

## Project Description

This project is inspired by Theo Jansen's Strandbeests. Jansen is a Dutch artist who has merged art and engineering in a dynamic illustration of movement. The Strandbeest uses mechanical design in linkages to mimic biological locomotion. Inspired by this design, BEEST continues to serve as a demonstration robot for TURTLE

## Methodology

The BEEST system was designed within an existing CAD model optimized for 3D-printed components. A Raspberry Pi interface syncs with an O-Drive linked to a remote controller to operate two brushless motors, providing efficient and precise actuation and speed. These motors drive Jansen-style linkages to convert rotational input into a biomimetic walking motion. In this iteration, silicone molded feet improve traction and stability on varied surfaces.



Figure 1. Angled View of BEEST

## Engineering Analysis

### Leg Linkages

BEEST's legs use a modified Jansen linkage with filleted vertices to improve strength and reduce stress concentrations. Additionally, the linkages now have I-beams with internal slots to add wall loops to improve density and strength. This linkage arrangement replicates efficient biological-style movement, as shown by the leg path in Figure 2. The design uses 3D-printed PLA components further enhance durability, reduce brittleness, and improve cost-effectiveness and manufacturability.

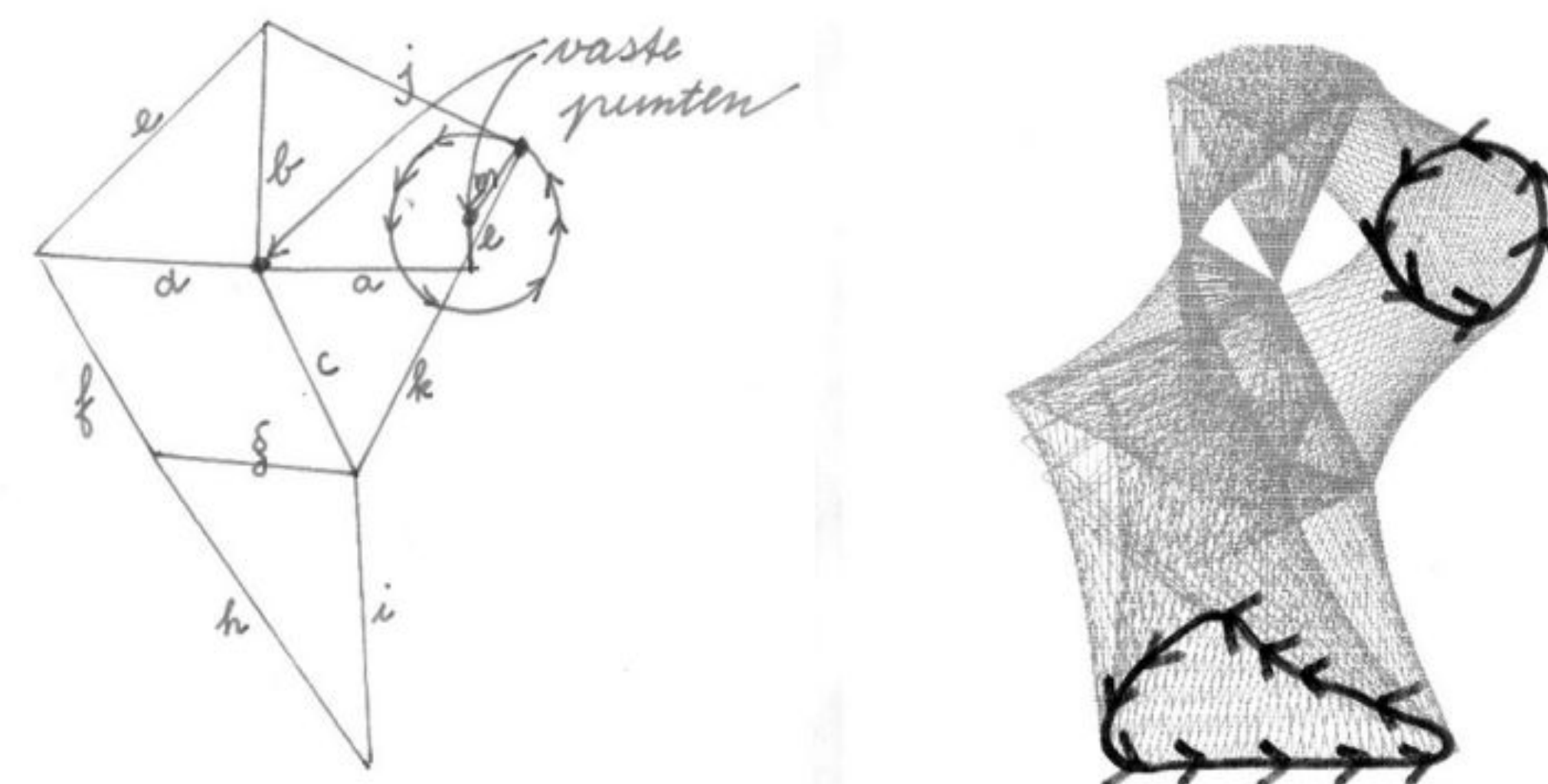


Figure 2. Paths of foot and gear

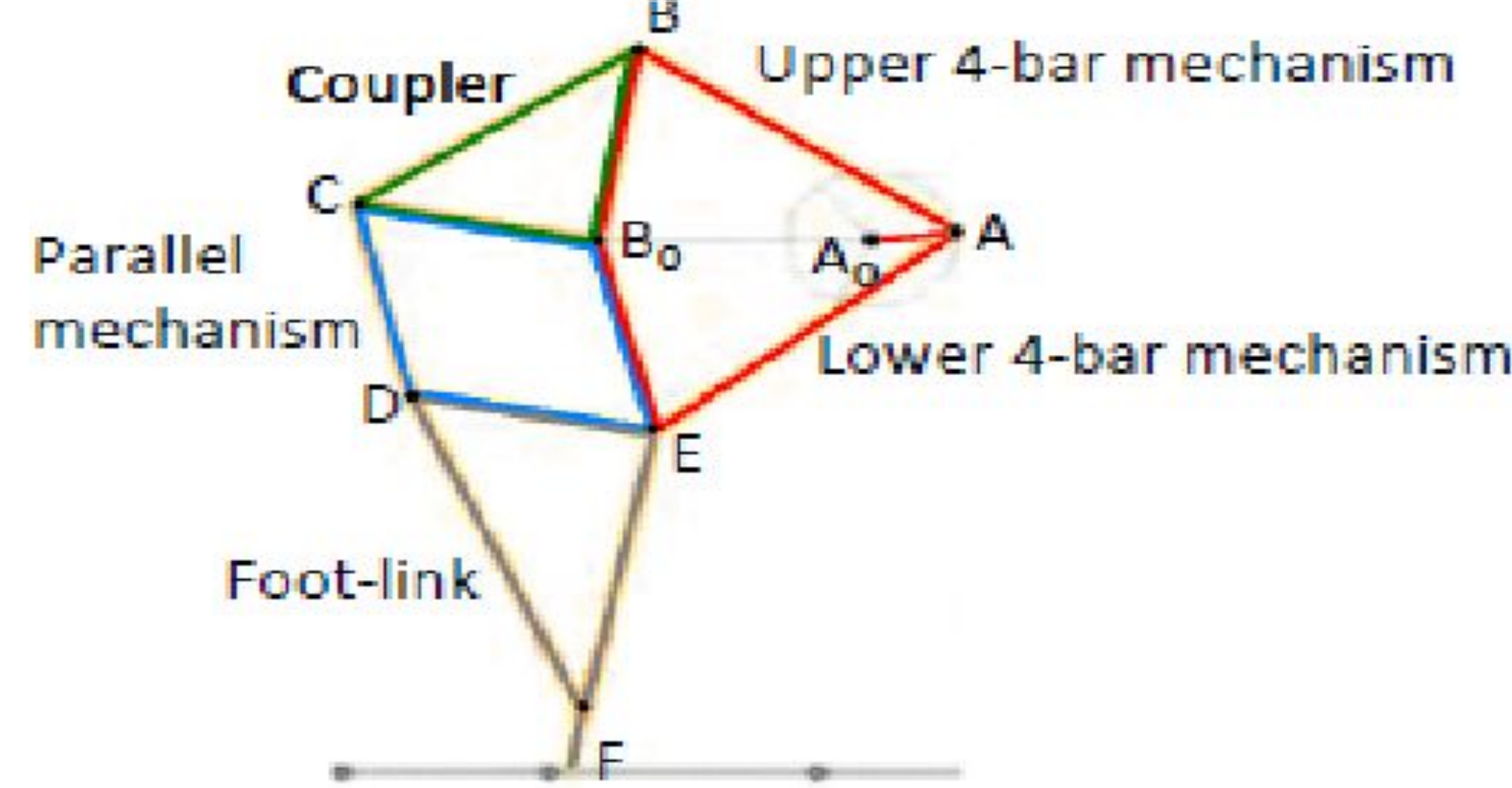


Figure 3. Theo Jansen's Linkage Strandbeest

### Mechanical Power and Motion Transmission

BEEST's mechanical motion begins with the rotary input provided by the motors. The motor shafts are coupled to D-shafts, which drive two gears each, one for each set of legs. The small gears drive two larger gears to ensure that the front and back legs remain in sync during operation.



Figure 4. Motor Shafts and Gears

