Automated Pen Plotter

- Group 24

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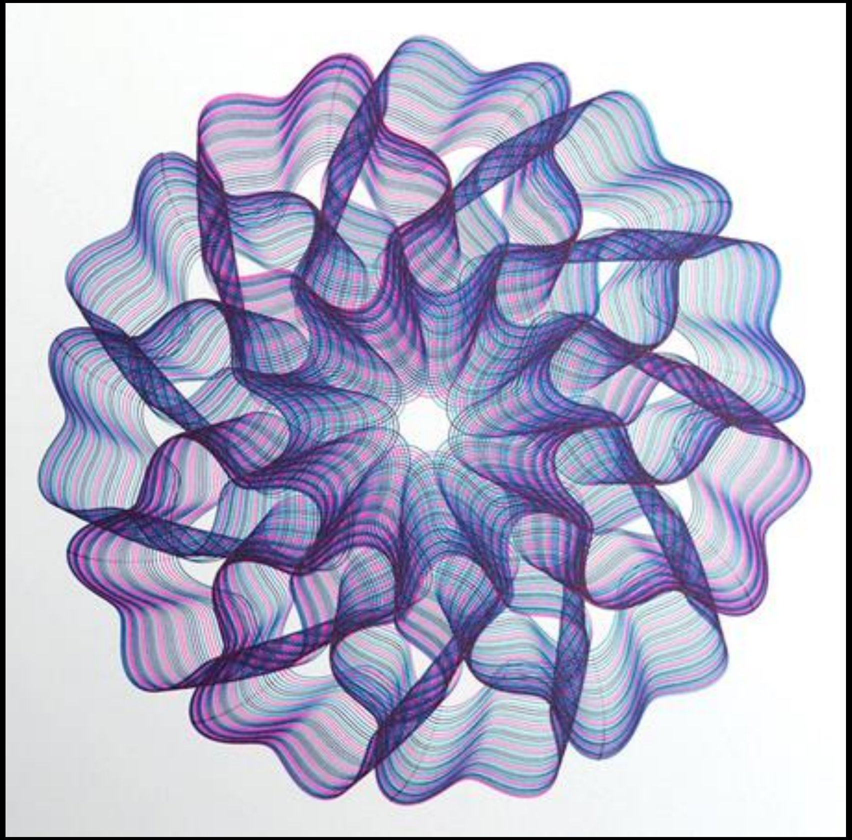
INTRODUCTION

- Unique way to generate images with speed and precision.
  - Unlike laser printers are able to print continuous lines.
- Mainly used by architects and engineers.
  - Used for blueprints, cad drawings and architectural renderings.
- Used by hobbyists for unique art piece and designs.
  - Typically smaller scale than professional designs.
  - Allow for the use of writing utensil of choice.



MOTIVATION

- Pen plotters can be very costly.
    - Typically priced at $300-$1000.
- Our design aims to be an easy to use and cheaper product that will create more interest in pen plotting.
- Pen plotting can create unique works of art we want to allow more hobbyists to explore.

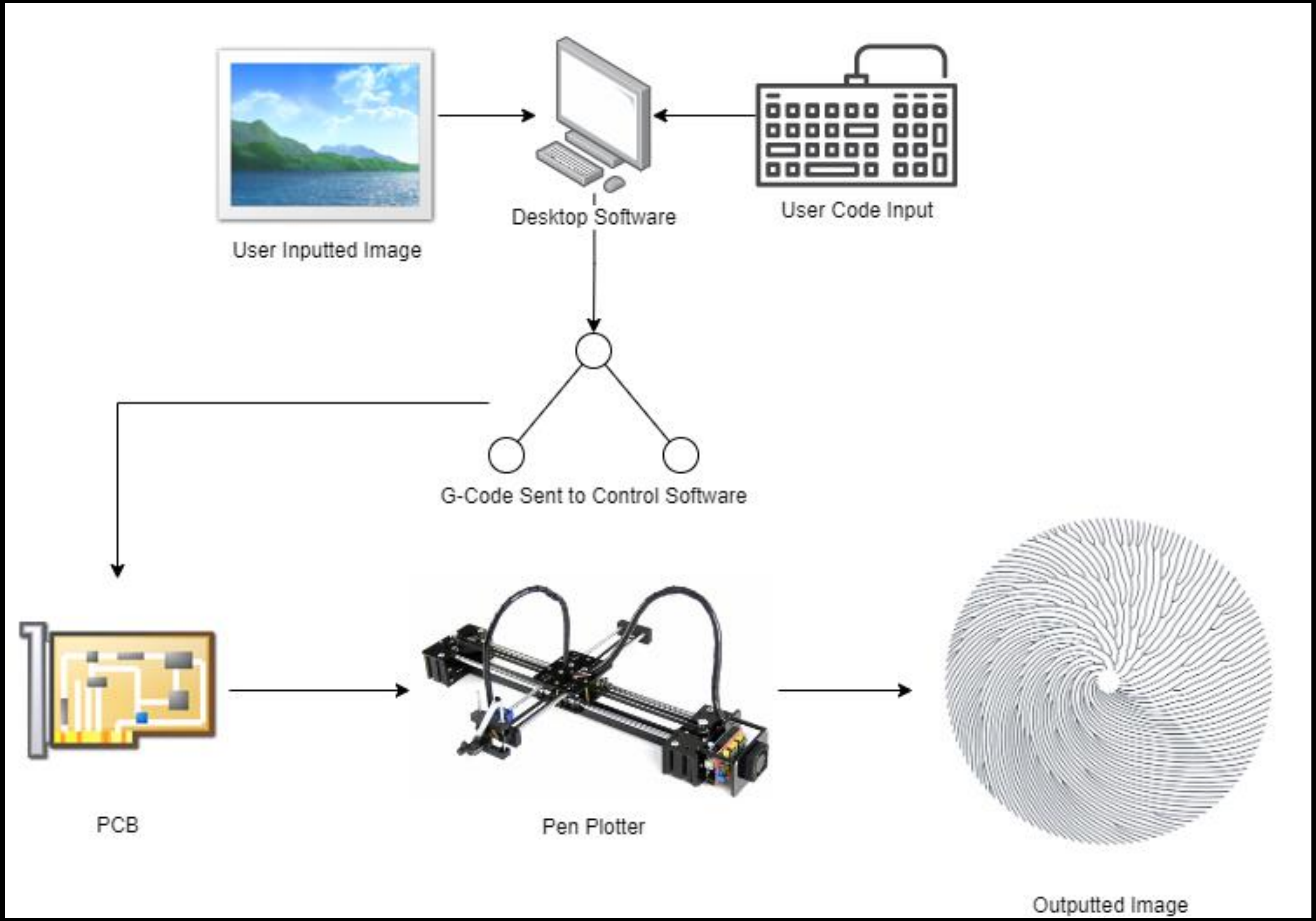
GOALS & OBJECTIVES

- Create a precise and mechanically sound design.
  - Plotter must be durable.
- Stability is important with this type of CNC adaptation.
- Allow the user to control the plotter from their PC.
- Ability for user to use the writing utensil and surface of their choice.
- Design an easy-to-use GUI which will control the entire process.

