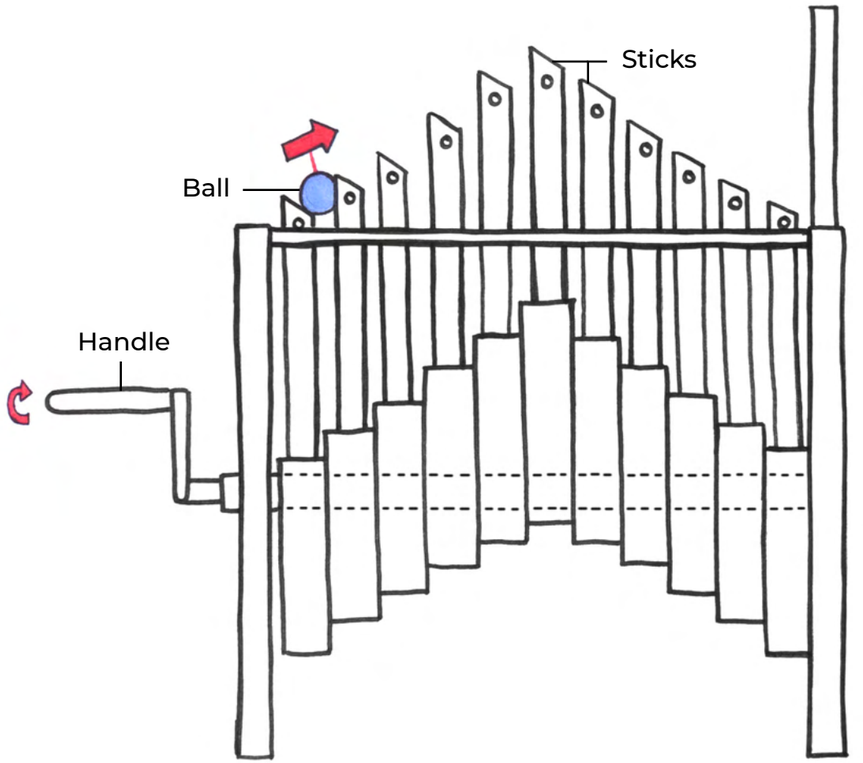
This machine is mimicking the lateral undulation of snakes. It creates a sine wave that moves a ball from left to right. The structure is approximately 17 inches long and it is made of cardboard. To make the cardboard thicker, possibly many pieces of cardboard will be glued together to create each surface.

The sticks have side bars that are pierced into them. Those bars help them to not fall into the hole at the top of the structure.





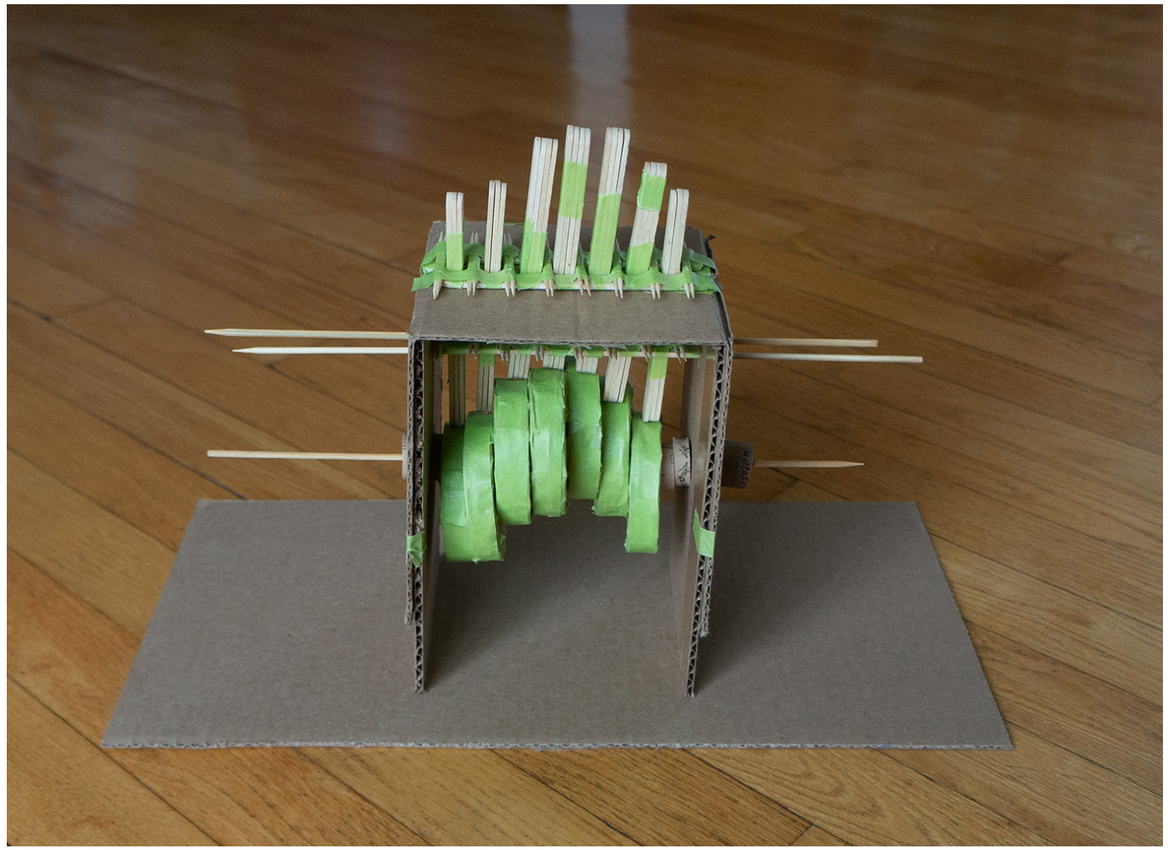
The wheels are placed as in the drawing (on the left) to create the sine wave: they will push the sticks so that they move vertically. The pivot point (fulcrum) is not at the center of the wheel. The spacing between the wheels allows them to move the sticks at different heights at the same time.

