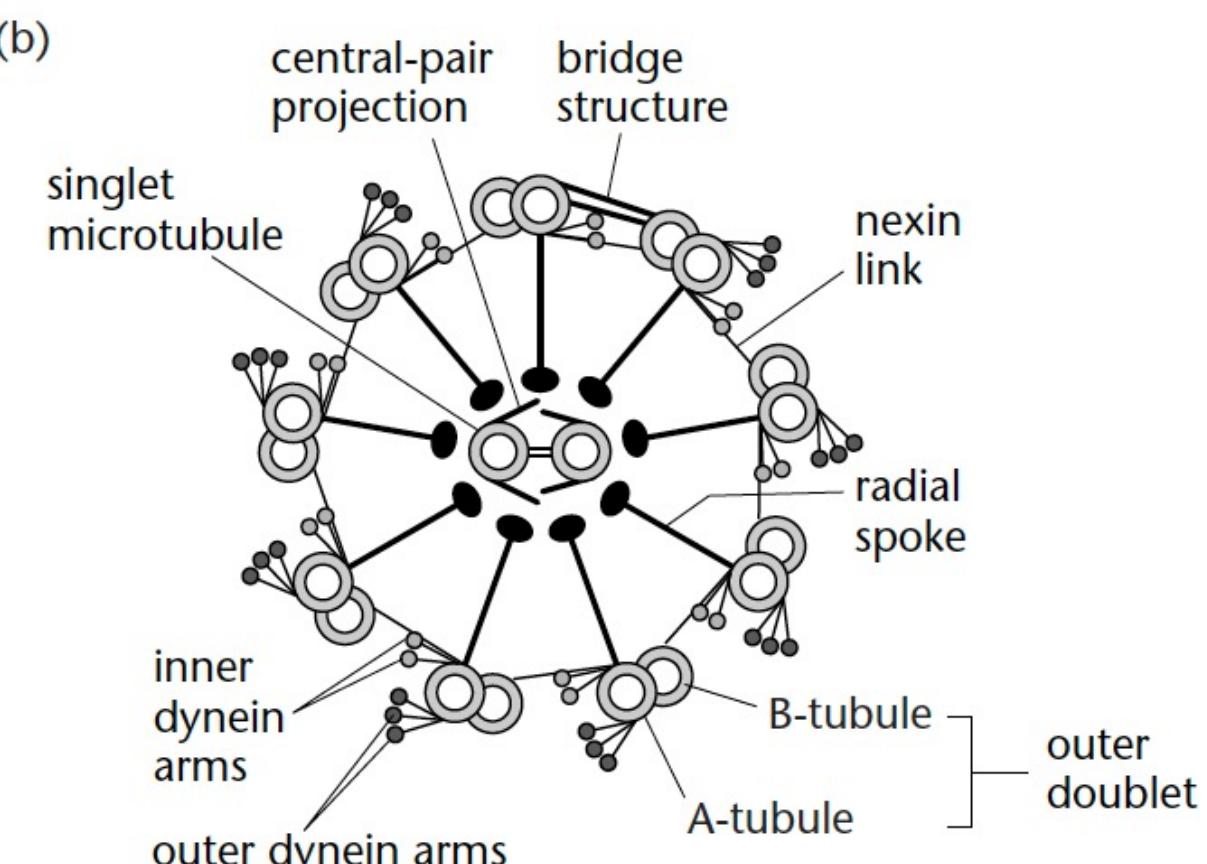
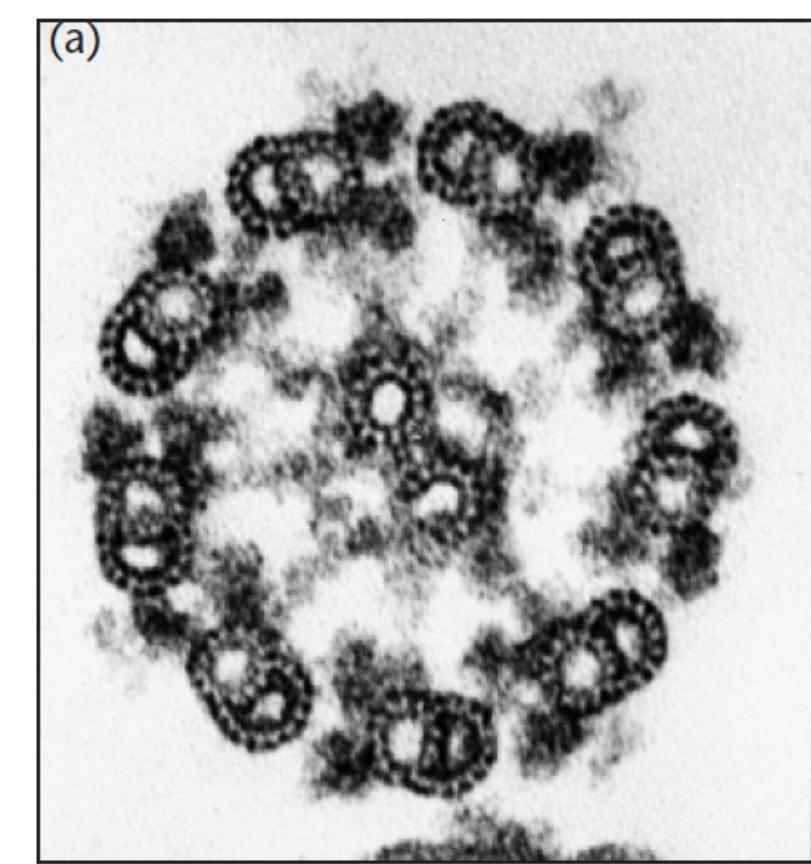