SPECIFICATIONS AND REQUIREMENTS

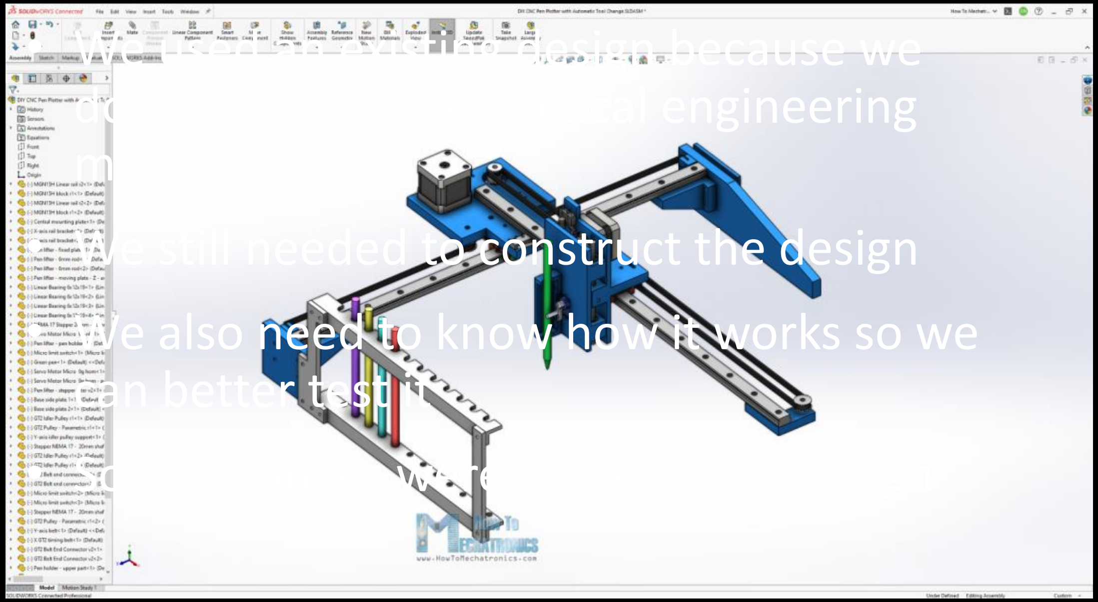
Specification	Requirement	Value
Stepper motors	X Y and Z axes	3 motors
Working area	the larger dimensions of A4 and U.S. Letter Sizes with additional margin of 0.5 Inches	9.5” x 12.75”, 242 mm x 324 mm or greater
Base size	working area plus 100 mm on top, 30 mm on each side, and 30 mm on bottom	302 mm x 454 mm or greater
Plotting precision	Much less than the line weight of a standard pen	0.1 mm or less in the X and Y directions
Plotting speed	Reasonable speed for writing or drawing	~20 mm per second
Clamp fitting for pen	Fits most standard pen sizes	6 mm to 14 mm
PCB full size	Plenty of room for display and controls	120 mm x 100 mm or smaller
Switches	Confirm, cancel, and emergency stop	3 switches
Motor power supply voltage	Appropriate voltage for chosen motors	12V
Microprocessor power supply	Appropriate voltage for microprocessor	5V
Firmware size	Size of medium size C code when converted to 32 bit machine code	~10 kB or smaller

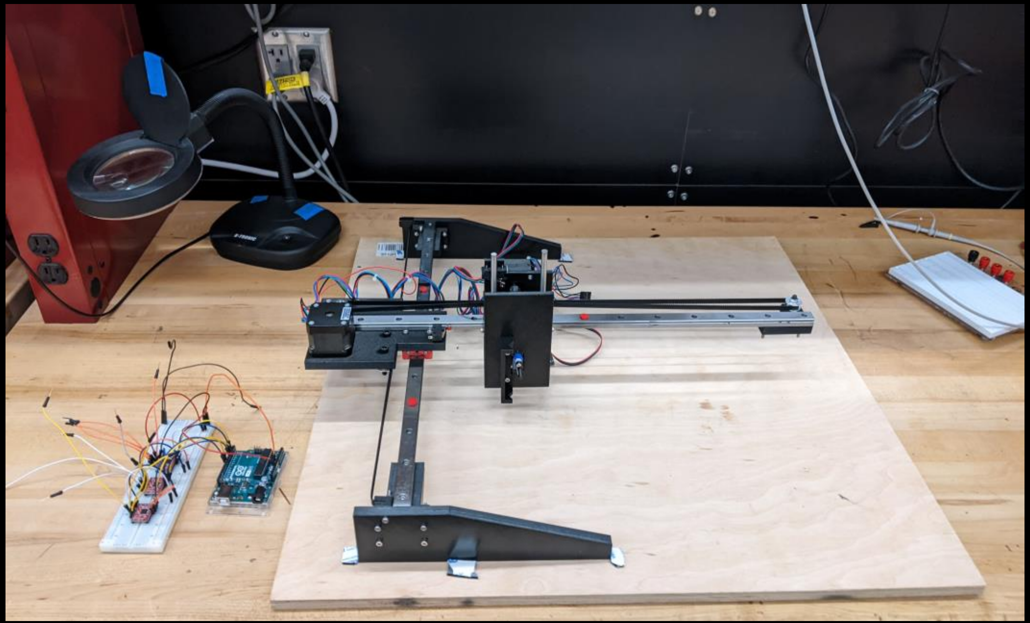
OVERALL PROJECT DIAGRAM



Mechanical Design

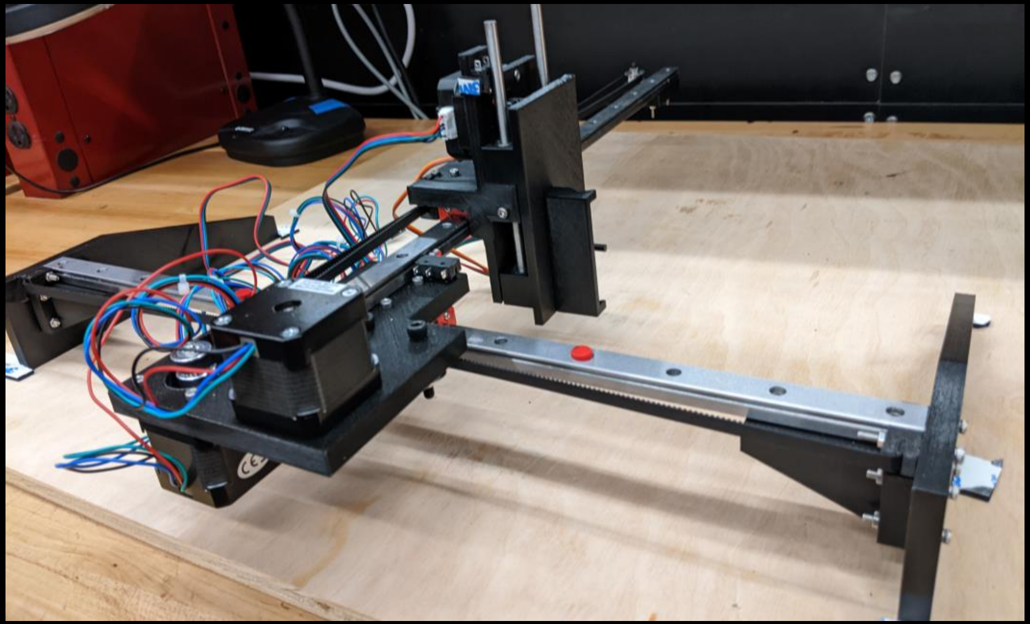
- We used an existing design because we don't have any mechanical engineering majors
- We still needed to construct the design
- We also need to know how it works so we can better test it
- So [illegible] we're [illegible] design

