MEMORANDUM

To: Charlie Refvem, Lecturer, Department of Mechanical Engineering, Cal Poly SLO
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From: Kyle Schumacher

Date: **4/13/2025**

RE: **Term Project Proposal**

Introduction

This project's goal is to create a robot that can play a game of miniature air hockey against an opponent. This project will utilize an STM32 microcontroller on a custom PCB with all major functionality on that PCB. The system will work utilizing a camera connected to a Raspberry Pi with OpenCv to detect the puck. It will then send the coordinates of the puck location to the STM32, which will control 3x stepper to get to the right location to block the shot.

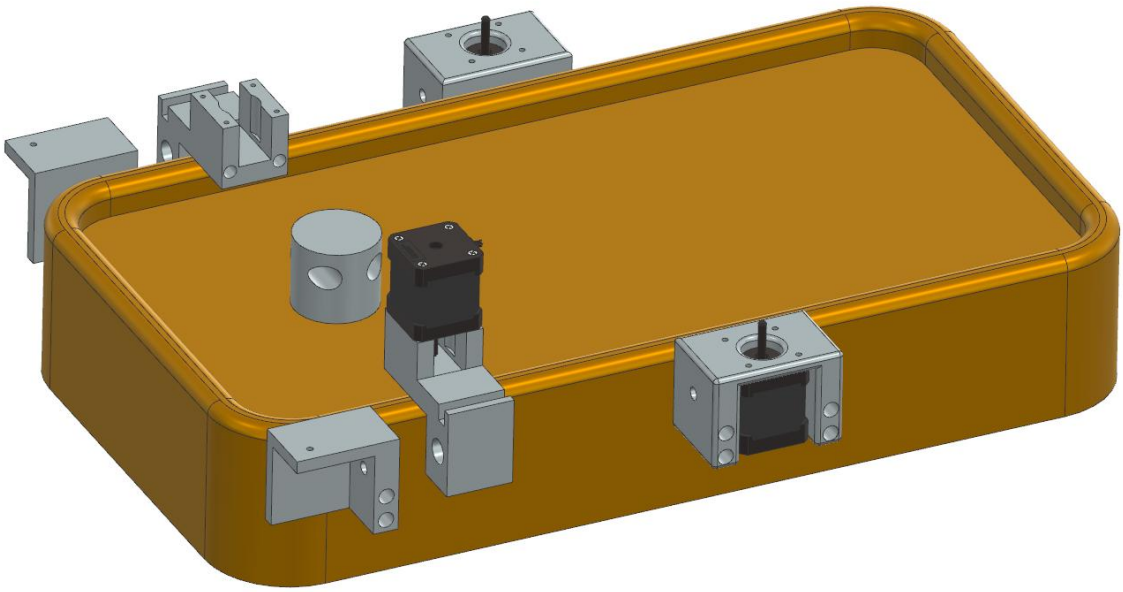


Figure 1. CAD of the air hockey robot

Manufacturing Plan

This robot is primarily constructed using additive manufacturing and basic machining tools available at Cal Poly's on-campus facilities.