# Developing a Roller-Based Robotic Model of the Cilium

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## Background



Cilia are a type of organelle that can be found on various cell types. Their distribution spans a multitude of human body systems, including key areas such as the lungs, brain, and the reproductive system, showcasing their extensive functionality and importance. The core architectural feature of cilia is the axoneme structure which is made up of microtubule doublets; which form the skeleton of the cilia. The characteristic motion of cilia, can be attributed to the action of dynein filaments, specific motor proteins that enable sliding of adjacent microtubules against each other.

All non-original images courtesy of Bray Cell Movements

## Previous (Bristle-Based) Designs



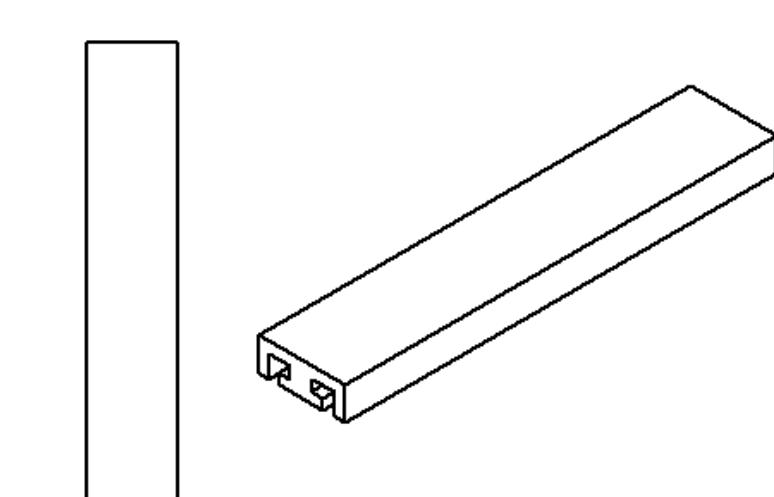
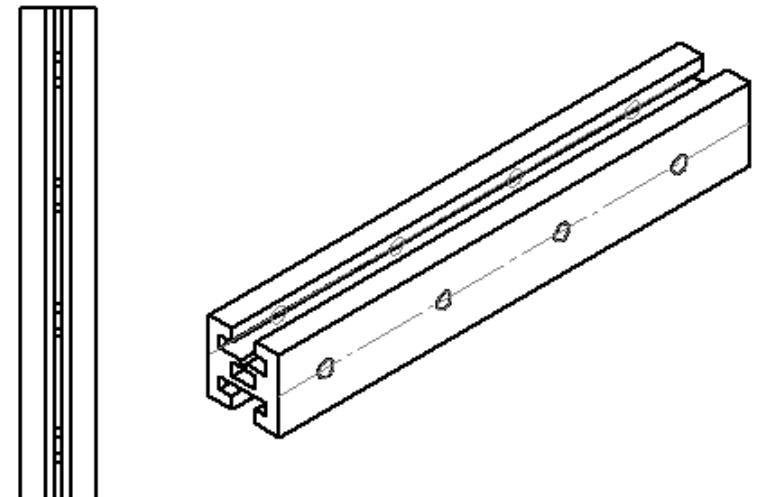
The Bristlebot model of the cilium utilizes vibrating motors along with flexible bristles to enable the movement of plastic pieces it interacts with. The Bristlebot model has progressed to successfully produce sliding and bending movements. However, the model has not yet been able to replicate the characteristic motion exhibited by natural cilia.