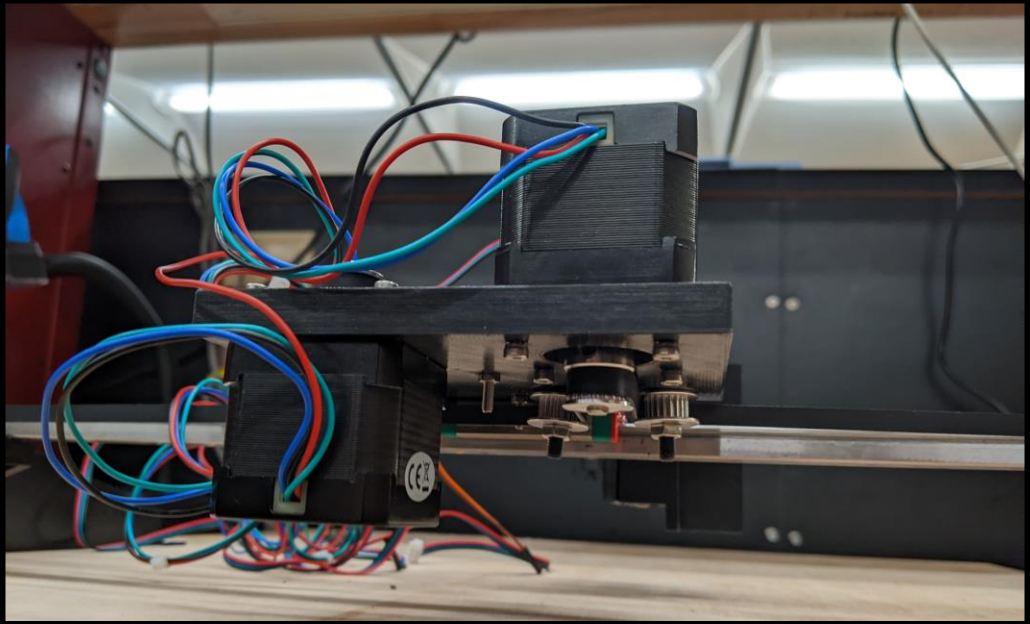




X Axis

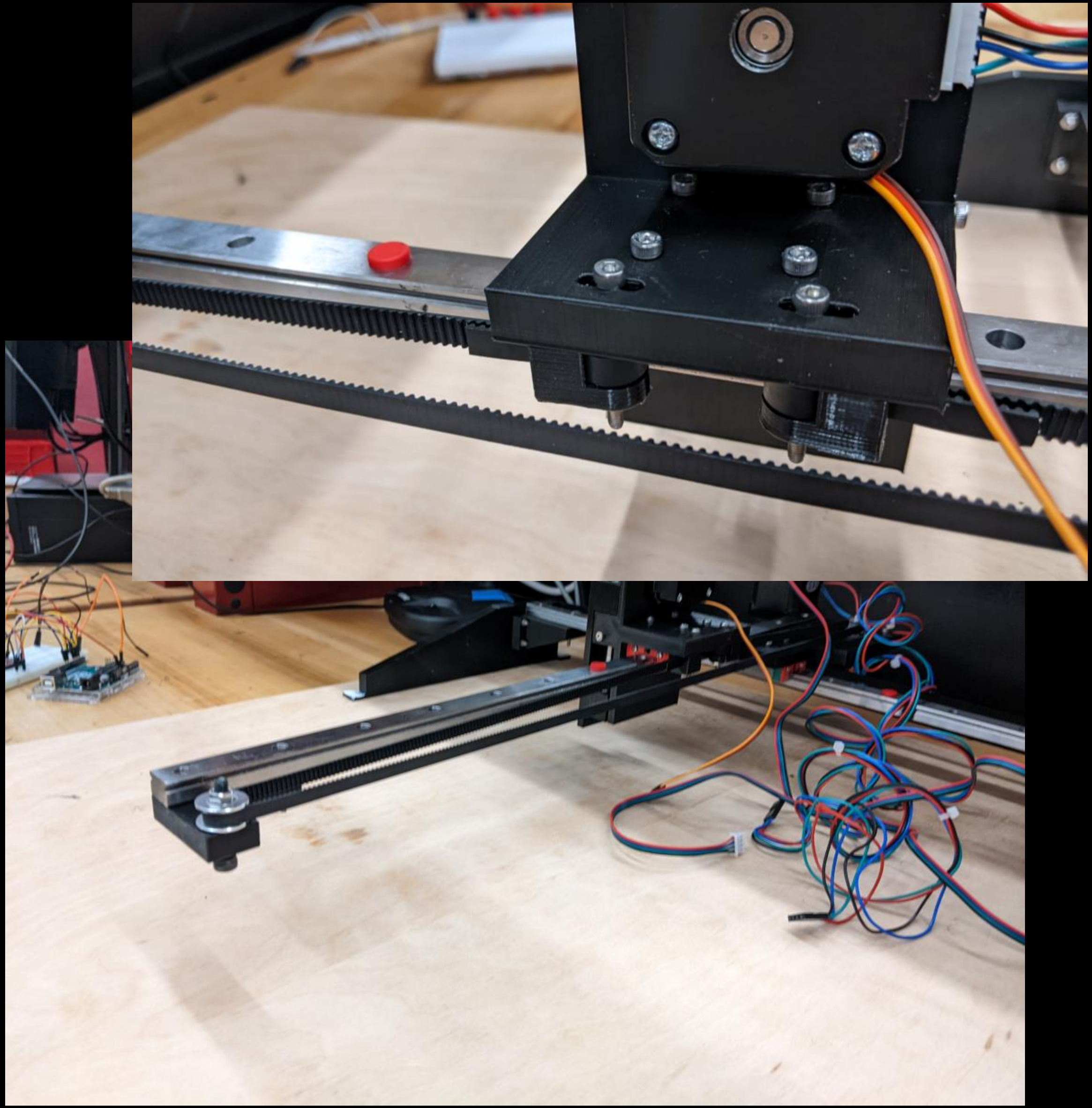
- The X axis motion is controlled by a belt and pinion system
- This allows the X and Y axis motors to be together
- As with almost all systems, backlash may be a concern





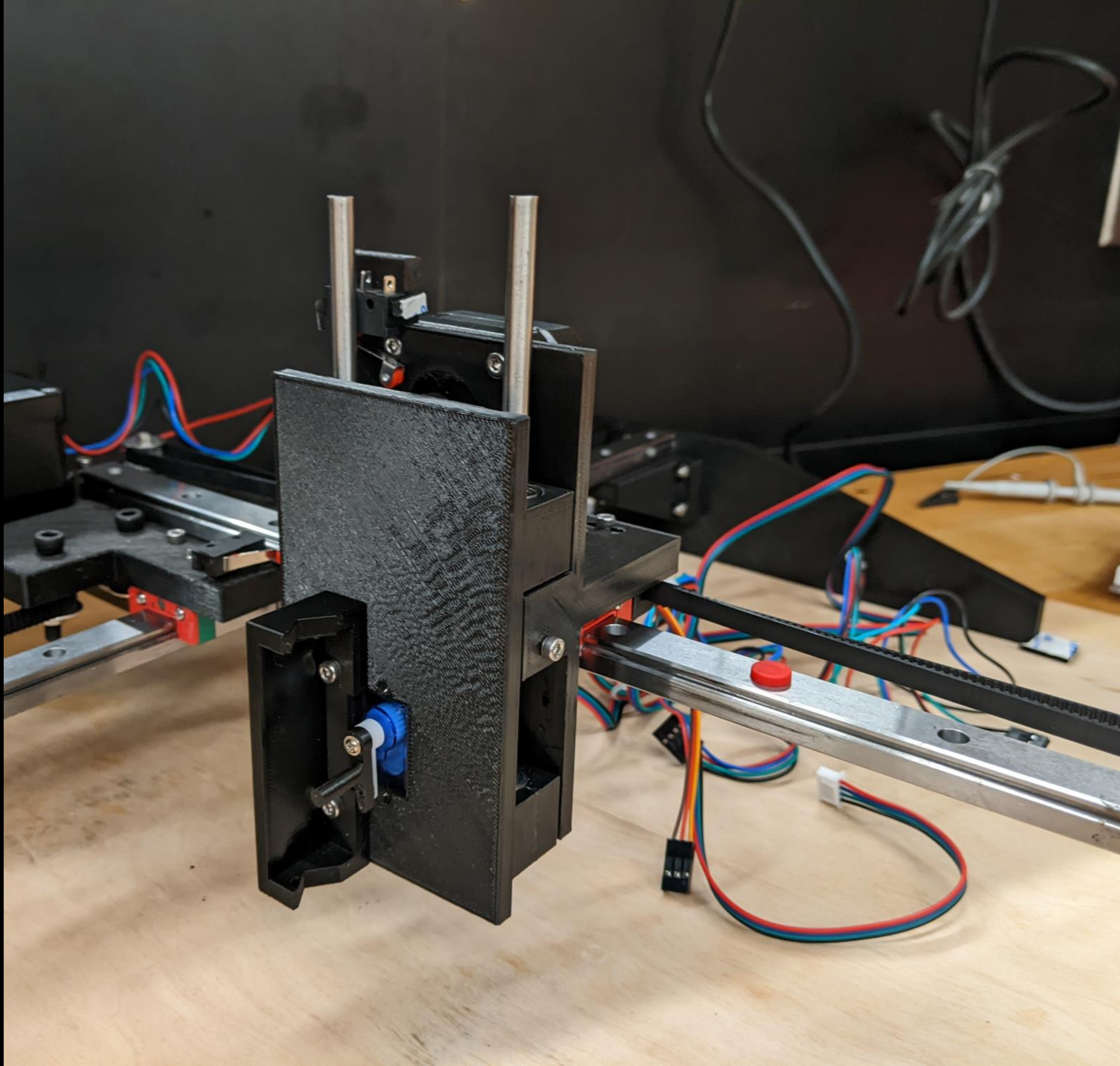
Y Axis

- The Y axis uses a pulley actuator system
- This allows the X and Y motors to be together
- Backlash still a possible concern