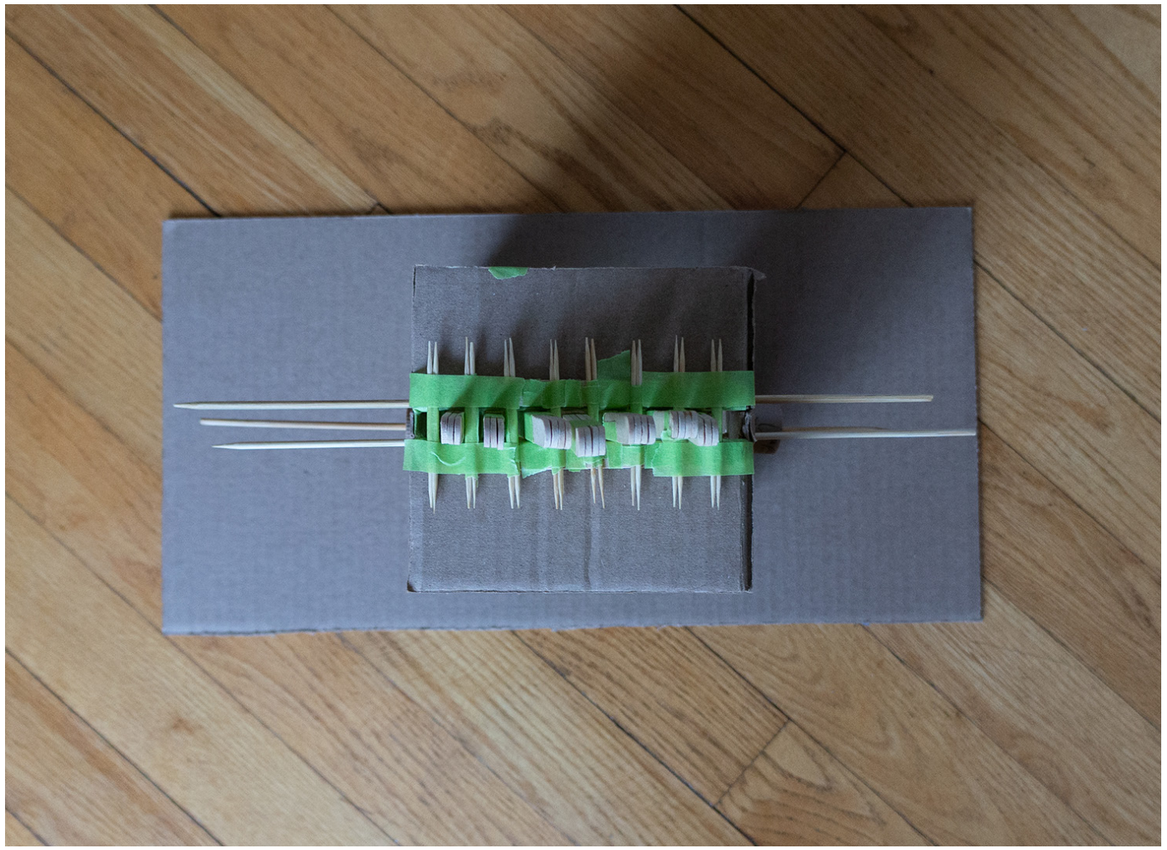


When the handle makes a continuous circular motion, the sine wave structure begins to move. First, the ball will slowly go up, like a snake that prepares to catch its prey. Then, the ball will descend quickly, simulating how snakes perform an attack.

Step 3.

Maquette

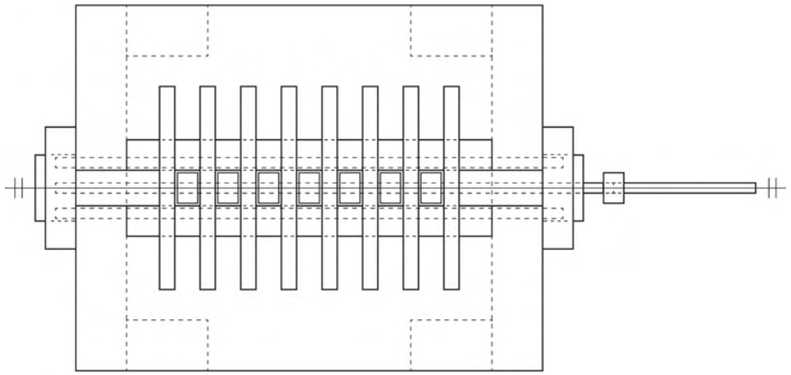


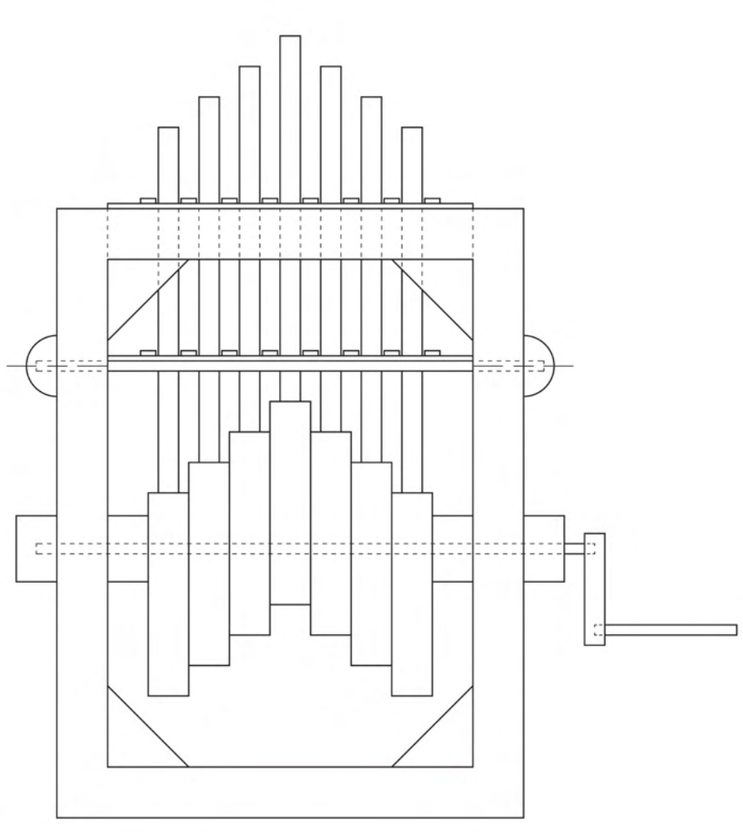


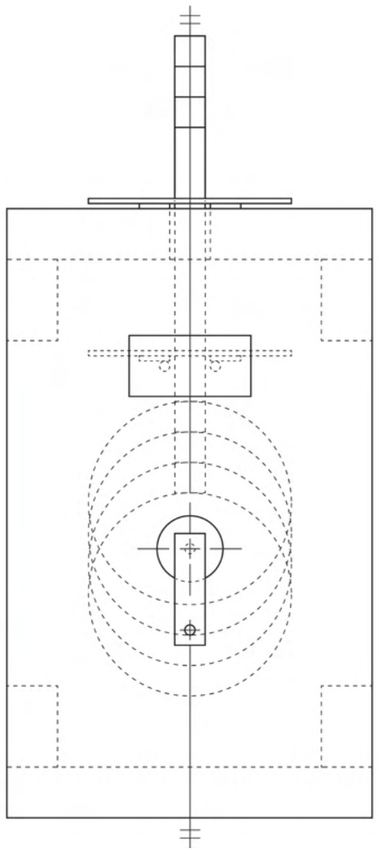
The maquette worked well but I encountered some issues. I had to restart it twice because I needed to adjust its measurements. As I was building it, I have encountered issues with friction between the wheels and the sticks. Also, the maquette was wobbly, which is an issue that I fixed for the final construction. I decided to remove the ball (that I wanted to use in my initial idea) to focus my construction on the lateral undulation.

Step 4.