### Feet

The previous foot design proved to be overly rigid, which caused BEEST to misstep during operation. To address this issue, the feet were redesigned with a spherical shape, eliminating the need for rotation about a fixed axis and allowing for more natural ground contact. Additionally, silicone molding was incorporated to improve traction without relying on grip tape, resulting in more consistent performance across surfaces. To streamline development, molds from an older project were adapted and integrated with updated versions of the earlier 3D-printed feet, combining existing resources with the new design improvements.

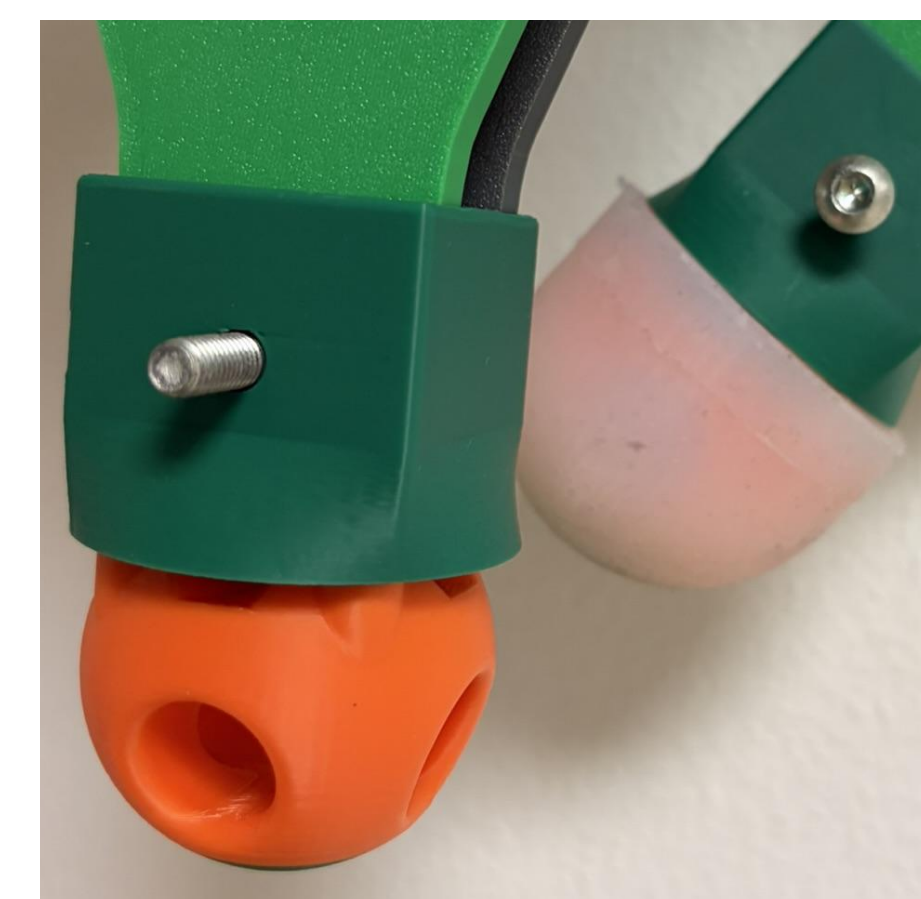


Figure 5. BEEST feet with (right) and without (left) silicone

### Electronics and Software

A Raspberry Pi 4 runs Python scripts that interface a wireless controller with the O-Drive motor controller, enabling precise control of the system. The entire system is powered by a 22.2V, 6000mAh LiPo battery, providing sufficient energy for sustained operation.