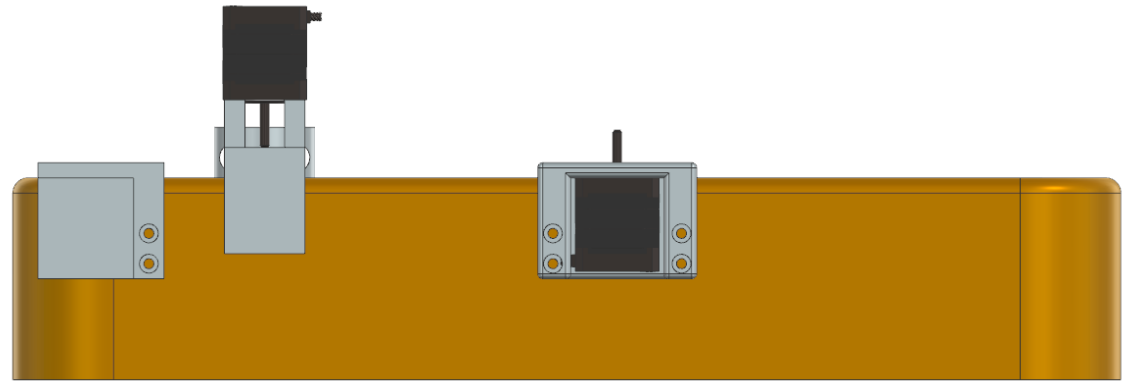
- **3D Printed Components:**
    - All motor mounts, pulley supports, camera stand, and limit switch holders will be printed using PLA on the Cal Poly 60 machine shop printers.
    - 3D prints will have through-holes for linear rod insertion and mounting points for fasteners.
- **Linear Rails:**
    - Purchased pre-fabricated rods.
    - Cut to length using a bandsaw in the machine shop.
    - Press-fit the linear bearings into the 3D printed components.
- **Assembly:**
    - Components will be attached to the air hockey table using wood screws and pre-drilled holes (hand drill).
    - Belts and pulleys installed on the stepper motors and slider carriages.
- **Compliance:**
    - All manufacturing follows safety and size requirements of the competition.
    - No hazardous materials or off-limits processes used.