## Objectives

This project aims to develop a human-scale mechatronic version of a cilium which uses motors and rollers to produce sliding between flexible ribbons. This body should be able to produce sliding between filaments, and we will evaluate its capacity to create bending in the structure, overcome external resistance, and produce the same kind of oscillations that cilia and flagella do. The first aim is to produce two-part sliding, and then to form a larger structure using the same sliding mechanism to produce sliding in multiple directions.

## Design Iterations

### Version 1.0



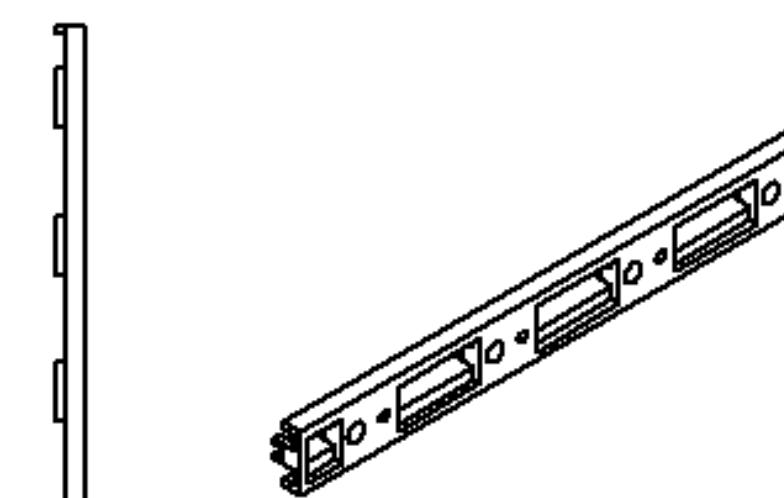
### Spine

- Holds motors
- Printed from flexible materials
- Slit in top for assembly

### Ribbon

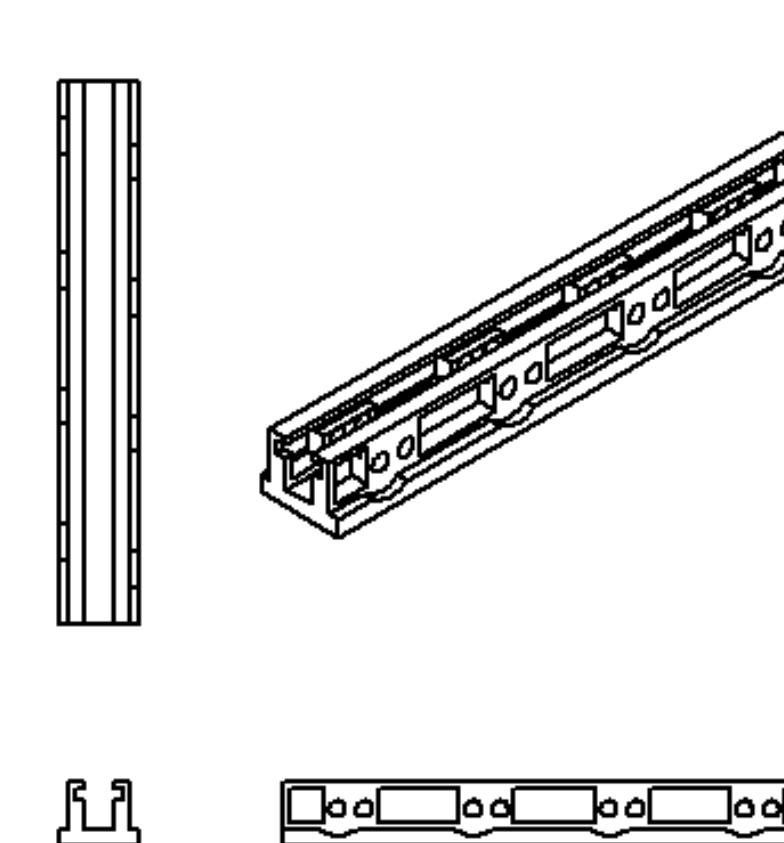
- Driven by friction from wheels
- Slides along spine
- Flexible for eventual bending