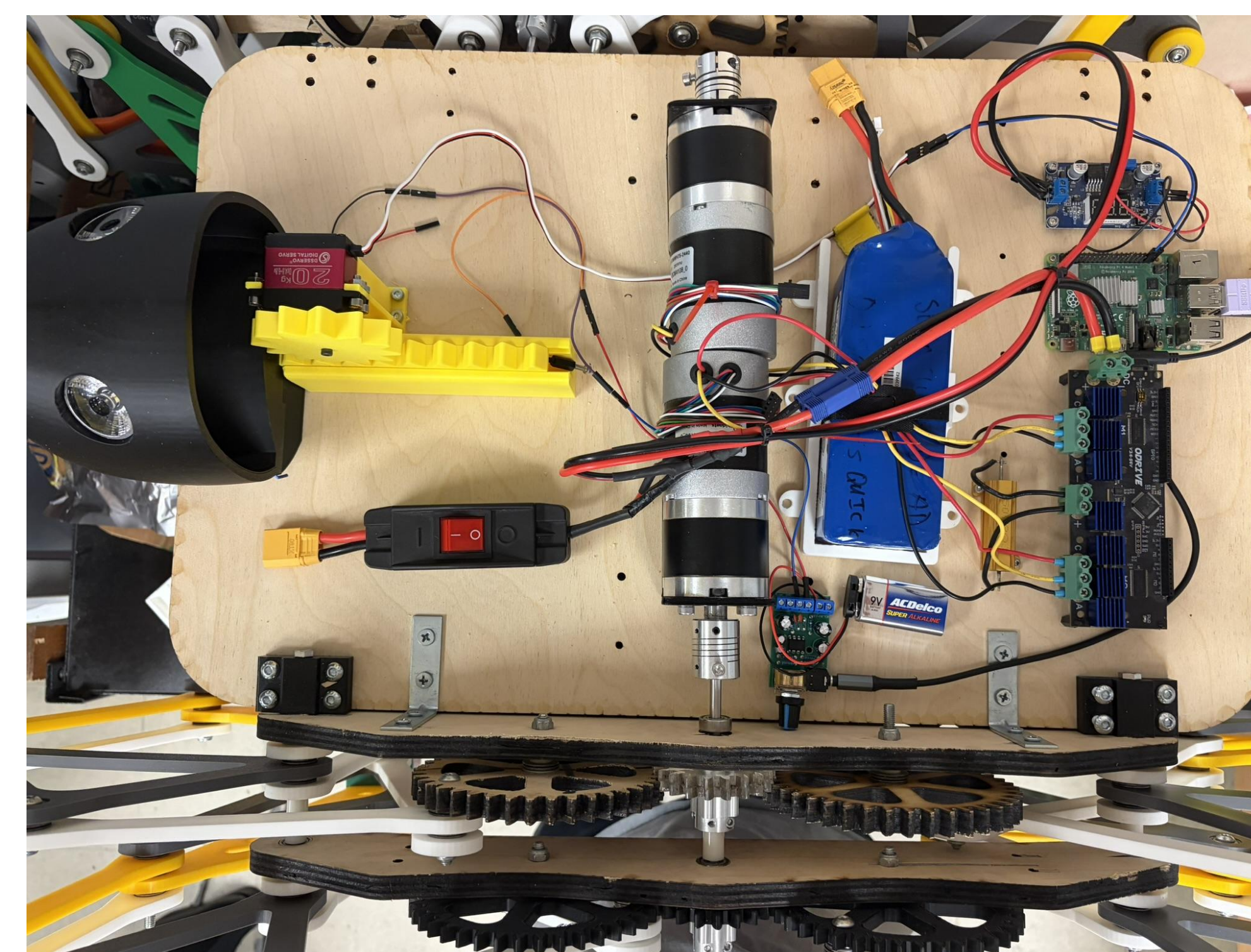


Figure 6. View of BEEST's Electronics System  
Note: Shell modifications still in progress

### Head

BEEST's head is modeled off a turtle. The jaw opens and closes with the assistance of gravity by using a rack and pinion to move the head forward and backward. The head contains a speaker that plays music via controller input.