Planning and Preparing for Production



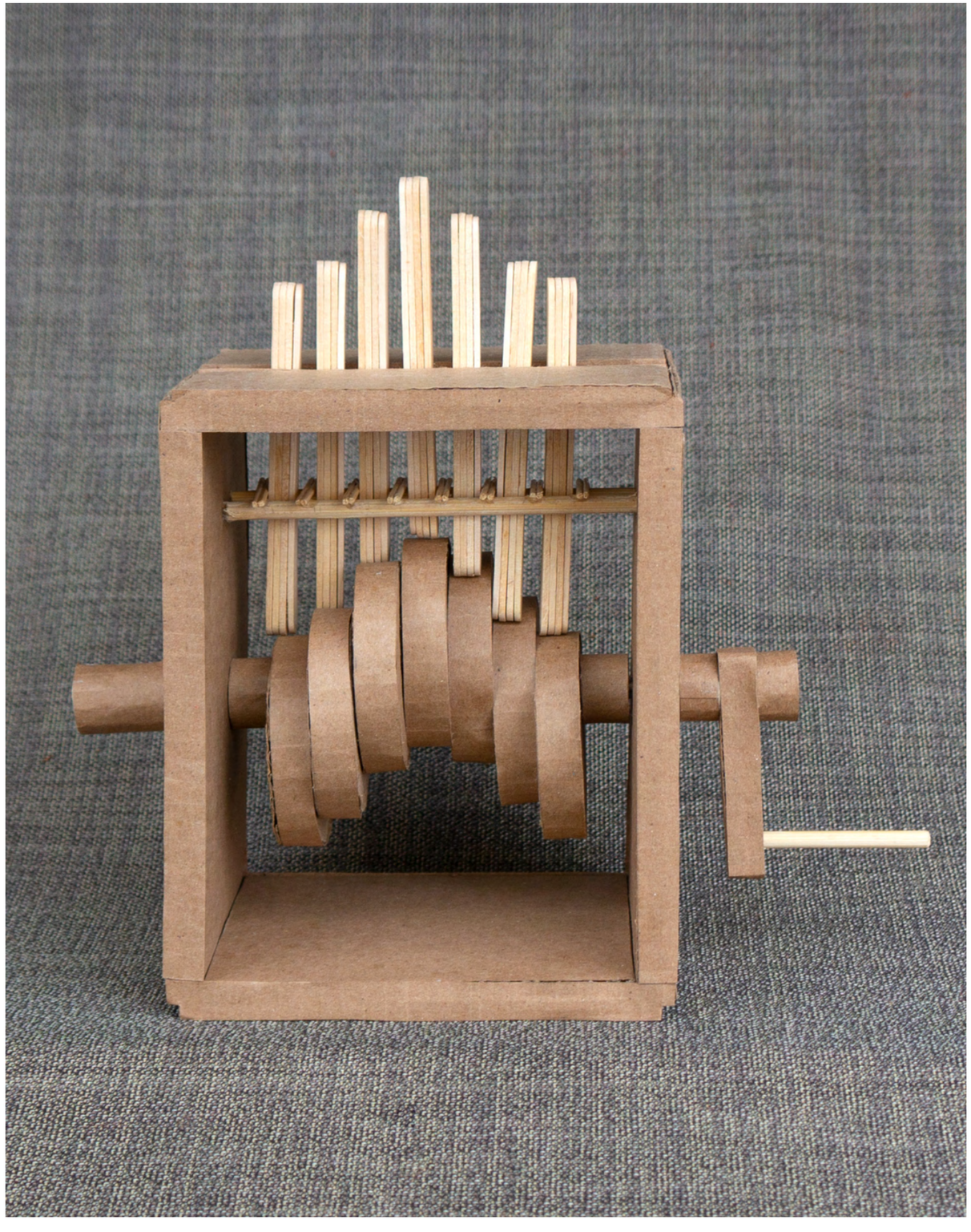


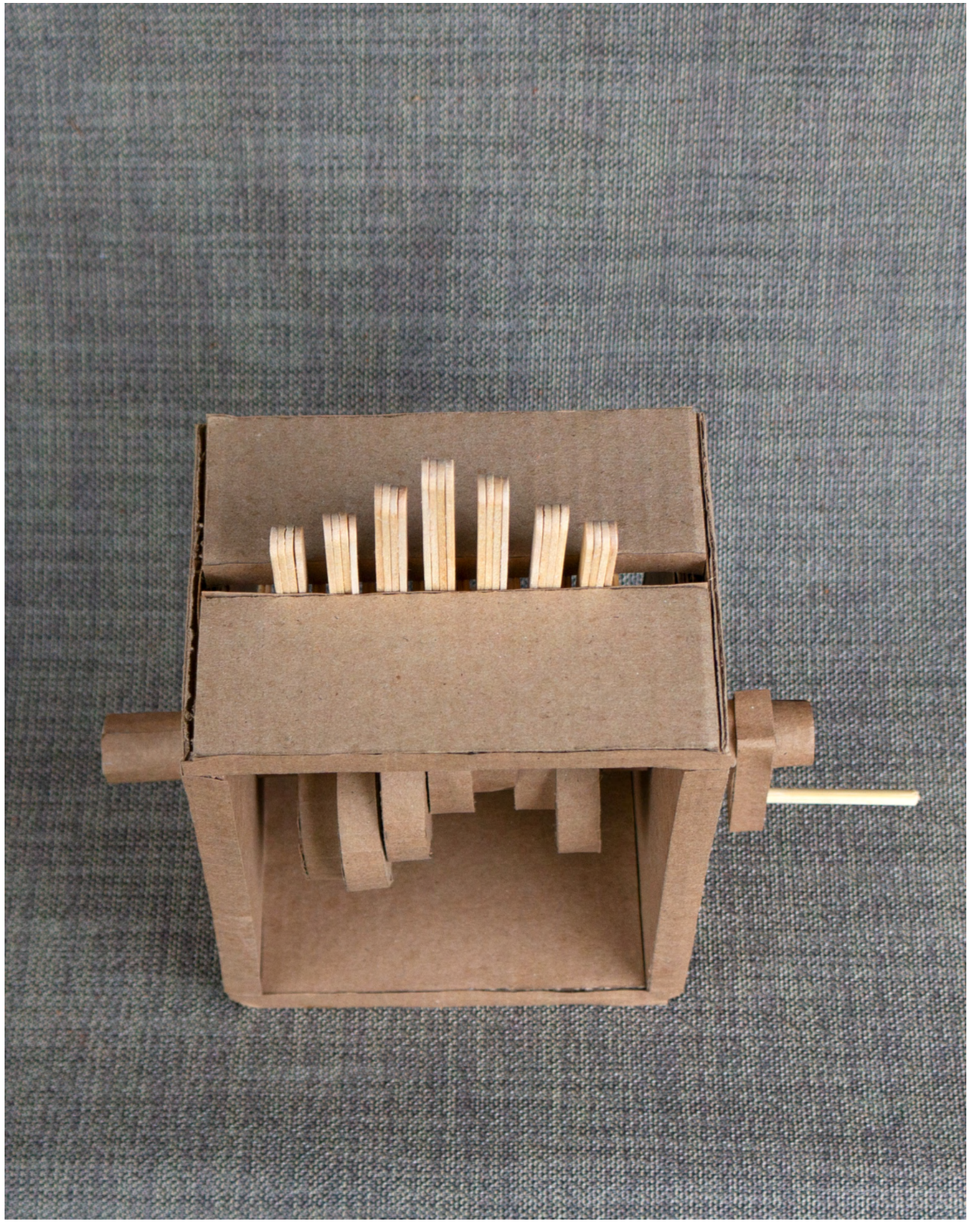


At this step, I did my first draft of technical drawings of the construction. There, I decided to fix the wobbling issue by adding corners to my project. I added a handle to facilitate the rotation of the wheels.

Step 5.