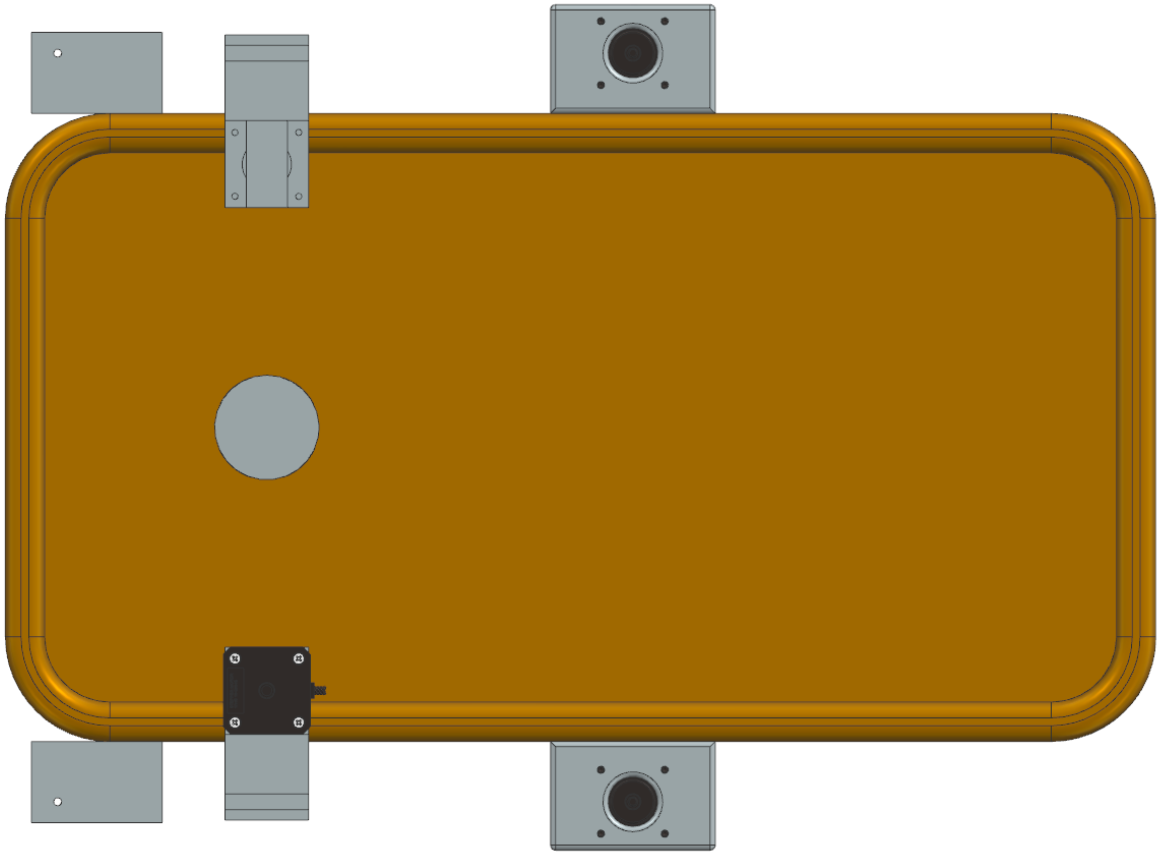
BOM

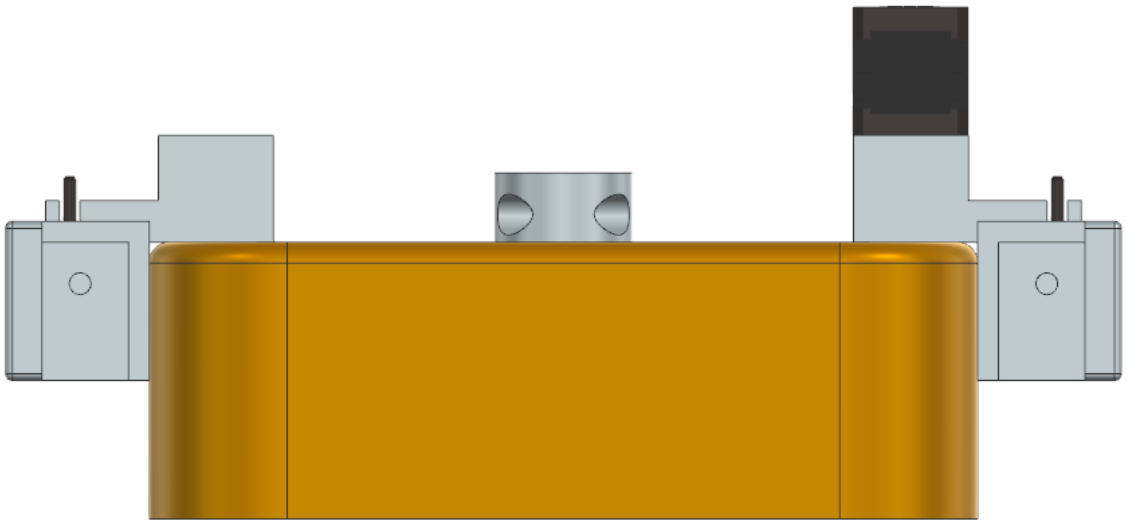
ITEM	QTY	COST	TOTAL
Stepper Motor	3	$ 13.99	$ 41.97
Raspberry Pi Camera	1	$ 12.99	$ 12.99
Raspberry Pi	1	N/A OWN	$ -
Power Cable	1	N/A OWN	$ -
GT2 Belt	1	$ 9.99	$ 9.99
Pulleys	1	$ 13.99	$ 13.99
Linear Rods	2	$ 9.99	$ 19.98
Linear Bearings	1	$ 11.99	$ 11.99
Air Hockey Table	1	$ 42.41	$ 42.41
Limit Switches	1	N/A OWN	$ -

The main electrical components of this build are the stepper motors, raspberry pi, raspberry pi camera, and the limit switches. There are 3x stepper motors to meet the actuator requirement of the project. The inputs are a camera into the raspberry pi, and limit switches to meet the sensor requirements. The mechanical portion of the project uses mostly off the shelf components that are typically used to create 3D printers.