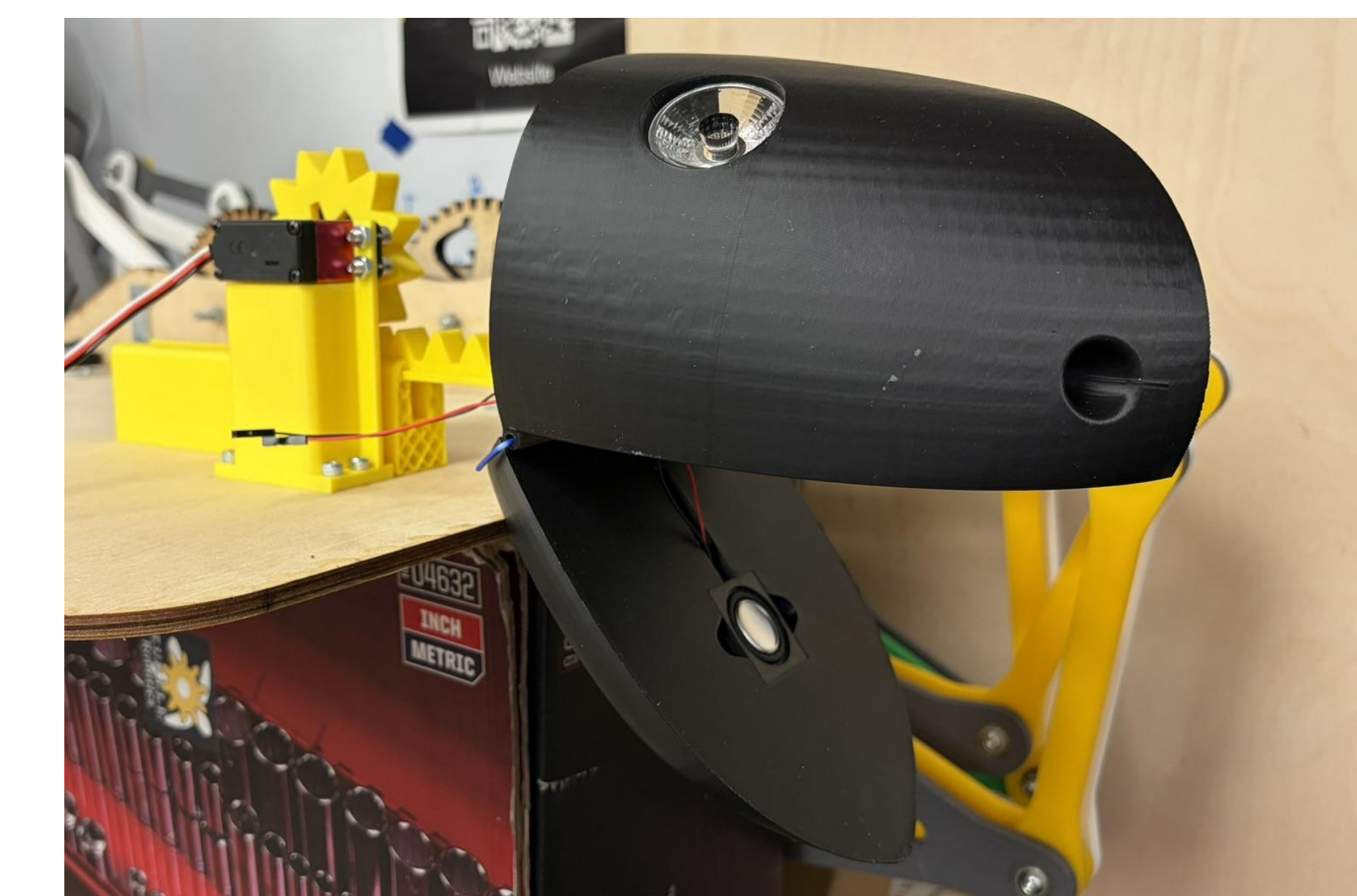


Figure 7. View of BEEST's Head Subsystem

### Shell

The shell is made of EVA foam with a carved turtle shell pattern in addition to the TURTLE logo, and it is held in place with neodymium magnets on the corners. The shell is designed to protect BEEST's electronics. The shell mounts to the base via neodymium magnets.