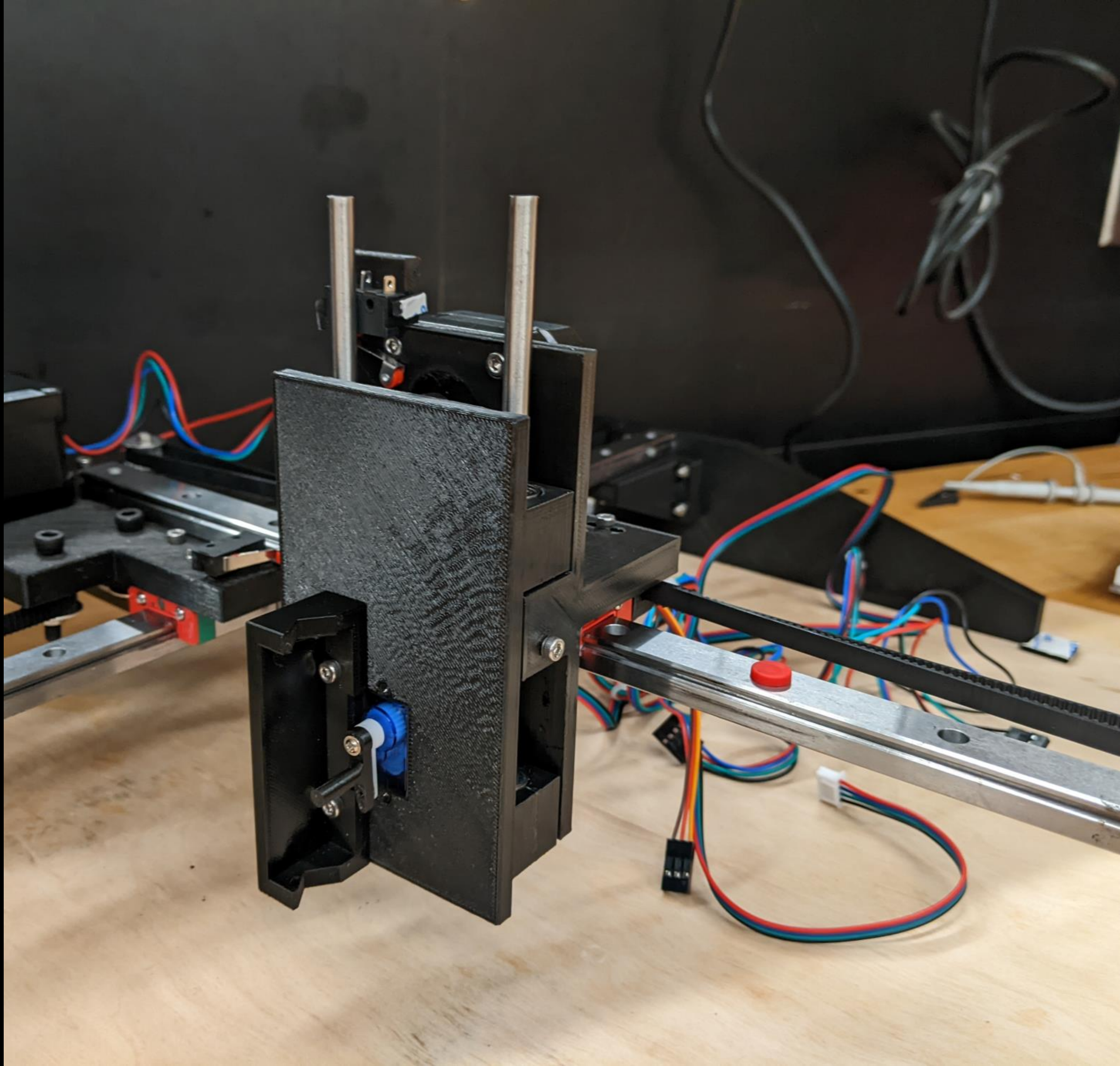
Z Axis

- The Z axis uses a lever arm to raise or lower a spring loaded linear slider
- Low range of motion
- Printing difficulties



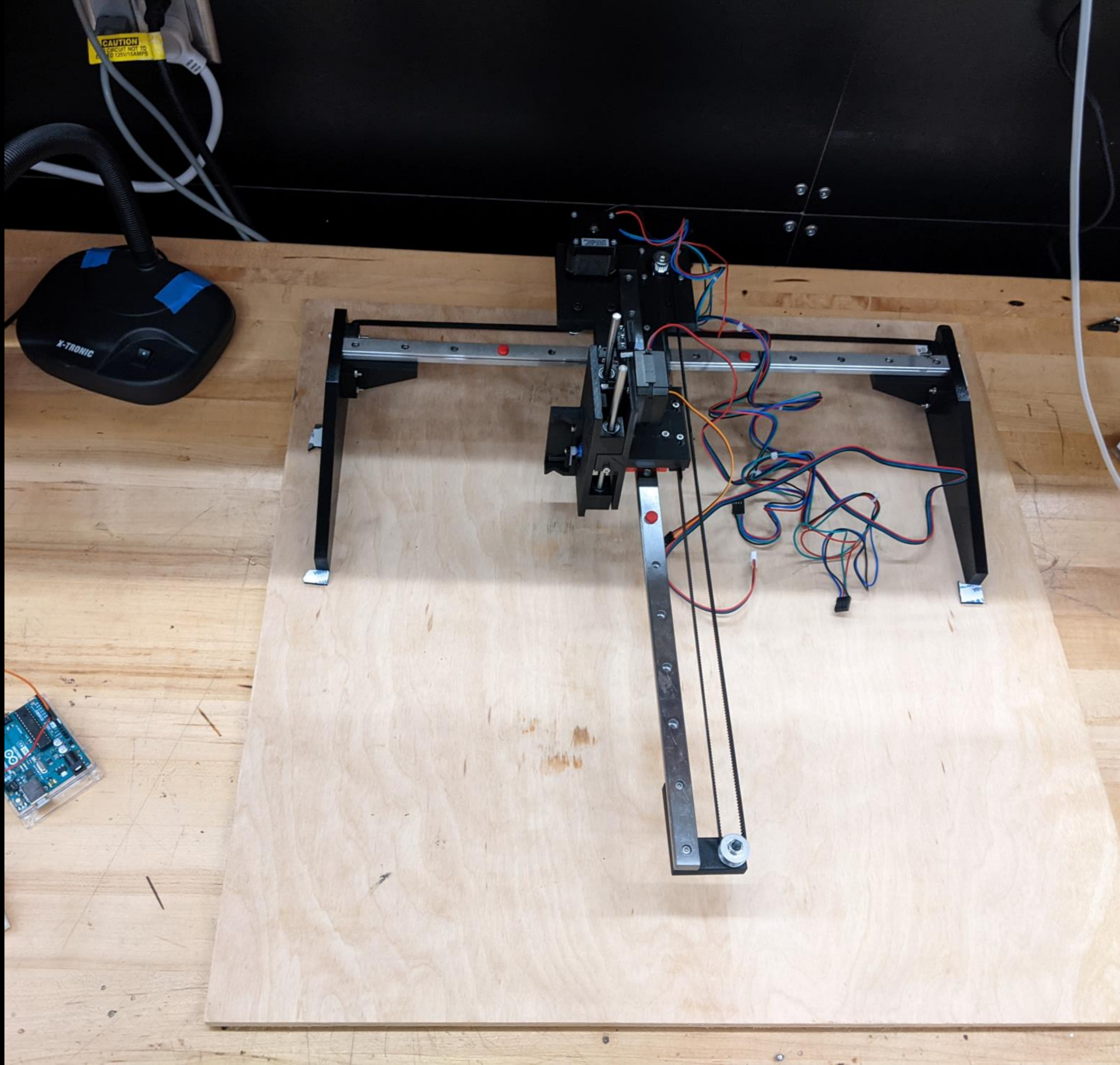
Pen Gripper

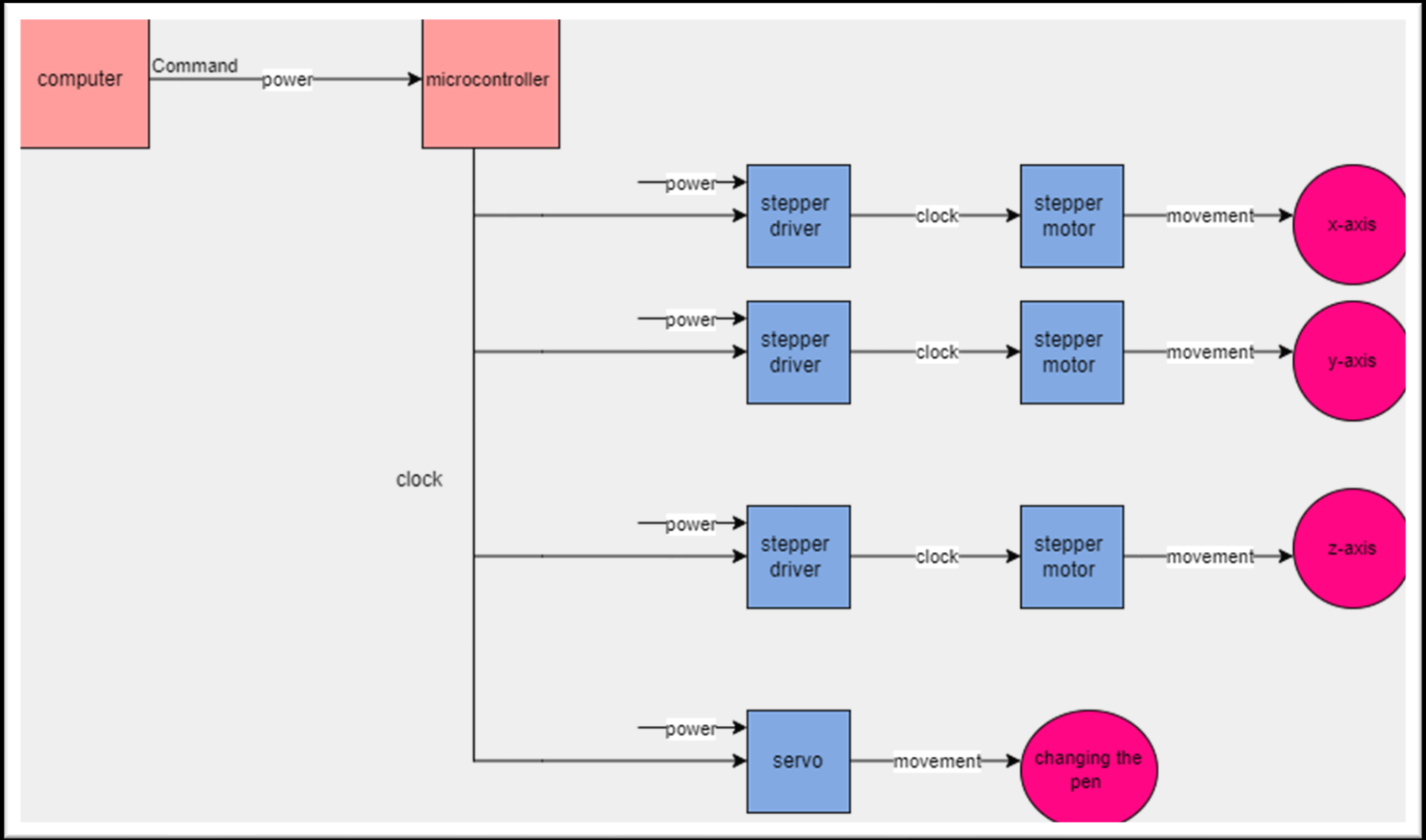
- The pen gripper uses a lever arm to hold the pen against the groove in the plastic
- Possibly raise friction