Fabrication





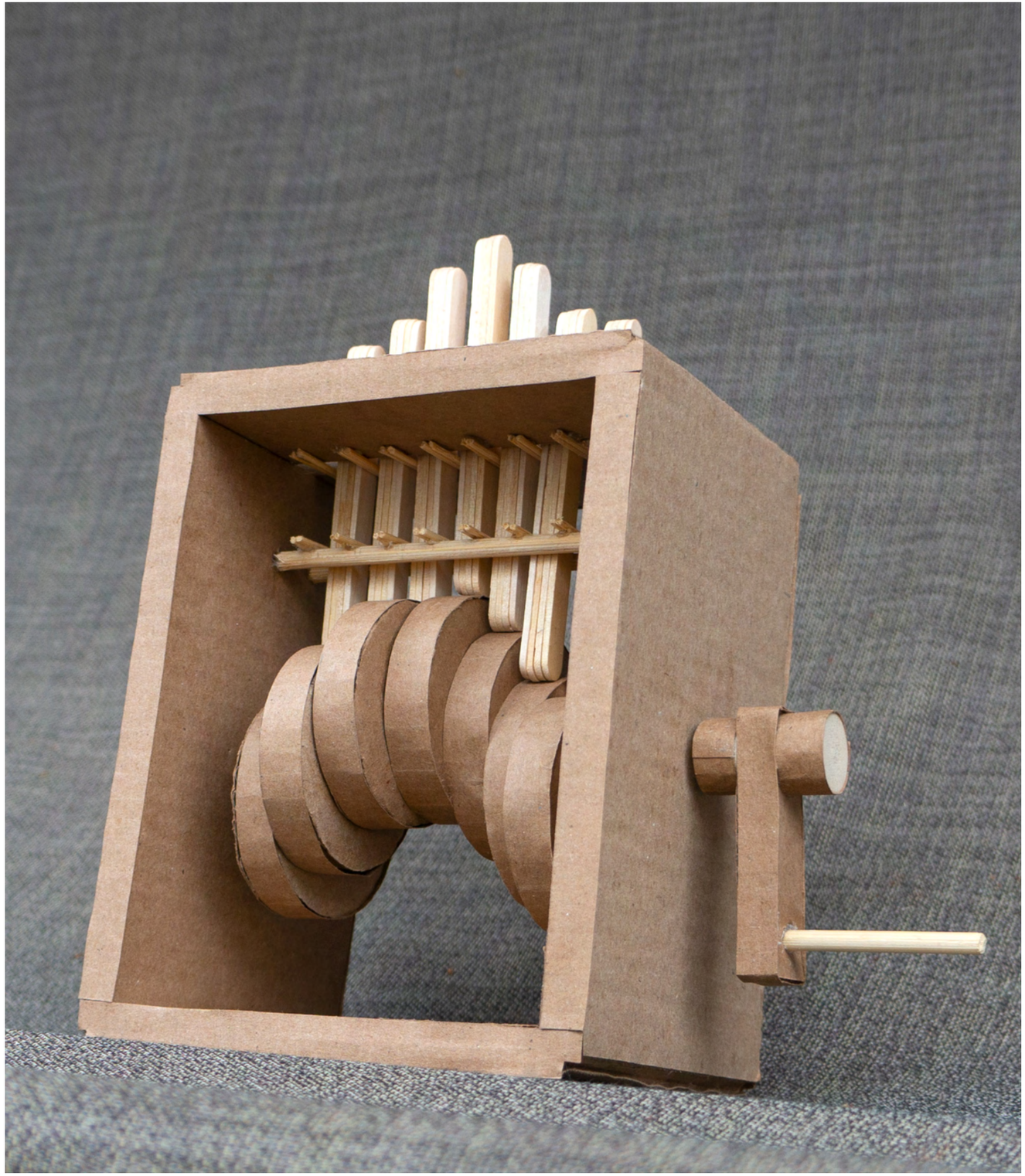
Materials: Recycled corrugated cardboard, recycled cork stoppers, popsicle sticks, wooden chopsticks, barbecue stick, toothpicks.

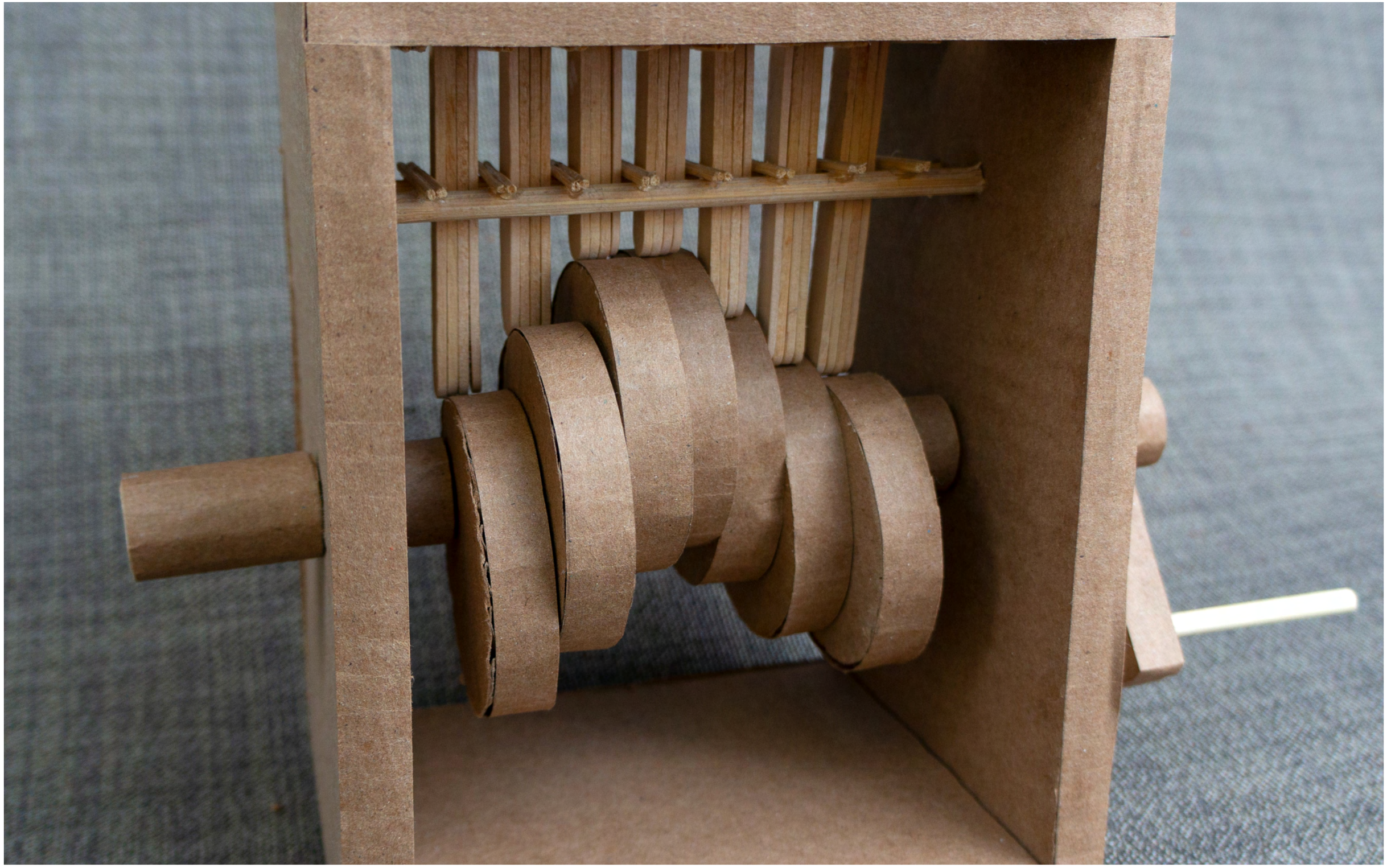
Glue: Dura Pro AW 4400 (White Glue)