### Version 2.0



- Center piece split for ease of assembly
- Cable managing piece removed
- Pockets created to increase flexibility
- Printed entirely from NinjaFlex

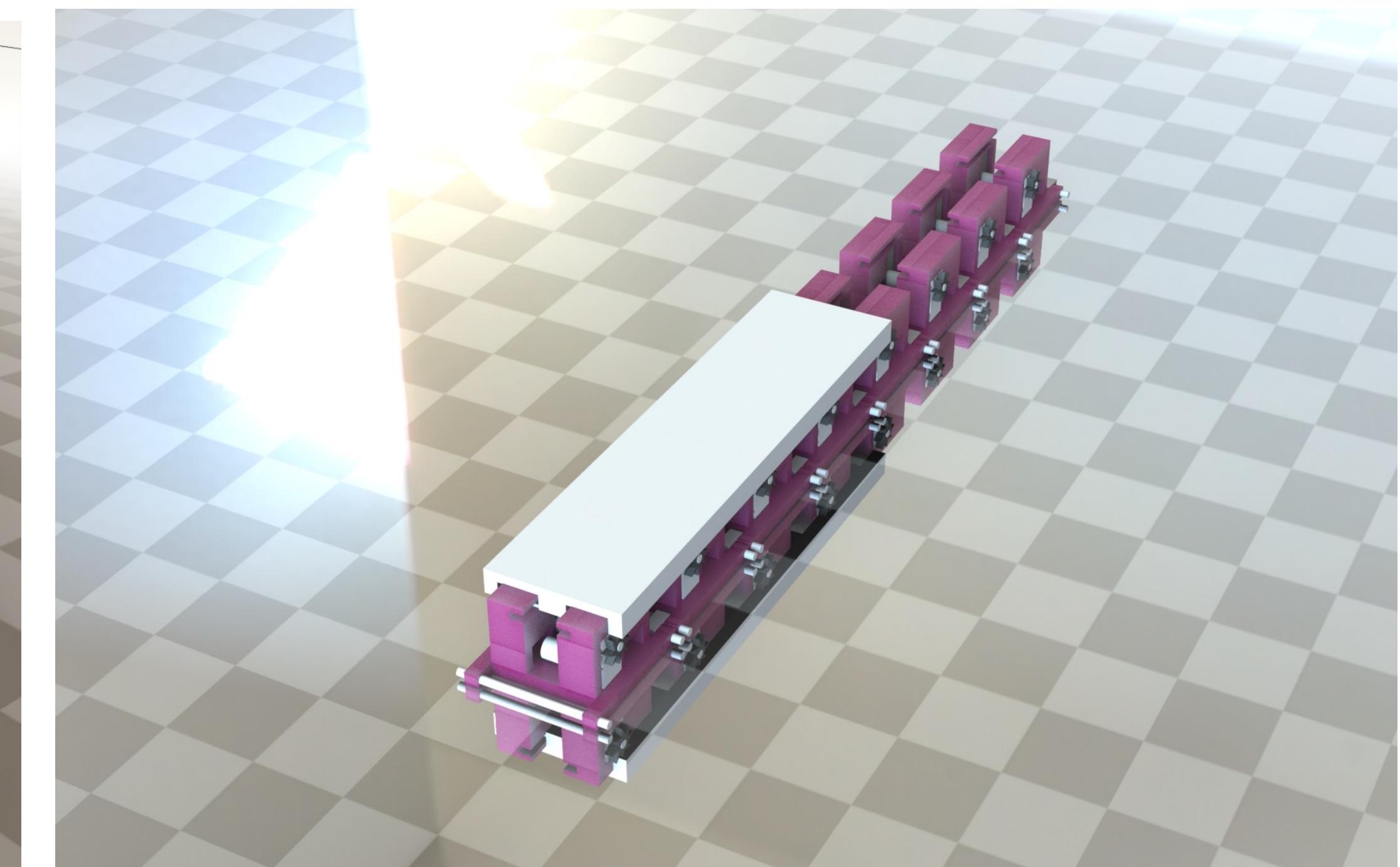
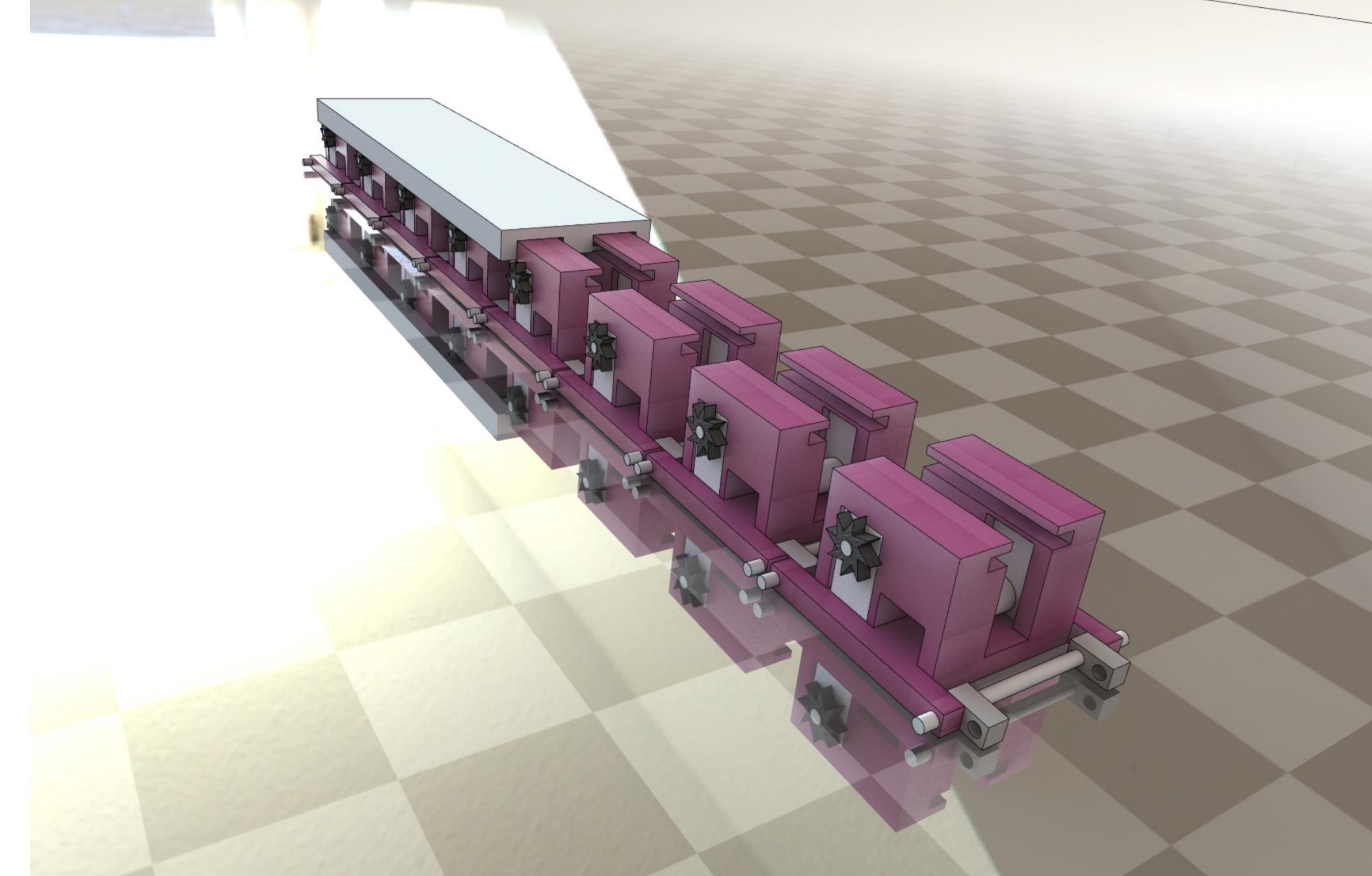
### Version 3.0