Remaining Steps

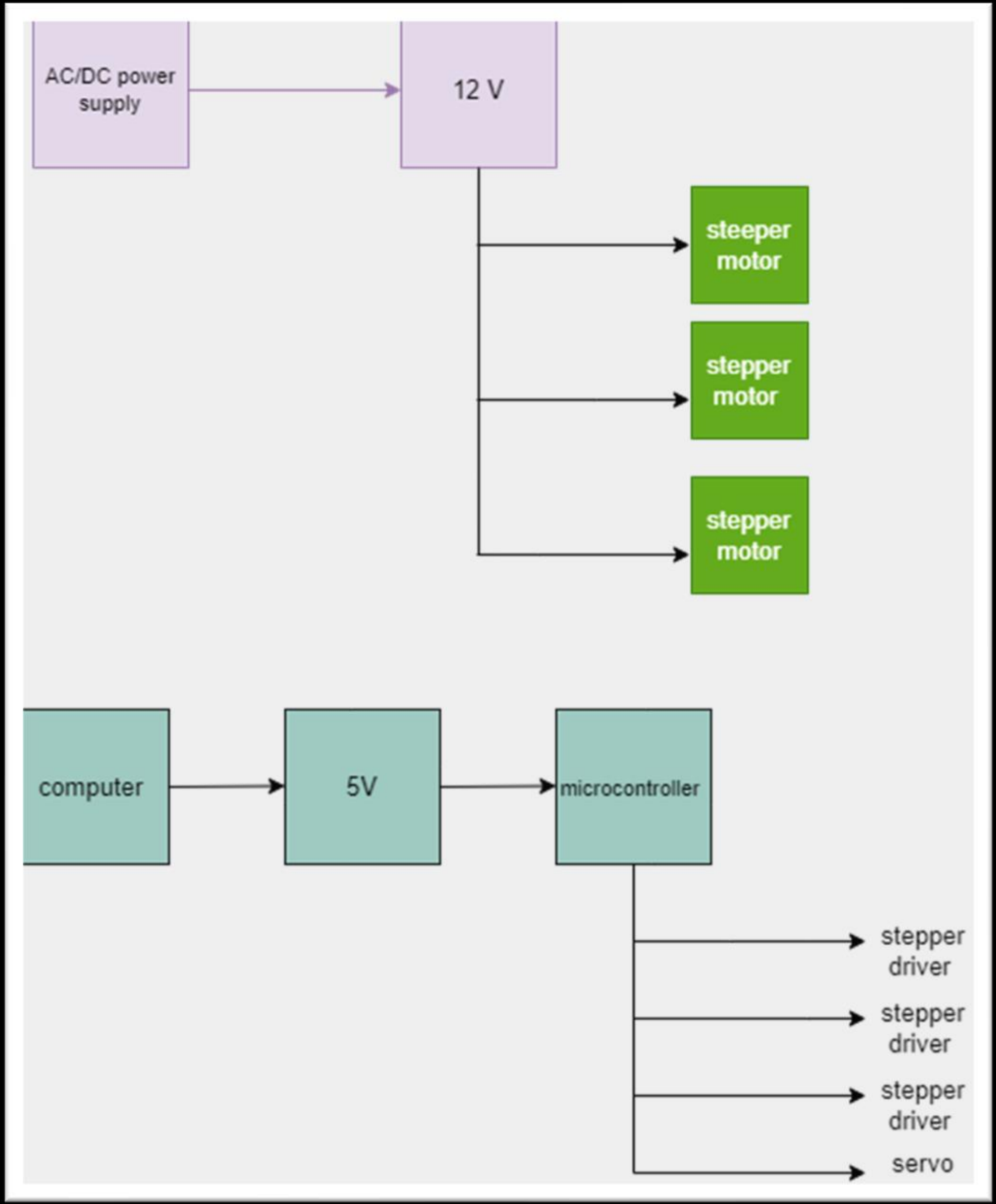
- Cable management
- Limit switches
- PCB attachment
- Paper alignment



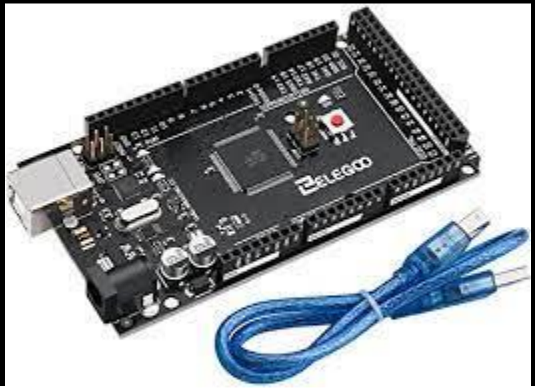


System block diagram:

Power distribution diagram:



Microcontroller:



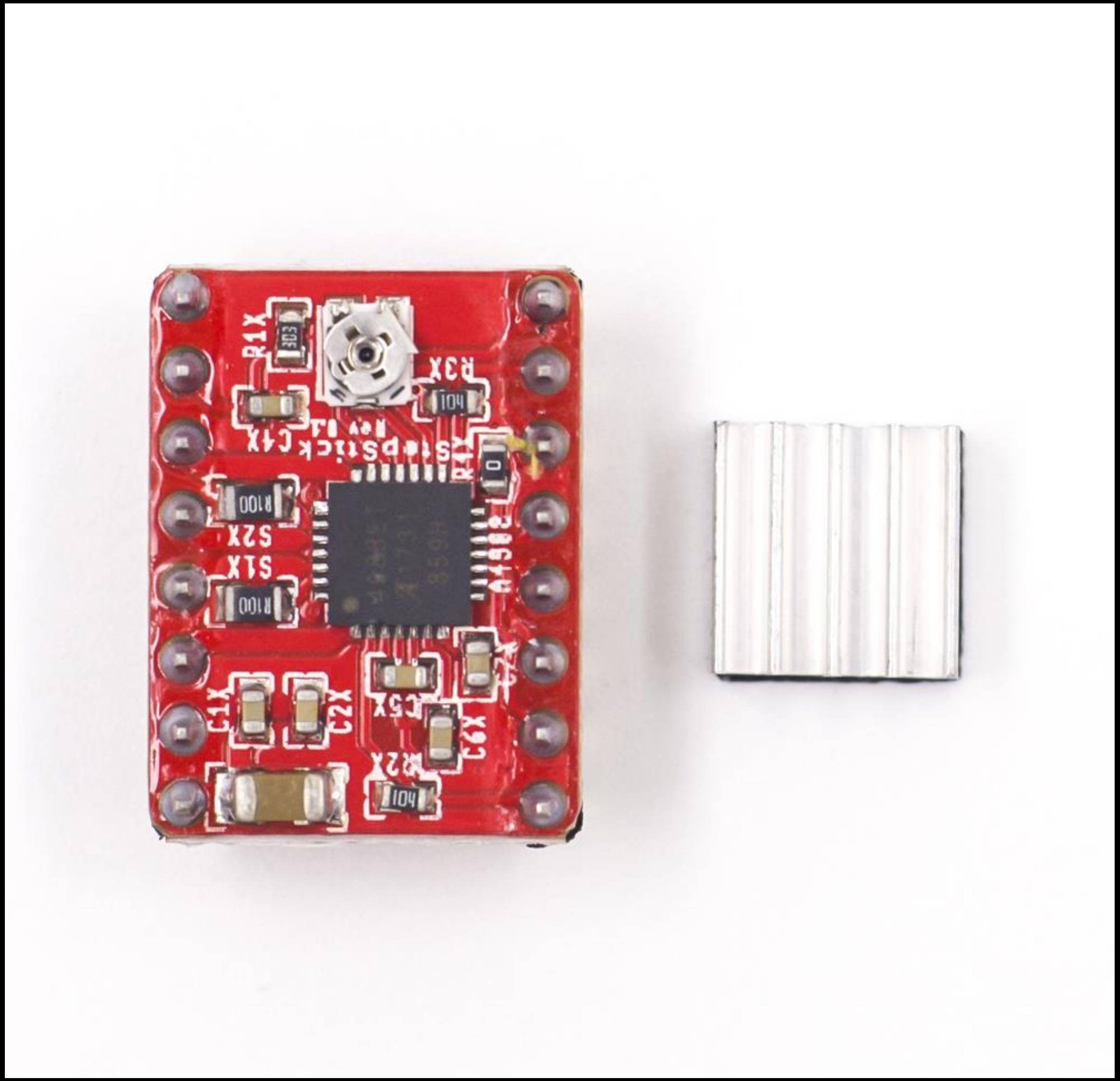
Specifications	Arduino Nano	Elegoo Mega R3
Microcontroller	ATmega328	ATmega2560
Voltage	5V	5V
Flash memory	32KB	256KB
SRAM	2KB	8KB
PCB size	18*45mm	101.52*53.3mm
Price	$19.80	$20

