Tennis Ball Machine Demonstration Final Presentation

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Agenda

I. Background, Objectives
II. System Overview
III. Design Progression
IV. Mechanical Design
V. Electrical Design
VI. Future Testing
VII. Conclusion

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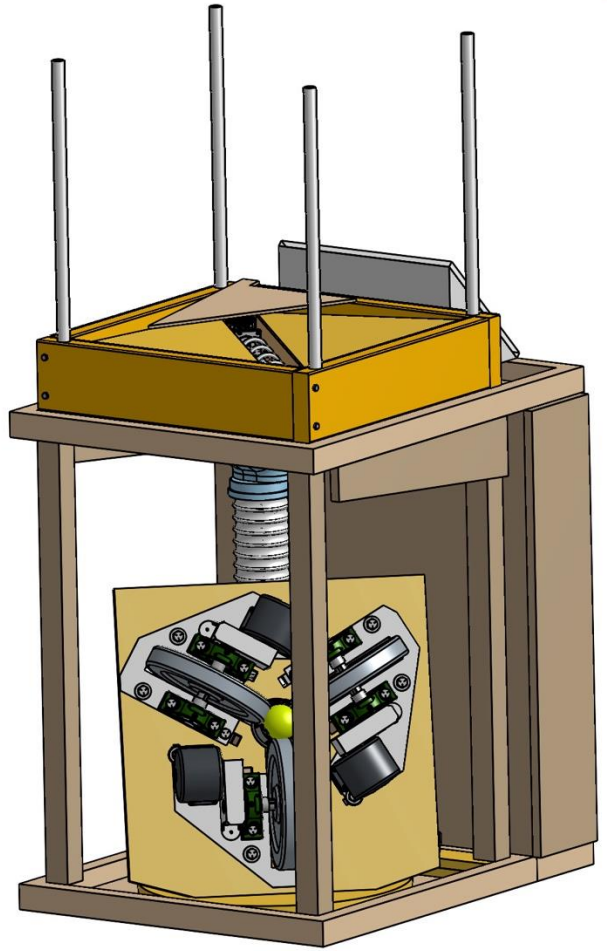
Background

- The tennis machine is an alternative training partner.
- Most tennis pitching machines are two-wheeled mechanism with limited spins.
- We wanted to build a machine that can do the same amount of spins as the baseball pitching machine.

Background (Overall Design Capacity)

- **Objective**: Design a machine that can store 100+ tennis balls for extended practice sessions and overall ease of use.
- **Initial Challenges:** Traditional ball hopper designs make use of rigid walls which reduce overall capacity while increasing weight.
- **Changes Made:** Contrary to traditional pitching machines, we implemented the use of netting to both decrease the weight of the machine while also increasing capacity. This substitution also contributed to a significant reduction in cost.



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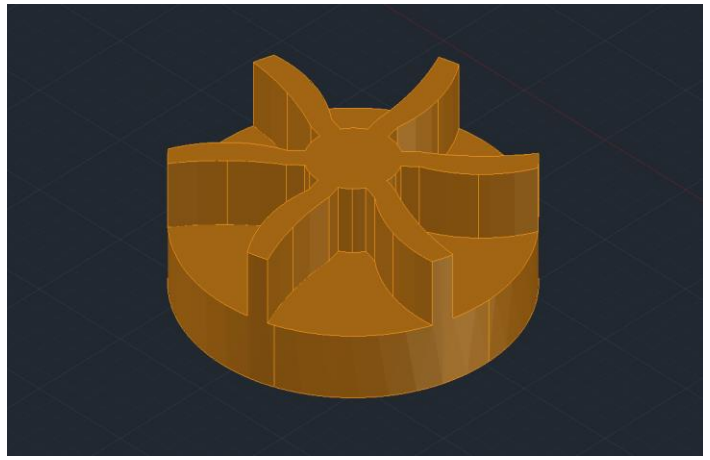
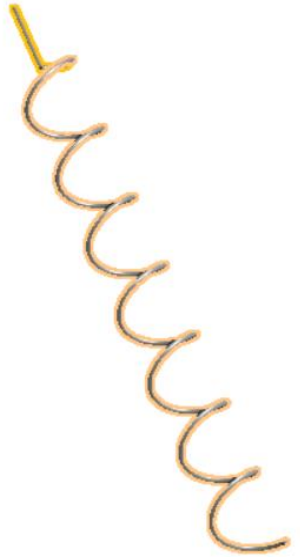
System Overview (Hopper Screw)

- **Initial Concepts:** Many different designs were evalulated for transporting balls from the hopper, the mechanism shown to the right being one of these initial designs is an example of this.
- **Design Used:** An Archimedes' Screw was implemented as it both agitated the balls in the hopper constantly preventing jams, while consistently delivering balls to be pitched.