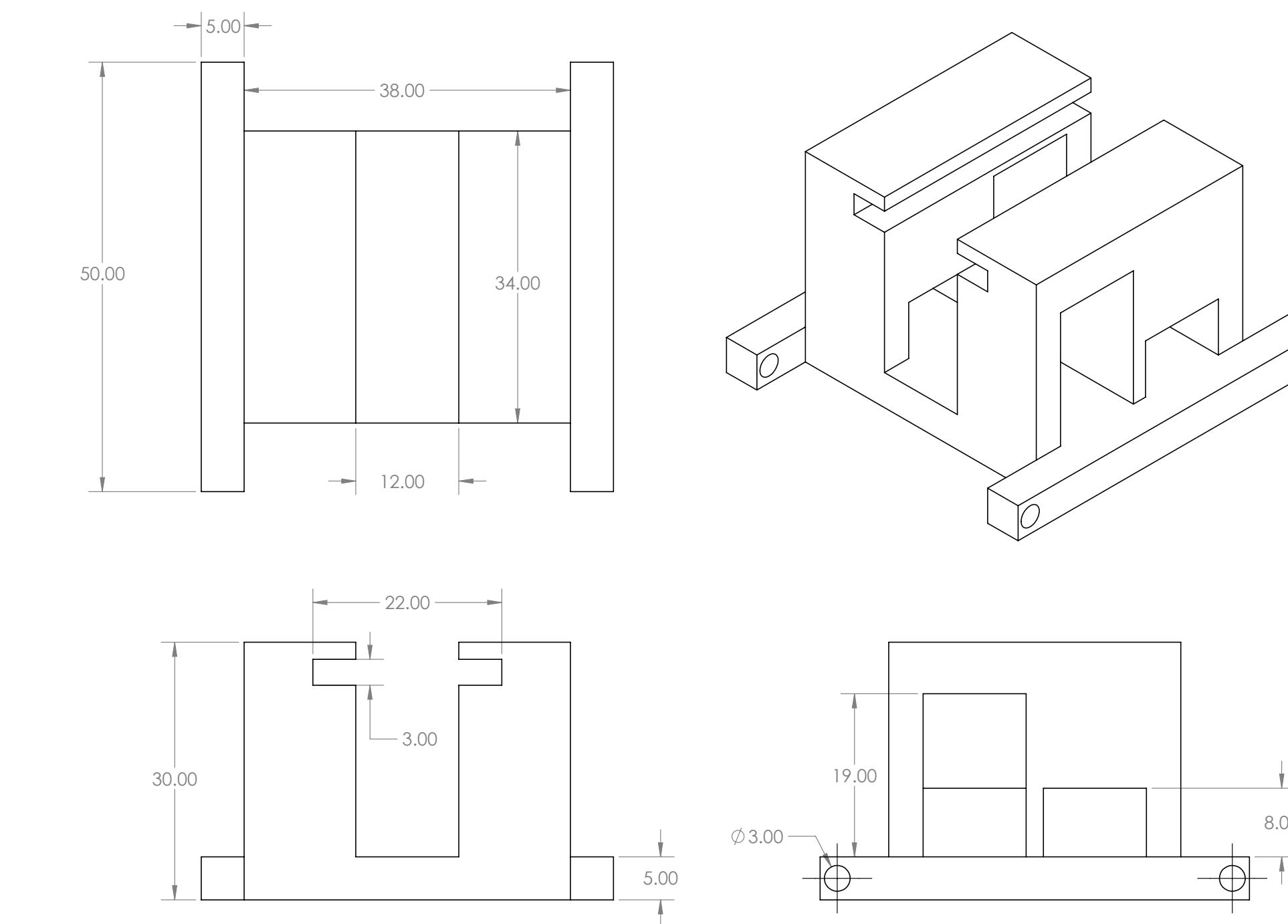
- Spine pieces and base combined
- Clearance created, wheels only in contact with top
- Less infill for greater flexibility
- Greater tolerances to reduce internal friction