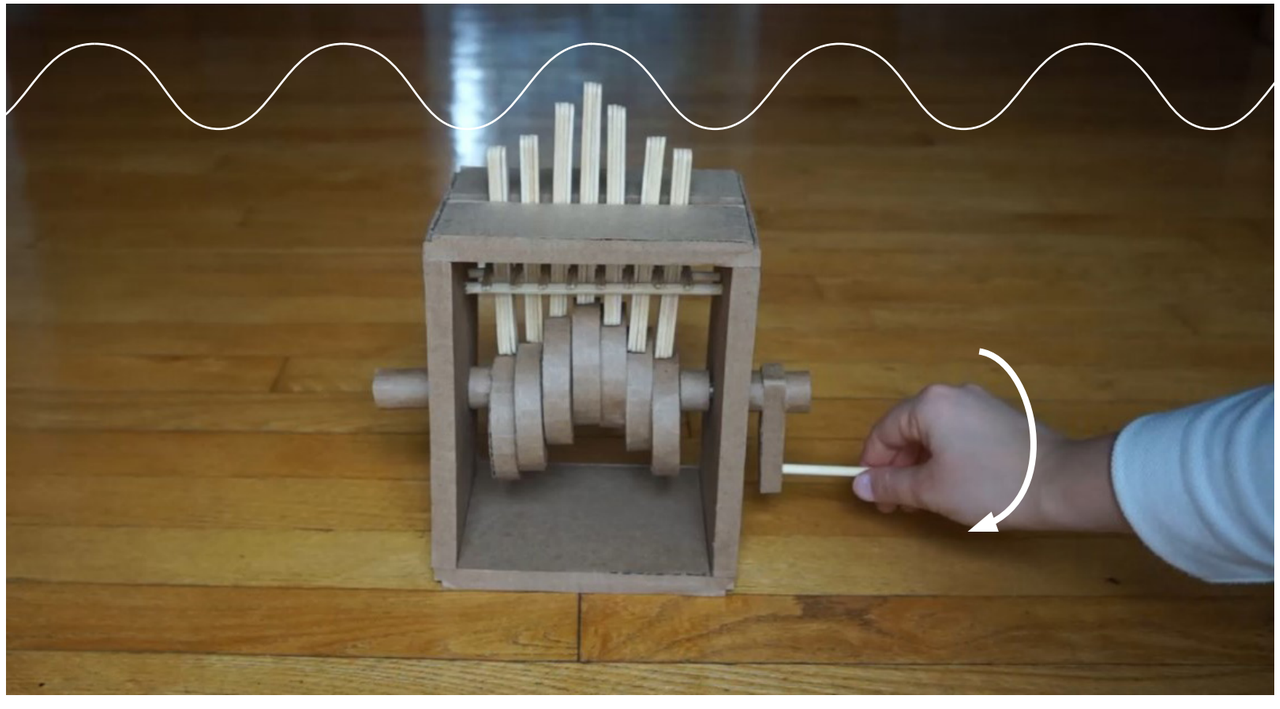
For the cardboard elements, I glued four layers of corrugated cardboard to create each surface to make my structure more solid. Then, I peeled off another sheet of corrugated cardboard and used its surfaces to cover the cardboard layers for aesthetic purposes.

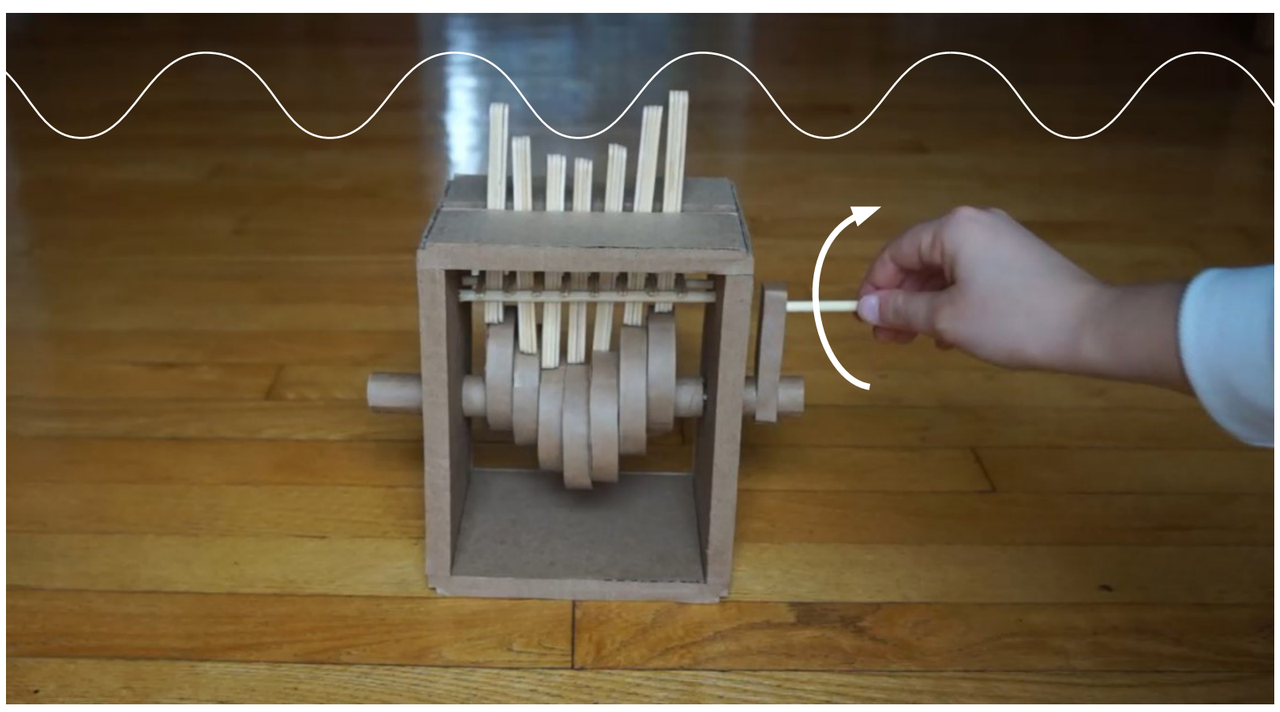
In the final construction, I decided to move the top stick holders under the top surface of the structure to make the top view of the project more uniform.

I decided not to add the corners to the structure because the wobbling problem was already solved by the solidity of the new structure. Also, I changed the design and the size of the handle to make it easier to manipulate.