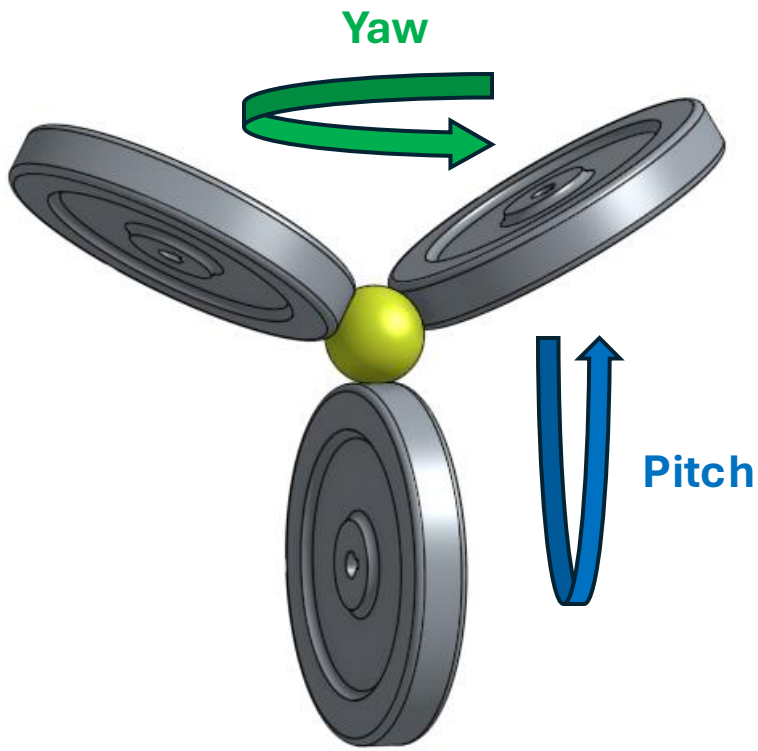
System Overview (Pitching and Aiming Mechanism)

Three-wheel pitching mechanism:

- launch tennis ball at variable speeds and distances (with our maximum speed goal is 80MPH)
- Grip Adjustment between wheels and ball

Aiming mechanism:

- Allow yaw and pitch adjustment for pitching mechanism



3-wheel pitching mechanism

System Overview (Control Panel)

- Speed
  - Velocity at which the pitching mechanism shoots the tennis balls out.
- Pitch Rate
  - The frequency at which the machine launches the tennis balls.
- Oscillation Mode
  - "Side-to-side" movement of the machine, the range of direction.
- Spin Type
  - Flat Spin, Top Spin, Back Spin, Left Curve, Right Curve

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Coupling Design (Hopper)

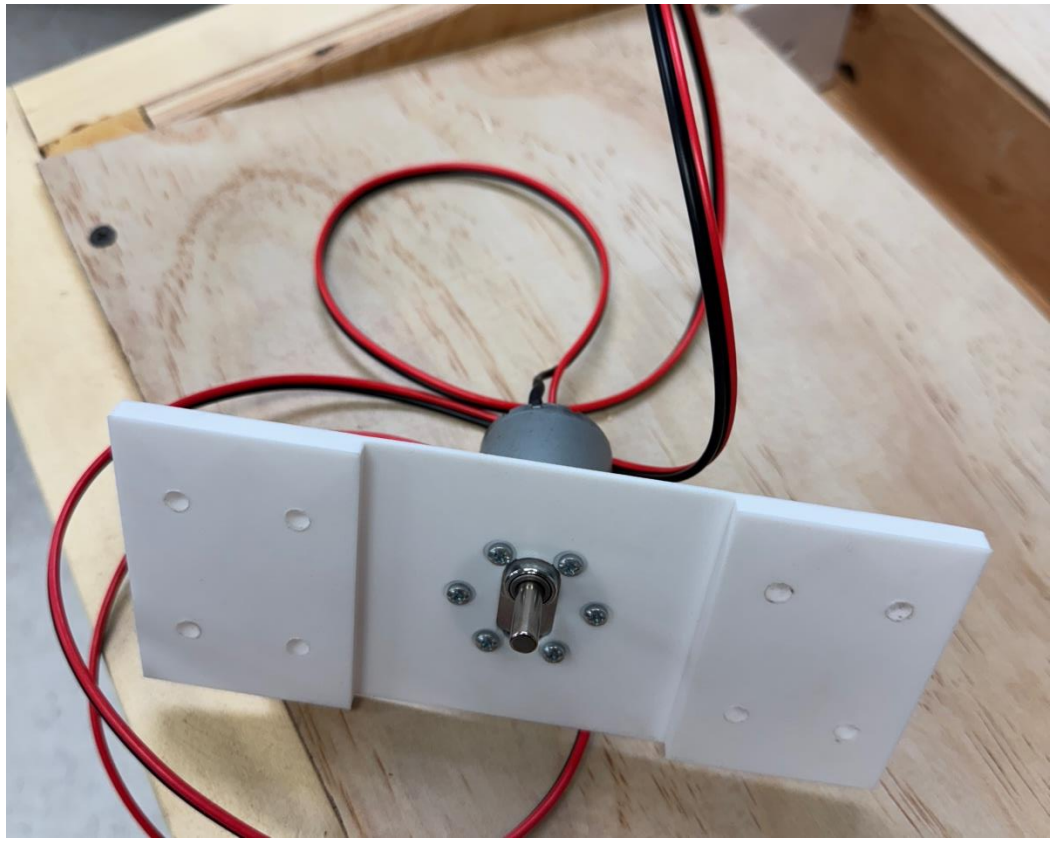
- The coupling design consists of five strategically positioned holes throughout its structure.
- The body includes three holes of identical dimensions, each equipped with threading to ensure secure connections.
- It's important to note that the top and bottom pieces of the coupling have different dimensions tailored to specific requirements.