Mechanical Design Drawing

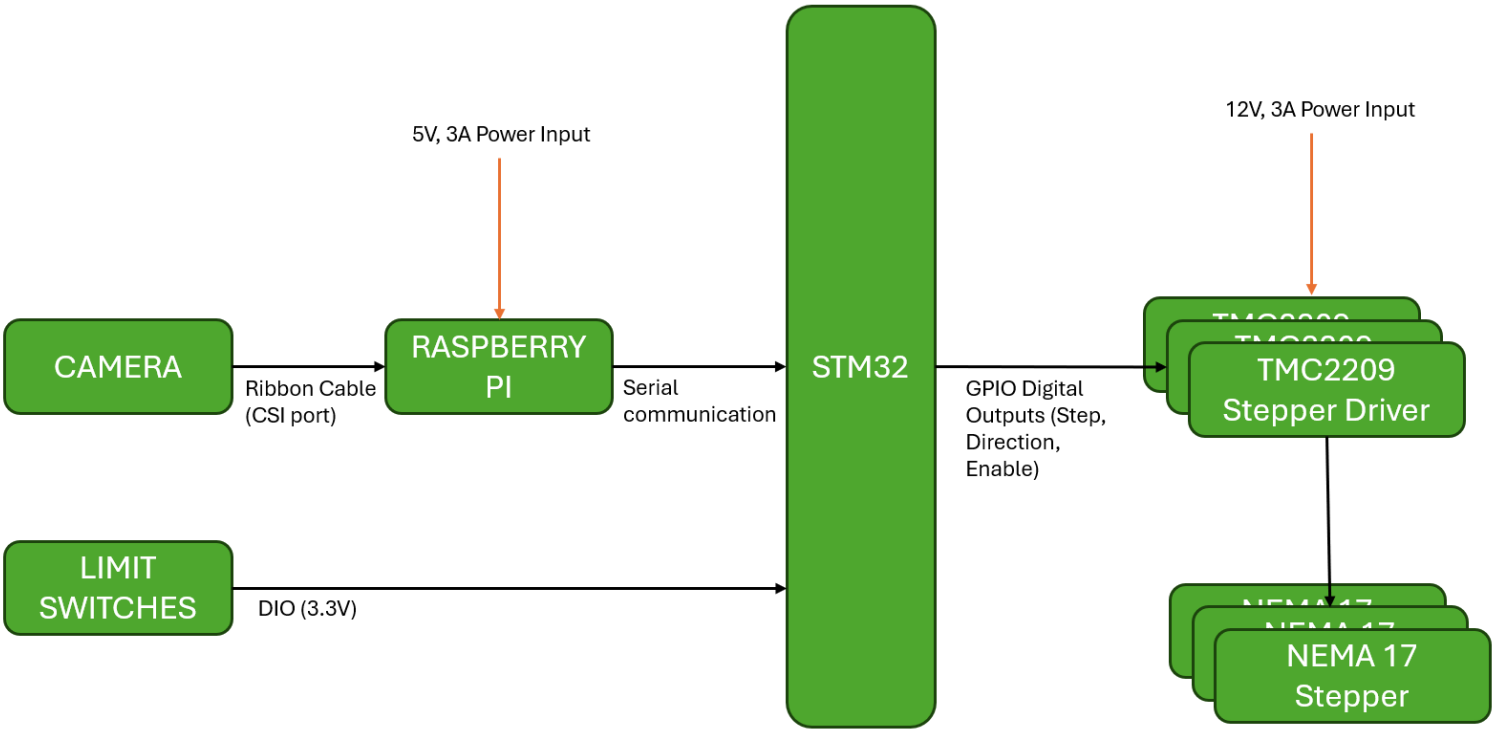






The robot's mechanical design consists of a rectangular mini air hockey table base with three primary linear motion systems. Two stepper motors control X and Y axes via timing belts, linear rods, and linear bearings. A third motor controls the paddle movement along the end effector. Structural supports for motors and sensors are 3D printed. The Raspberry Pi camera is mounted above the playfield for puck tracking. Limit switches are installed at end-stops to prevent over-travel and zeroing of the stepper motors.

High Level Wiring Diagram



Component Selection

This design prioritizes affordability and compatibility. The stepper motors were selected for precise control of the X and Y axis, allowing for fast and accurate puck interception. These are typical motors for use in 3D printers, allowing for vast community support. The stepper motors are easily driven via GPIO pins, and motor drivers will regulate their power needs effectively. The motor drivers were selected as quiet stepper drivers. Most steppers without these can be very loud, so these attempt to make more silent operation.

The Raspberry Pi 4 was selected as I already own this component. The camera was selected to work alongside the Raspberry Pi. I have used the Raspberry Pi with this camera combination before for a similar application but wanted to apply it towards a different project.

The limit switches were selected based on what I already own. These are simple components that allow zeroing of each axis.

All selected components comply with the competition rules, use safe voltages and currents, and fit within the physical constraints of an air hockey table.