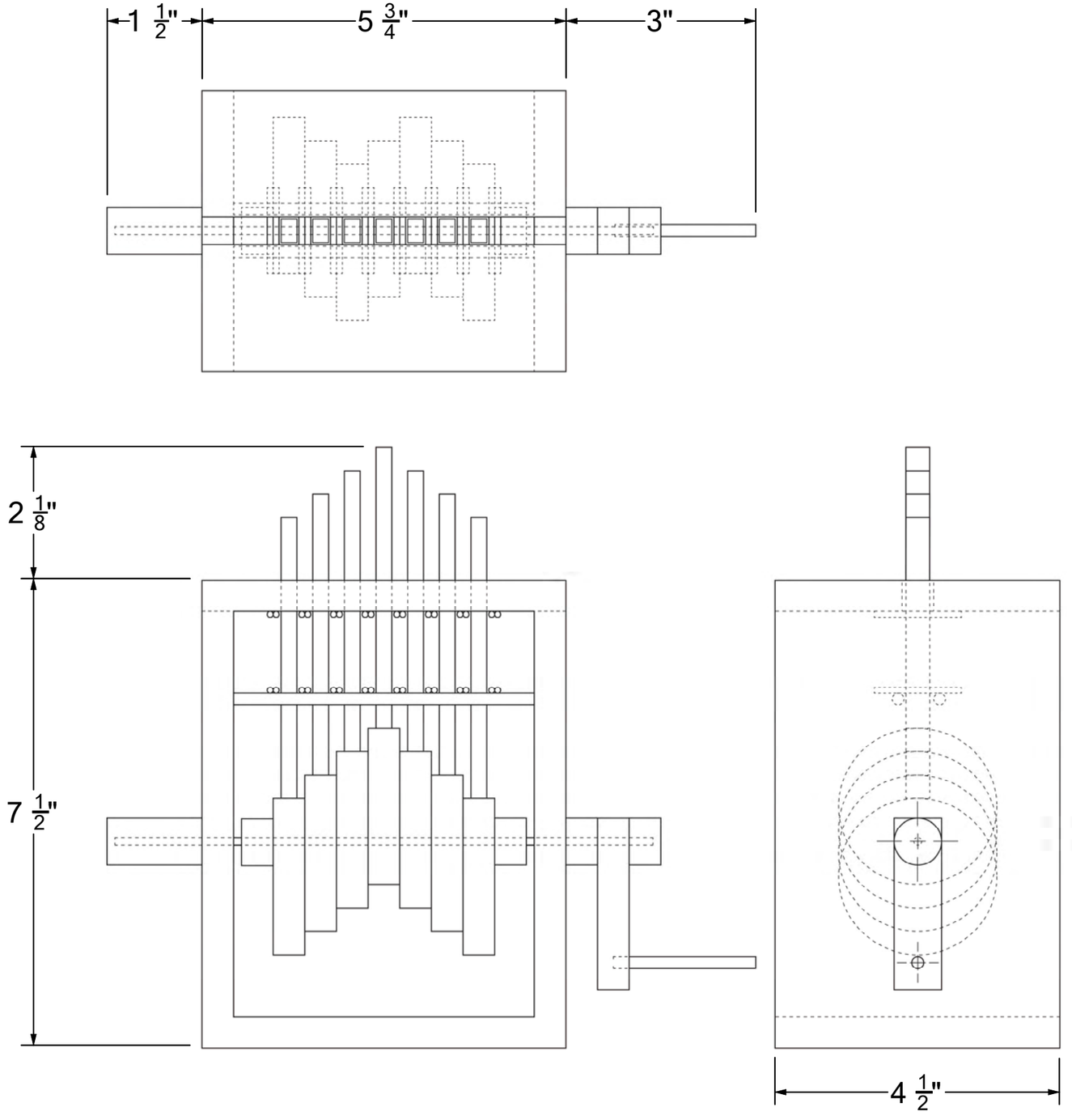








Technical Drawings



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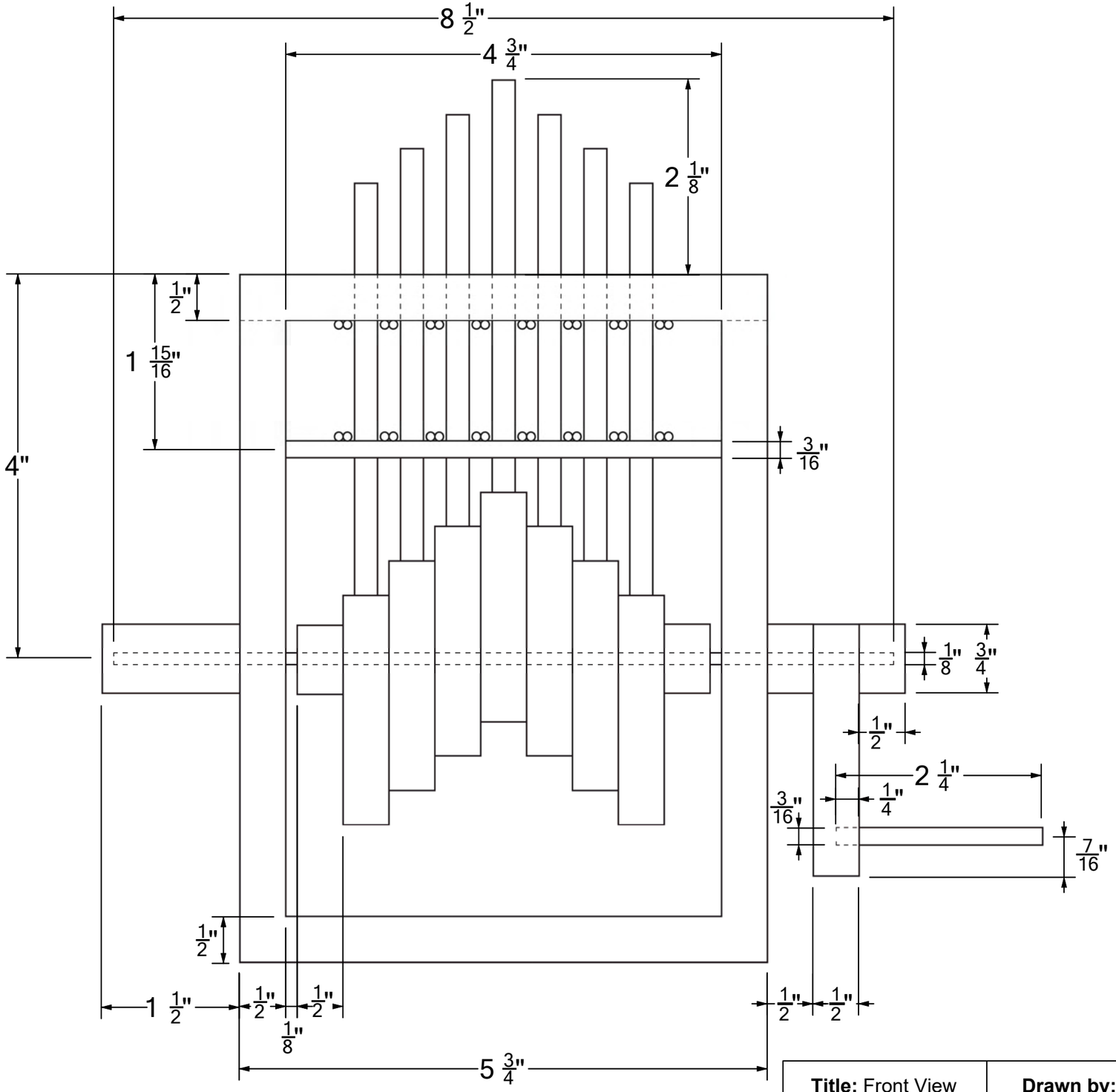
Project: Bio-Inspired Mechanism	**Date:** Apr. 15, 2021	**DWG No:** D-1



