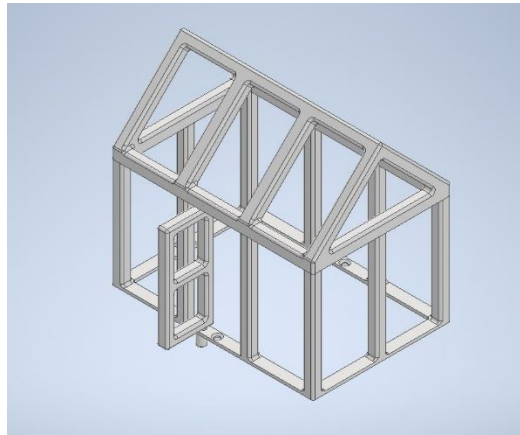# Smart Greenhouse – 3D printer and stepper motor

HARDWARE
- Stepper motor
- 3D printer (BambuLab A1 mini and BambuLab P2S)
- PLA

Prototyping and Assembly of the Automated Greenhouse

The greenhouse prototype was modelled using Autodesk Inventor CAD software and fabricated in black PLA using BambuLab A1 Mini and P2S printers. The structure was designed as an open "skeleton" to evaluate overall dimensions and test the door's movement.
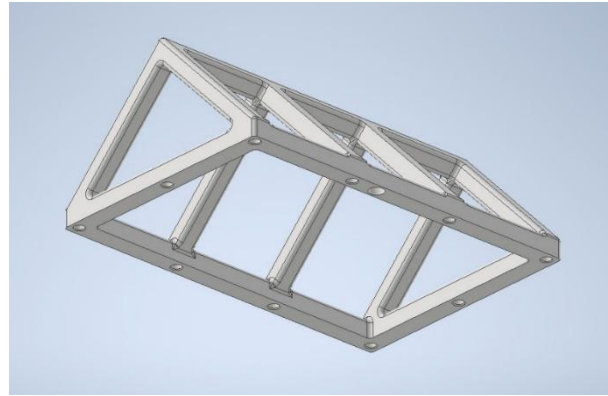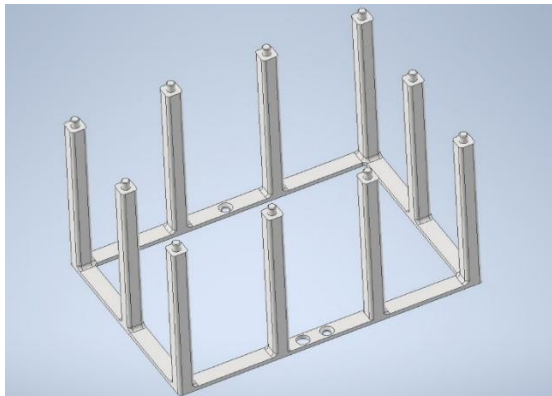
The structure consists of three main modules:

- Roof: Features female housings on the underside for mating with the base pillars, and a specific seat for the door's upper pivot.
- Base: Serves as the primary structural support. It includes two countersunk holes for screw-mounting to the axle, a clearance hole for the door's lower pivot, and pins on the top of each pillar for snap-fitting with the roof.
- Automated Door: Designed with two pivots (upper and lower). The upper pivot acts as a hinge within the roof, while the lower pivot passes through the base and axle to connect directly to the motor. The lower pivot features a "D-profile" recess (matching the motor shaft) to ensure a solid coupling and the transmission of rotational motion.
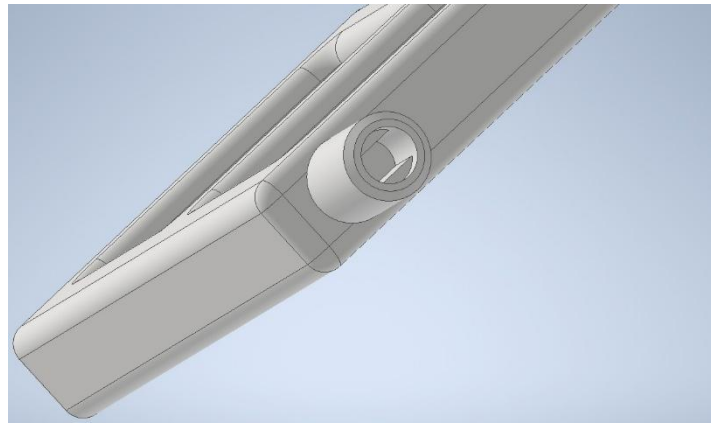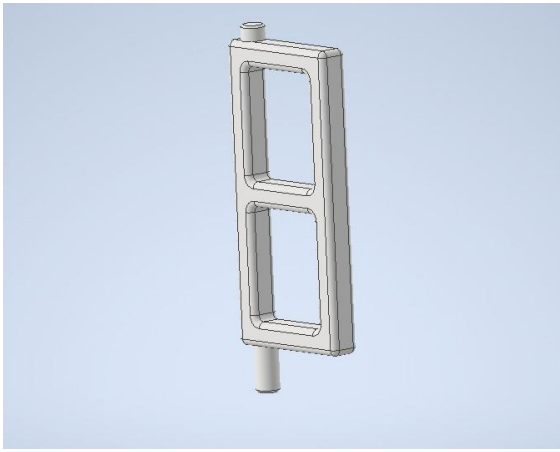
GREENHOUSE ASSEMBLY

STEPPER MOTOR SETUP

A stepper motor was selected for the actuation system, prioritizing precise angular control over speed. Unlike standard DC motors, the stepper motor allows for accurate positioning of the door at specific angles without the need for external feedback sensors.

STEPPER HARDWARE

Regarding the hardware configuration, the stepper motor is not powered directly by the microcontroller's GPIO pins due to current limitations that could damage the board. Instead, a dedicated motor driver is interposed to manage the power delivery and protect the logic unit.

STEPPER SOFTWARE

The control software calculates the necessary displacement based on the motor's resolution. The specific model employed has a standard resolution of 2048 steps per full revolution (360°).

$$Steps\ per\ degree = \frac{2048}{360} \approx 5.688\ steps/degree$$

To achieve a target opening angle of **120 degrees**, the required number of steps is calculated using the following ratio:

$$Total\ steps = 120 \times 5.688 \approx 683\ steps$$