## Final Design Specifications

### Final Design SOLIDWORKS Renders



### Version 4.0 Module



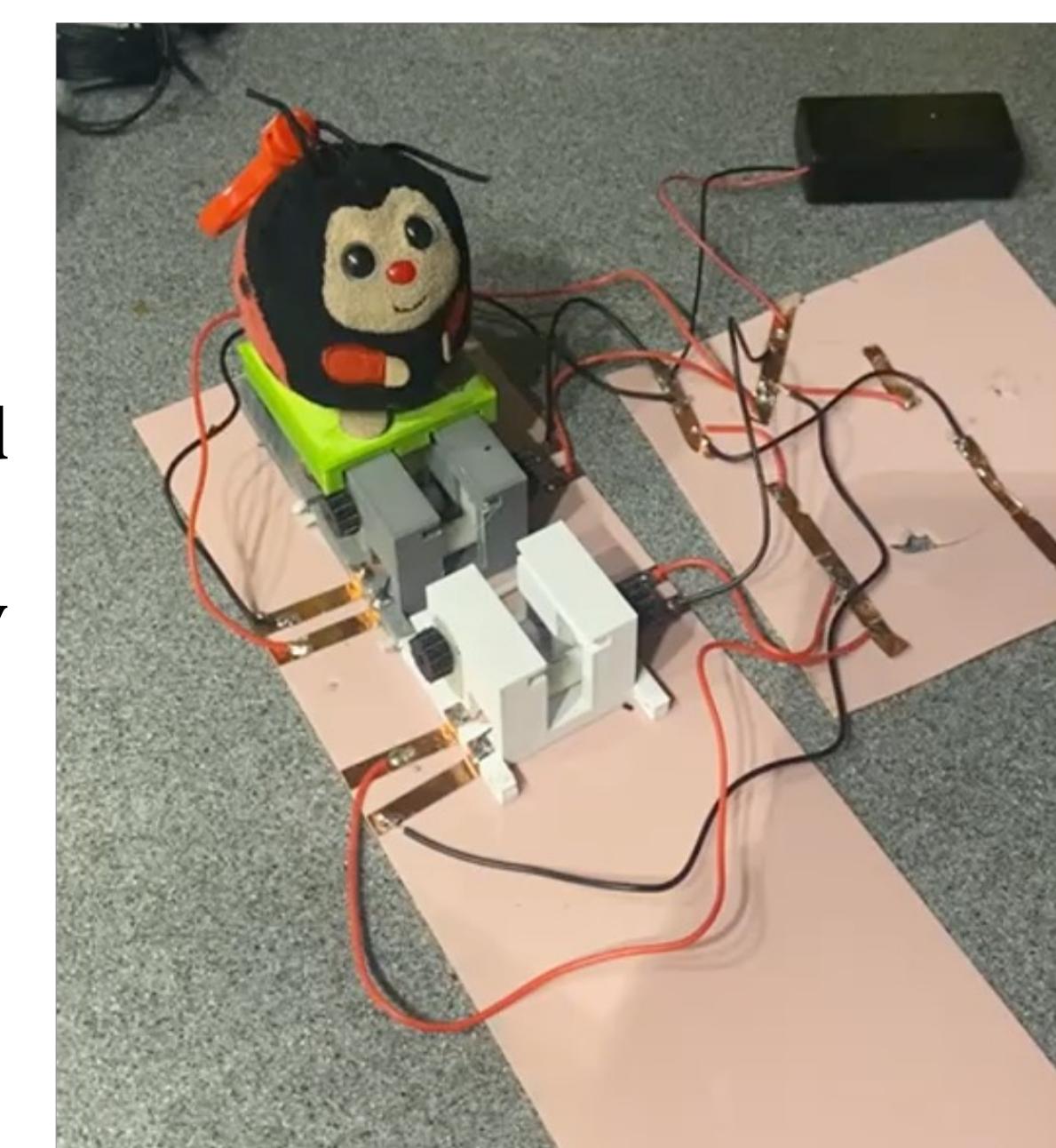
## Parts List

### • Printed Parts

- Module
- Ribbon
- Connecting Rod
- Link
- Compliant Wheels
- Electronics
  - GM-24 Motors
  - Copper Conductive Tape
  - 3V Power Supply

## Performance

- Sliding successfully produced w/ roller design
- Flexible ribbon unable to be printed to test bending, and only 3 modules fully assembled



## Future Steps

- Create more link modules for correct length-width ratio
- Pursue bending and collect data on the motion produced by the structure

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