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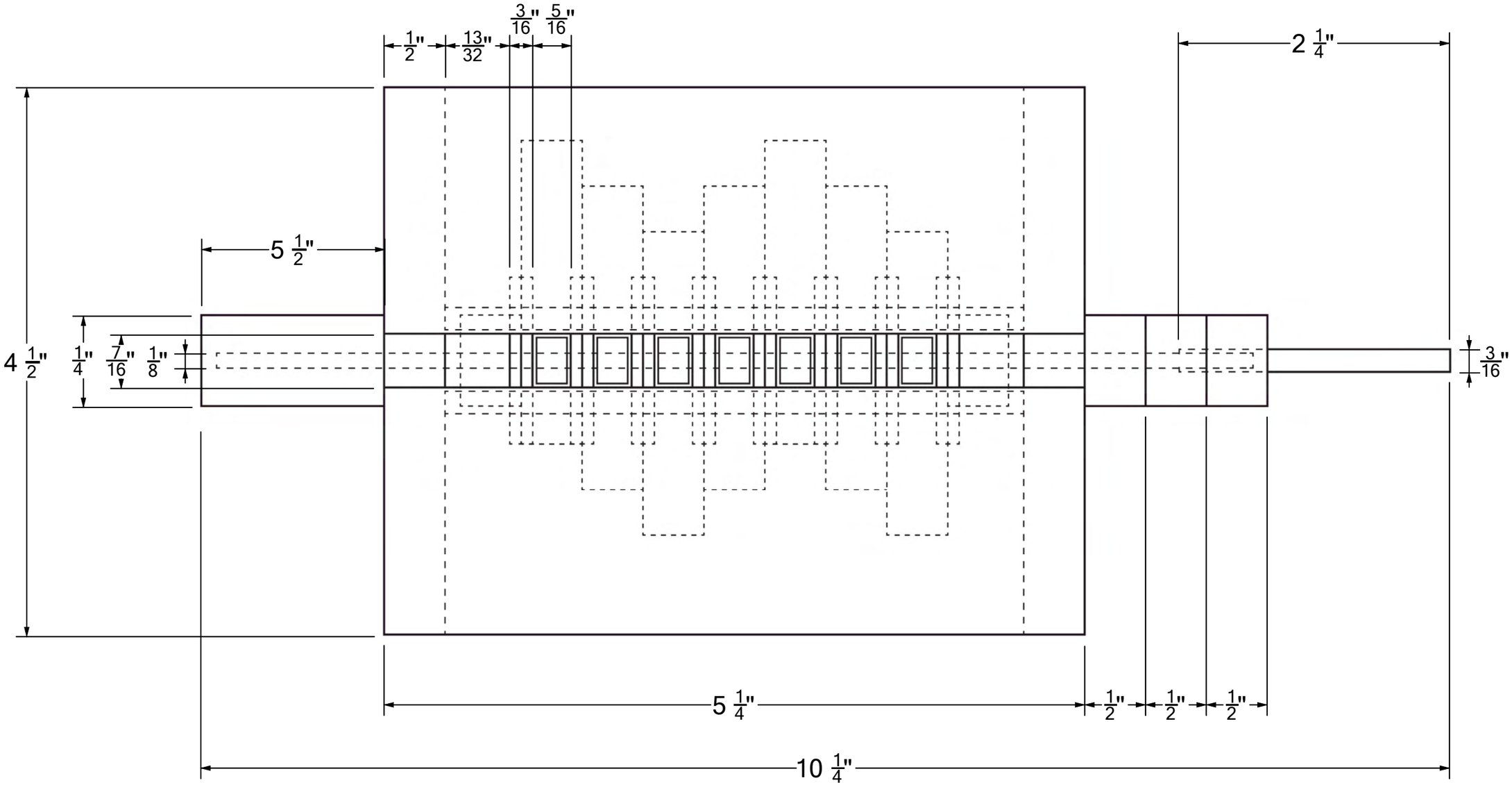
Project: Bio-Inspired Mechanism	**Date:** Apr. 15, 2021	**DWG No:** D-2



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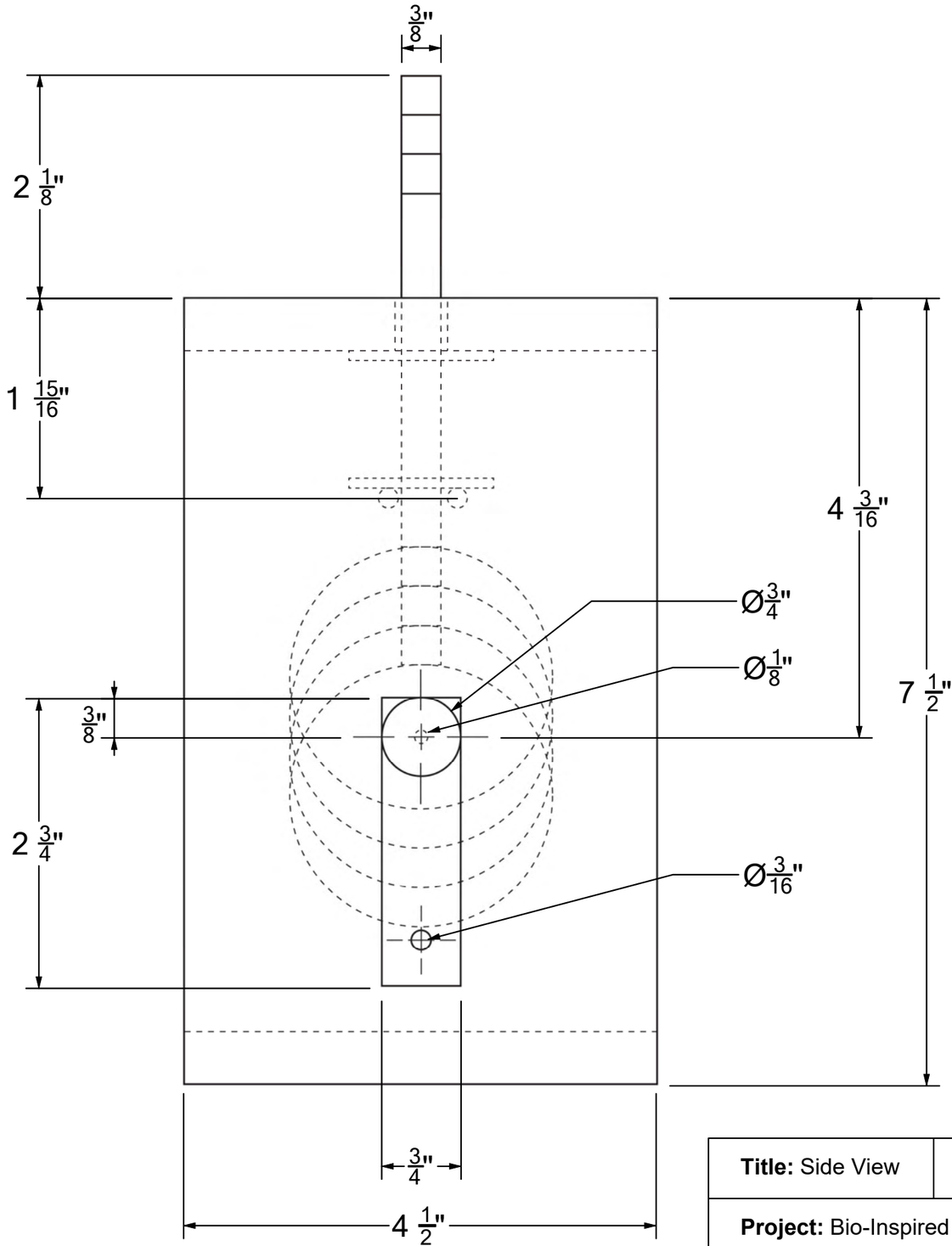
Project: Bio-Inspired Mechanism	**Date:** Apr. 15, 2021	**DWG No:** D-3