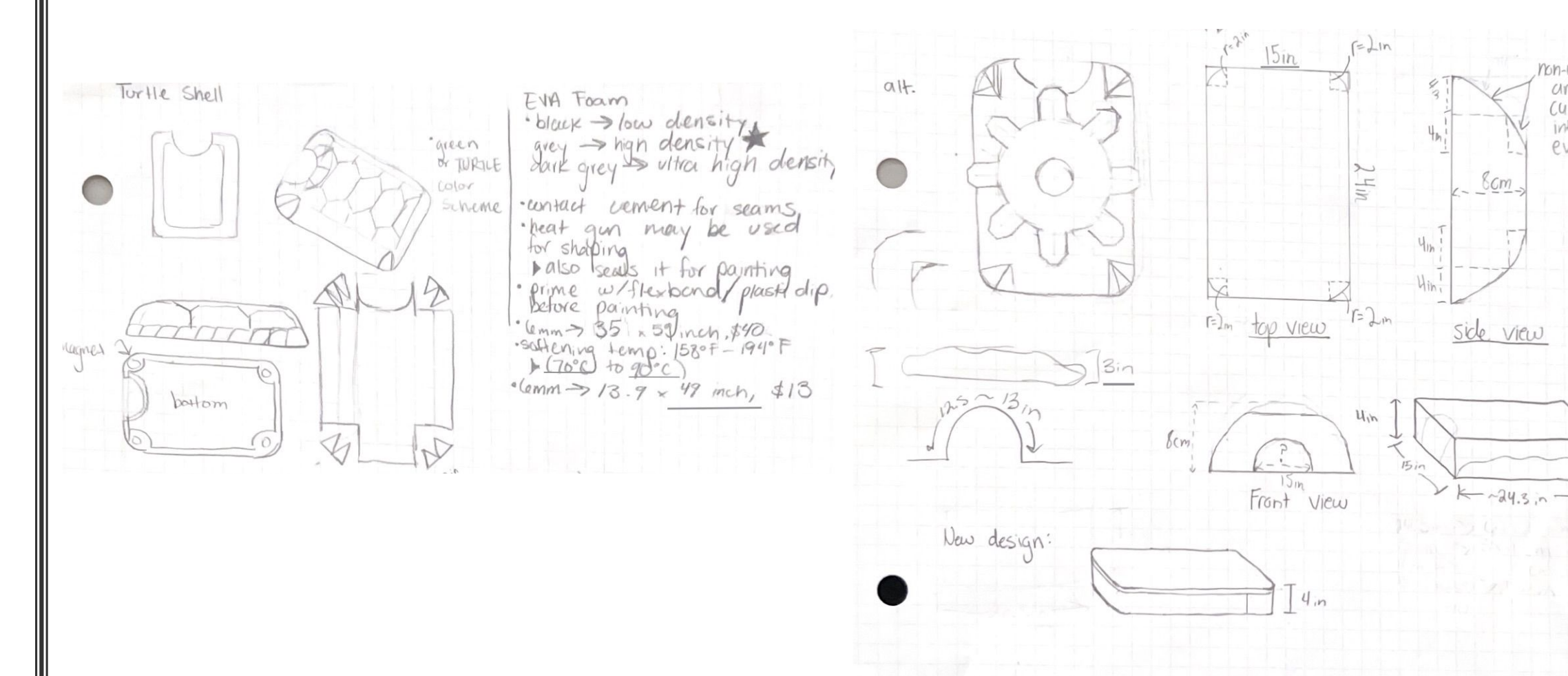


Figure 8. BEEST Shell Design

### Manufacturing

BEEST's main base plate was cut from 1/4" plywood. Custom linkages and gears were 3D-printed in PLA at 1/4" thickness. Manufacturability was the primary decision factor when designing the robot. Replacement parts need to be made quickly and easily, and 3D printing is the fastest and cheapest manufacturing method for TURTLE at the present moment.