Stepper Motors:

- Used for the movement of the carriage.
- There are several types of stepper motors.(hybrid stepper motor, variable reluctance stepper motor).
- Name 17 stepper:
- Commonly used in 3D printing.
- Higher torque at low speed.
- 1.8-degree step size .
- Torque 45Ncm.

Stepper derivers:

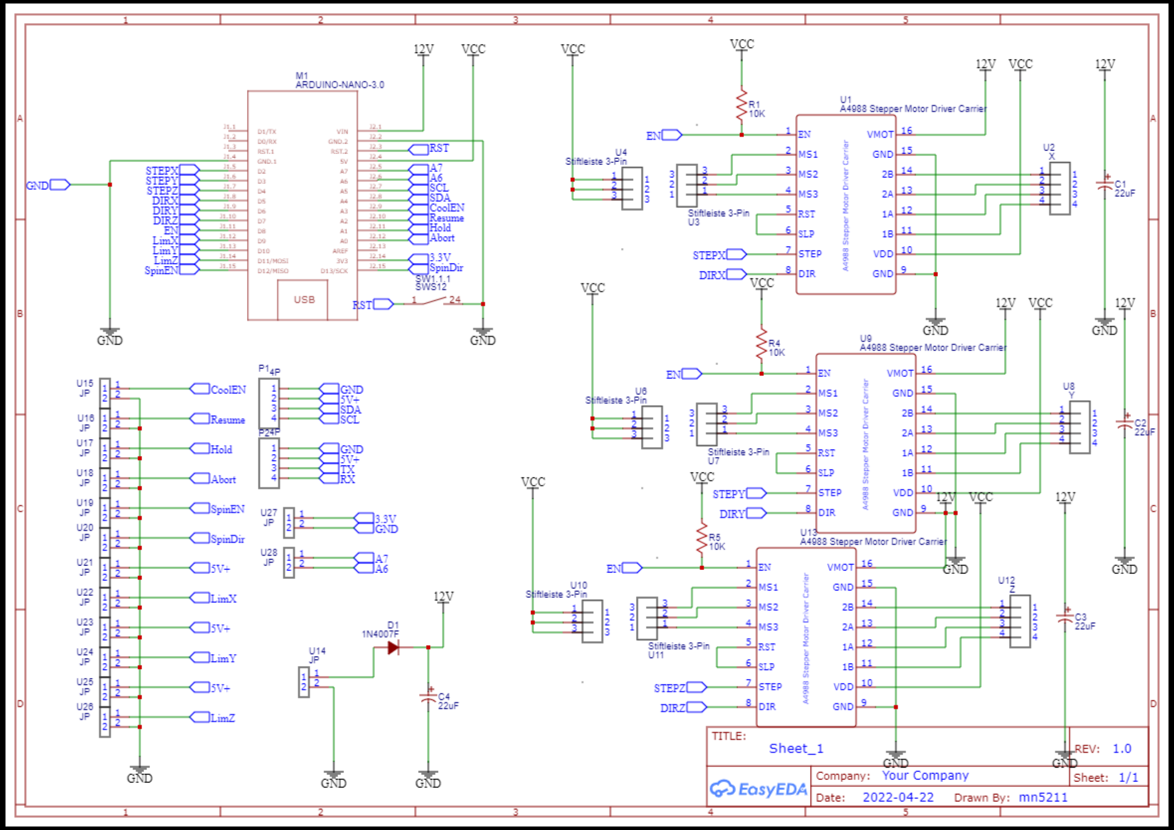
- Provides current required.
- Changing polarity.
- Voltage supply.
- Changing the step size
- Logic supply of 3.3-5V
- It can handle 36V and minimum voltage of 8V.
- stepper drivers. (A4988, STSPIN820…)



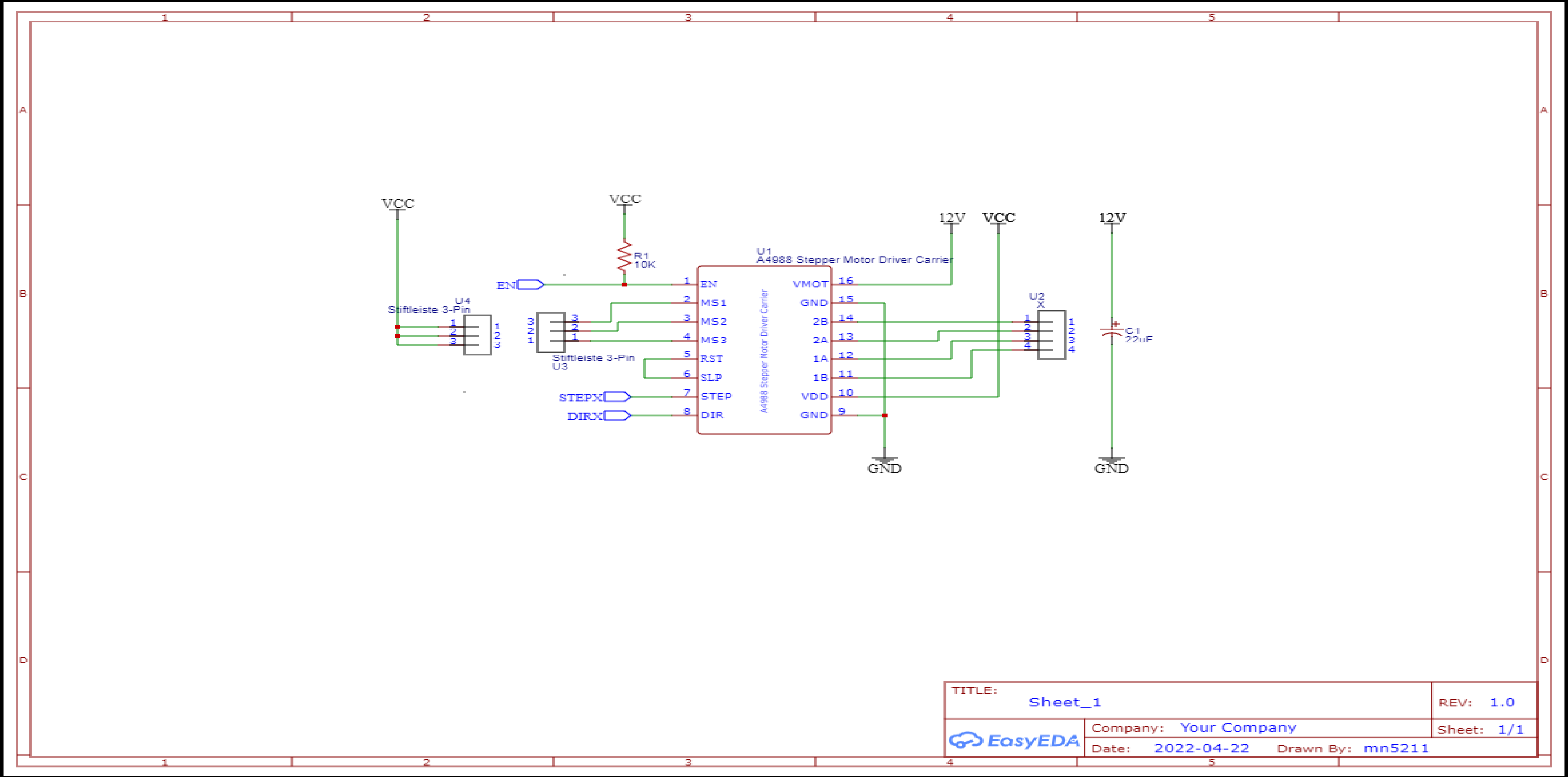
Limit switches:

- Commonly used in moving projects.
- Controls the movement and dimensions.
- prevent any issues that might cause by the moving parts.
- Used in (x-axis, y-axis, z-axis).
- Switches will be connected to the microcontroller.