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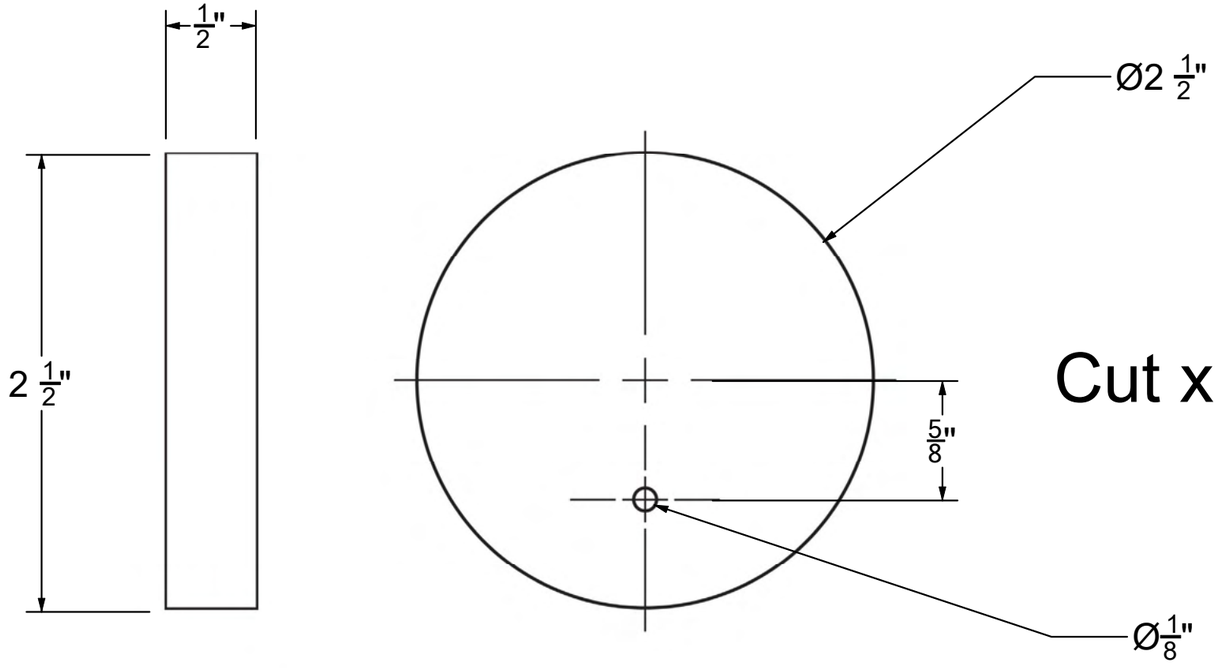
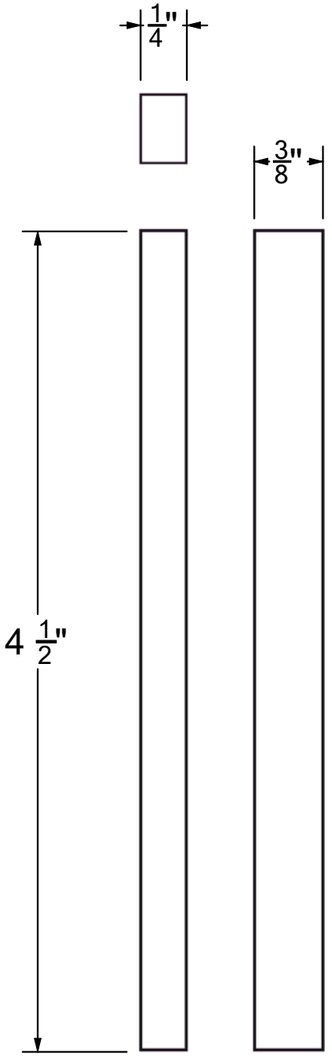


Cut x 7



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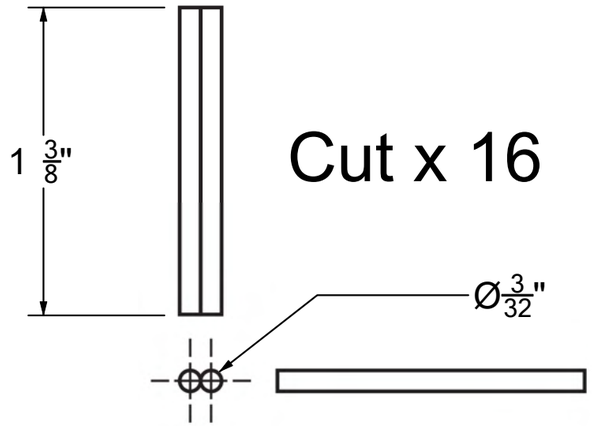
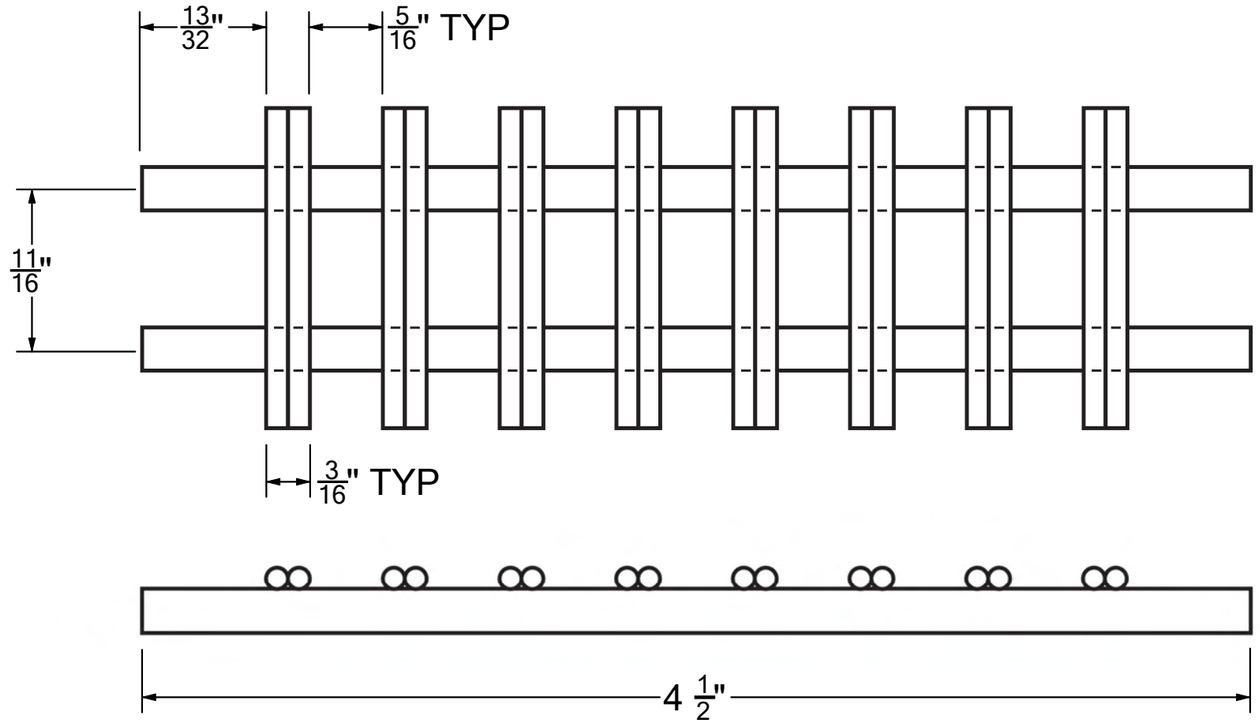
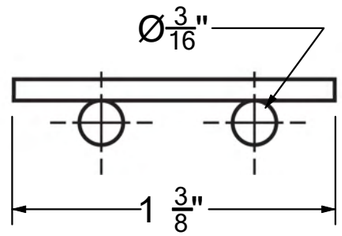
Title: Wheel and Stick	**Drawn by:** Tatiana Titov	**Scale:** 1 : 3
Project: Bio-Inspired Mechanism	**Date:** Apr. 15, 2021	**DWG No:** D-5







Title: Stick Holders	**Drawn by:** Tatiana Titov	**Scale:** 1 : 3
Project: Bio-Inspired Mechanism	**Date:** Apr. 15, 2021	**DWG No:** D-6