PCB schematic:



Stepper Driver Schematic:

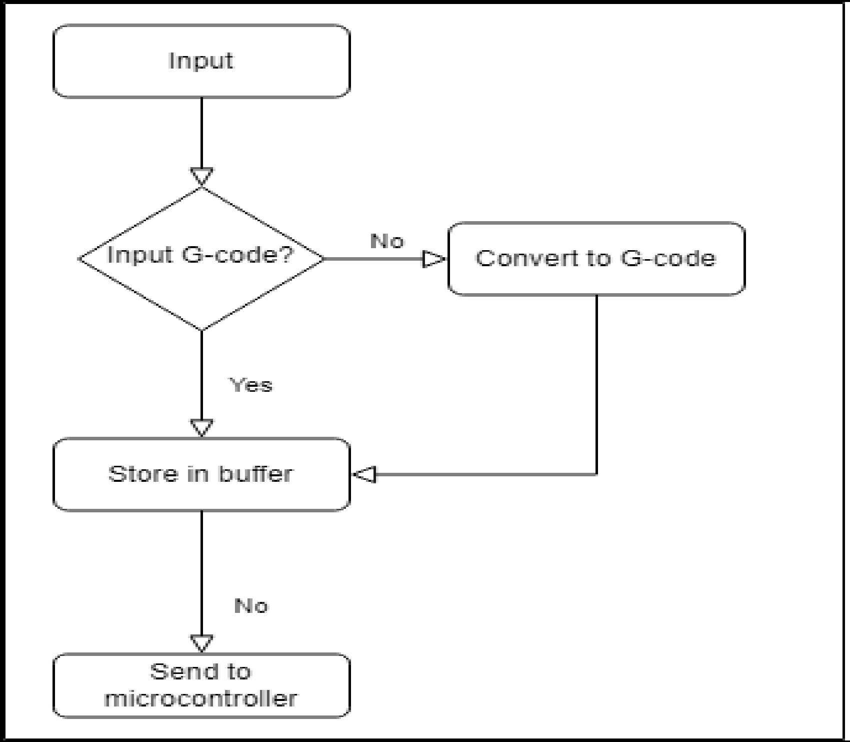


Software

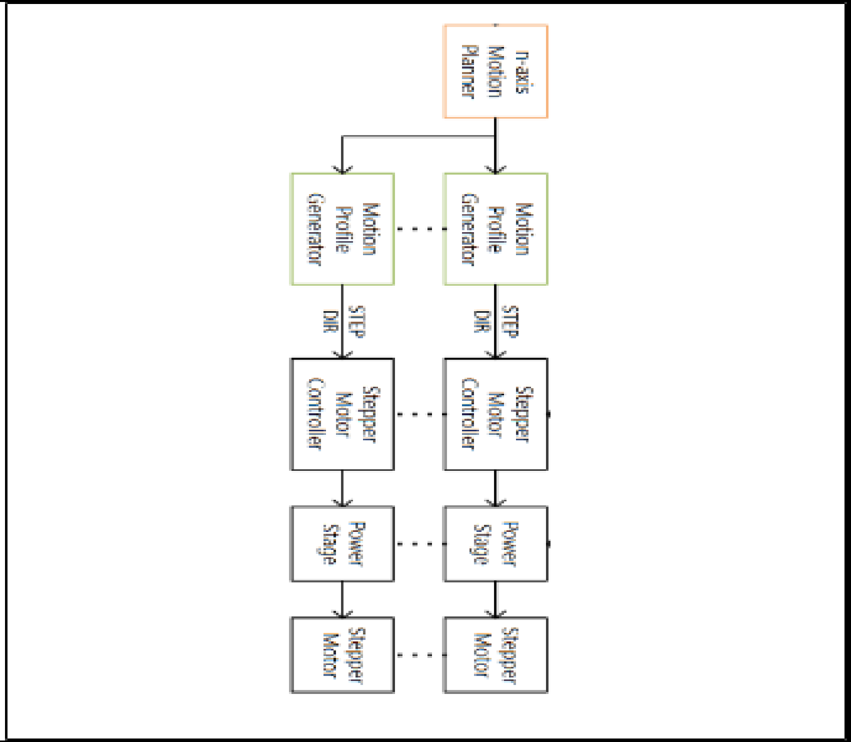
The project requires two different software modules to operate:

- The firmware :
  - It is responsible for motion and controlling the motors
- The control software:
  - Converts graphics into G-code
  - Sends the G-code to the motor-controlling microcontroller

Software Block Diagram



Controller Software



Firmware

What is G-code?

- Geometric-code is a programming language for Computer Numerical Control Machines (CNC)
- The G-code commands instruct the machine where to move, how fast to move and what path to follow.
- An example of G-code structure:
  - G## X## Y## Z## F#

Software Selection

For the firmware, grbl is the industry standard for CNC machines:

- Grbl is an open source firmware
- Used in the industry for motion control
- It takes in G-code as input, interpret and translate them to motion out put
- For our project, we will use a modified version called the grbl-servo

Software Selection

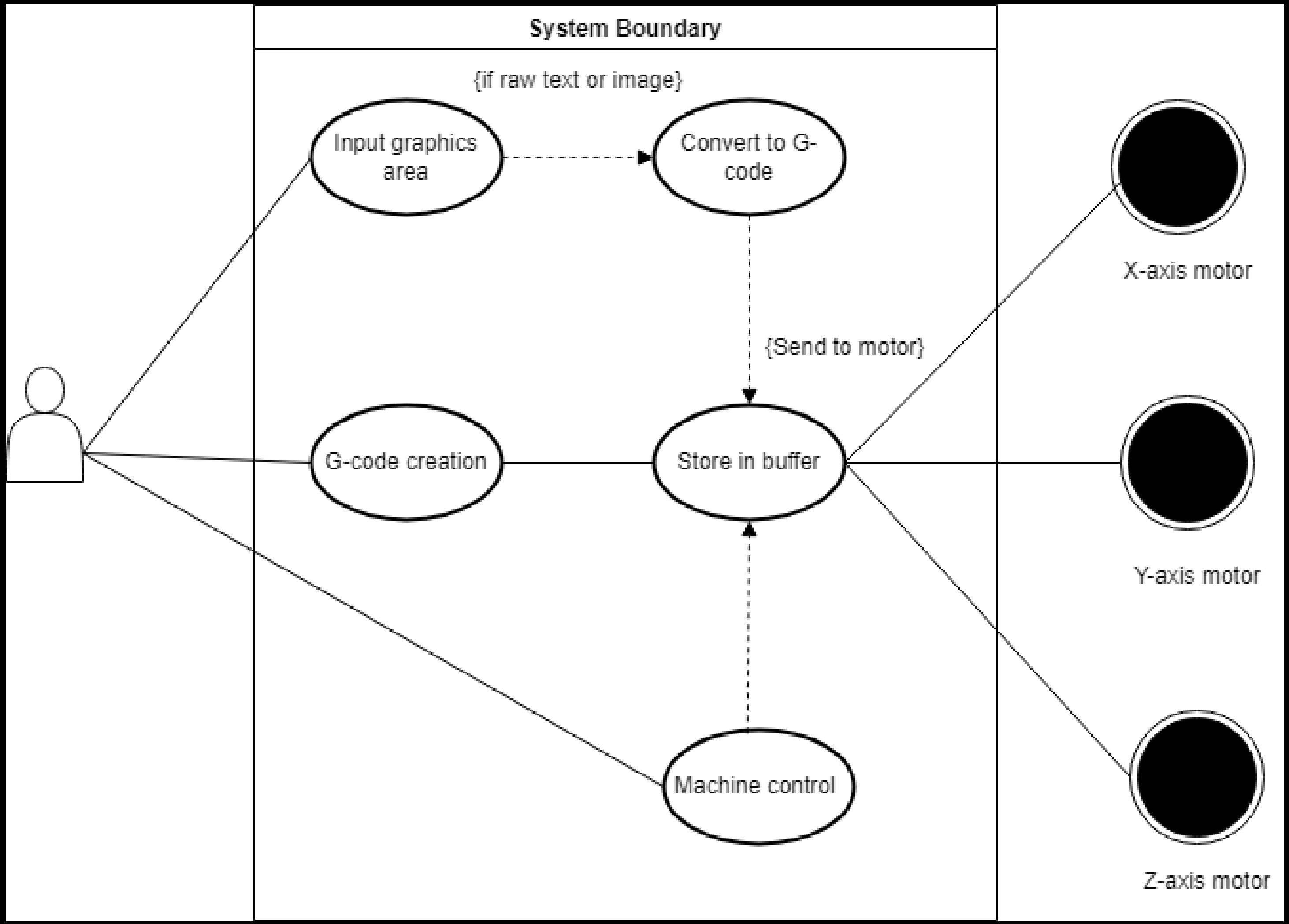
Grbl-plotter is an open source CNC control software

- This software is developed specifically for plotting devices
- It makes room to incorporate a graphics converter
- The graphic converter will be responsible for creating G-code out of inputted graphics

Use case diagram

From the UI of the control software, users can:

- Add raw text or graphics
- SVG files to G-code conversion
- Input and edit G-code
- Control machine variables



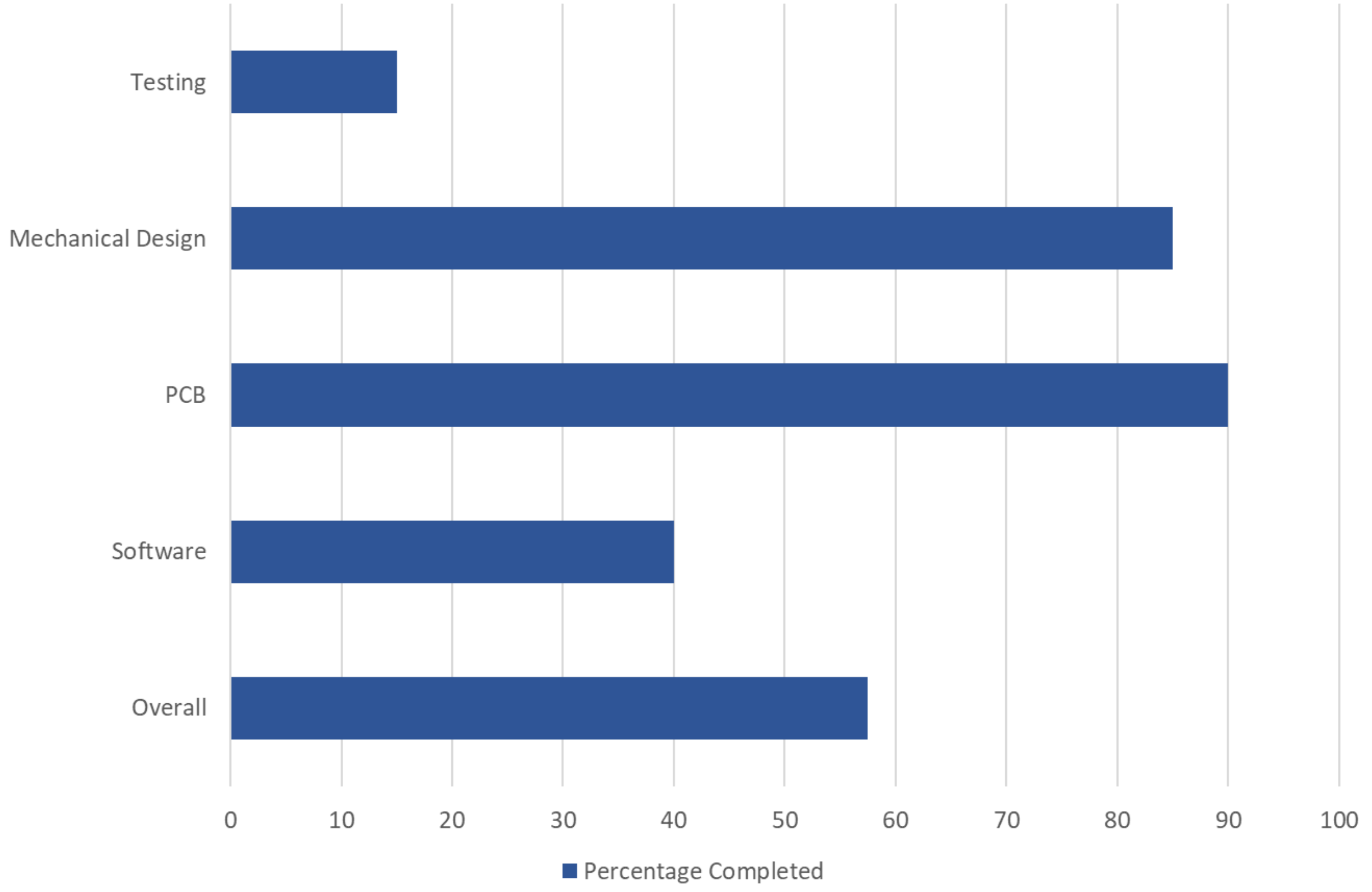
Budget

Part Name	Quantity	Cost
MGN15H Linear Rails	2	$88
Nema 17 Stepper Motors	3	$36
GT2 Belt & Pulley Kits	2	$50
Various bolts and nuts		$40
Linear Rod & Bearings	2 (each)	$20
Various 3D Printed Design Parts	20	$165
A4988 Stepper Drivers	1	$11
Servo Motor	1	$11
Limit Switches	1	$7
DC Power Supply	1	$13
Arduino Uno	1	$23
Arduino CNC Shield	1	$8
Total	$459	

Issues

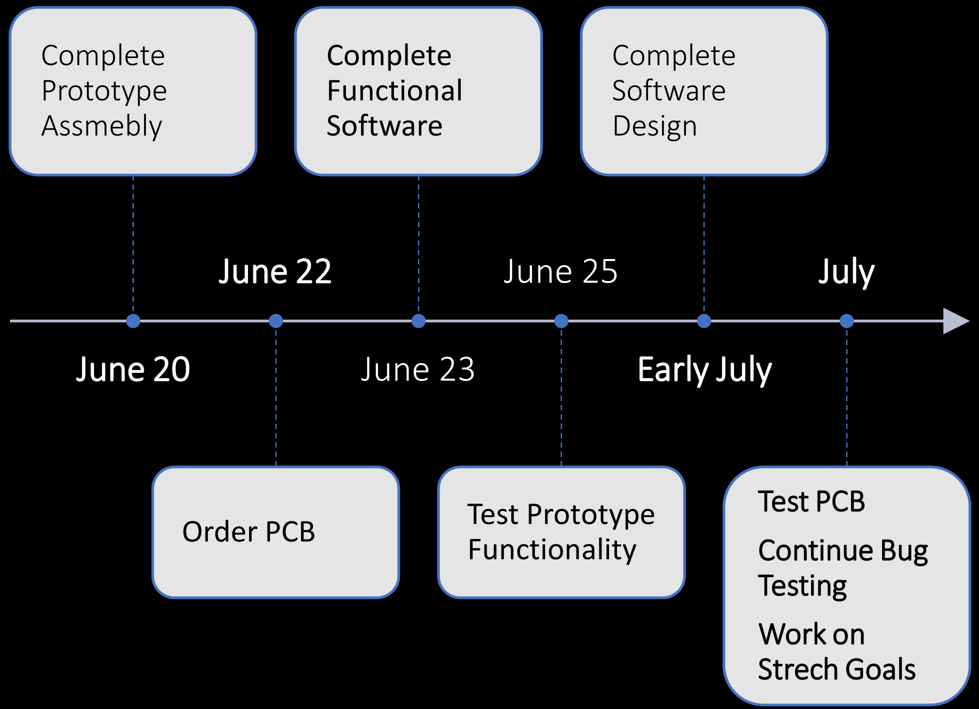
- Certain 3D printed parts not printed correctly.
- Mechanical design needing modifications when assembled.

Progress



Testing
Mechanical Design
PCB
Software
Overall
0
10
20
30
40
50
60
70
80
90
100
Percentage Completed

Milestones


Complete Prototype Assmebly
Complete Functional Software
Complete Software Design
June 22
June 25
July
June 20
June 23
Early July
Order PCB
Test Prototype Functionality
Test PCB
Continue Bug Testing
Work on Strech Goals


Questions?