Coupling Machine (Hopper)

- During the machining process of this component, we opted for steel as our material choice, primarily because it was the only option available at the time.
- We are aware that steel is not only heavy but also presents significant challenges in terms of cutting and threading.
- As a result, the tasks of cutting and creating threaded holes took considerably longer than we had originally estimated.

Motor Selection (Hopper)

- Motor for hopper chosen for application. With the weight of all tennis balls being placed on top of the Archimedes' Screw and it needing to consistently deliver balls to the feeder, a high torque low speed motor was the obvious choice for this application.
- Rated torque of motor is one kilogram-force centimeter, however, using a slower RPM through a reduction in voltage to the motor directly increases the overall torque delivered by the specified motor.



Greartisan 24V Geared Motor chosen for both high torque capabilities and budget.

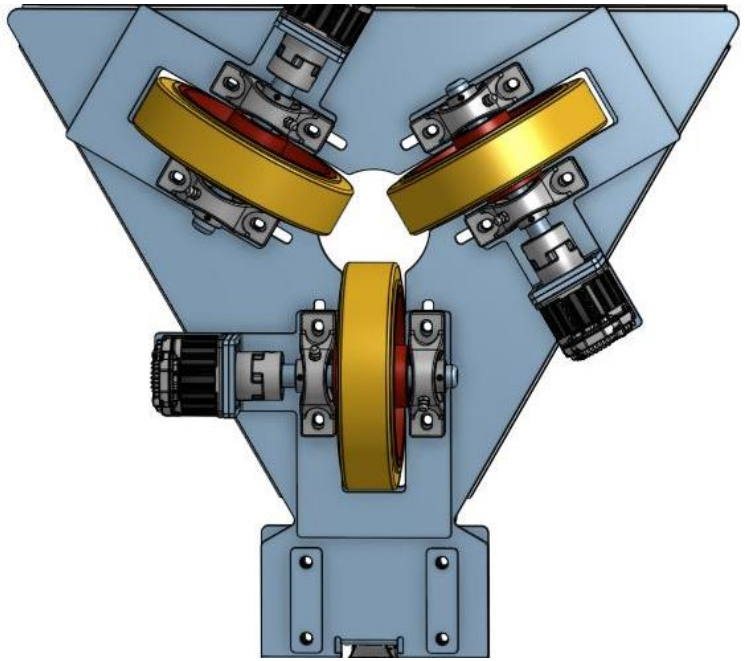
Motor Selection (Pitching Mechanism)

- It is crucial to have the right motor to pitch the ball accurately and can also reduce vibration.
- With a 10-in wheel, the torque is then considered using mechanical analysis to be around 2.5Nm during startup, and then 2.56Nm when the speed accelerating from 1mph to 80mph.
- This leaves with two options for the motors based on our torque and RPM (2000 RPM) needs:
  - CPM-SDSK-3432D-RLN (Teknic)
  - P40-350 Brushed Electric Motor (AmpFlow)

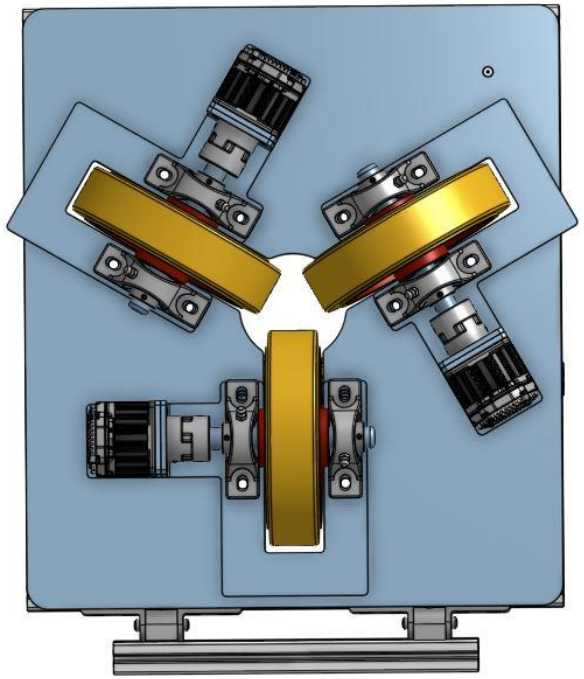
The P40-350 motor was chosen due to the budget.

Pitching mechanism

Initial concept:



Front view of initial aiming mechanism design

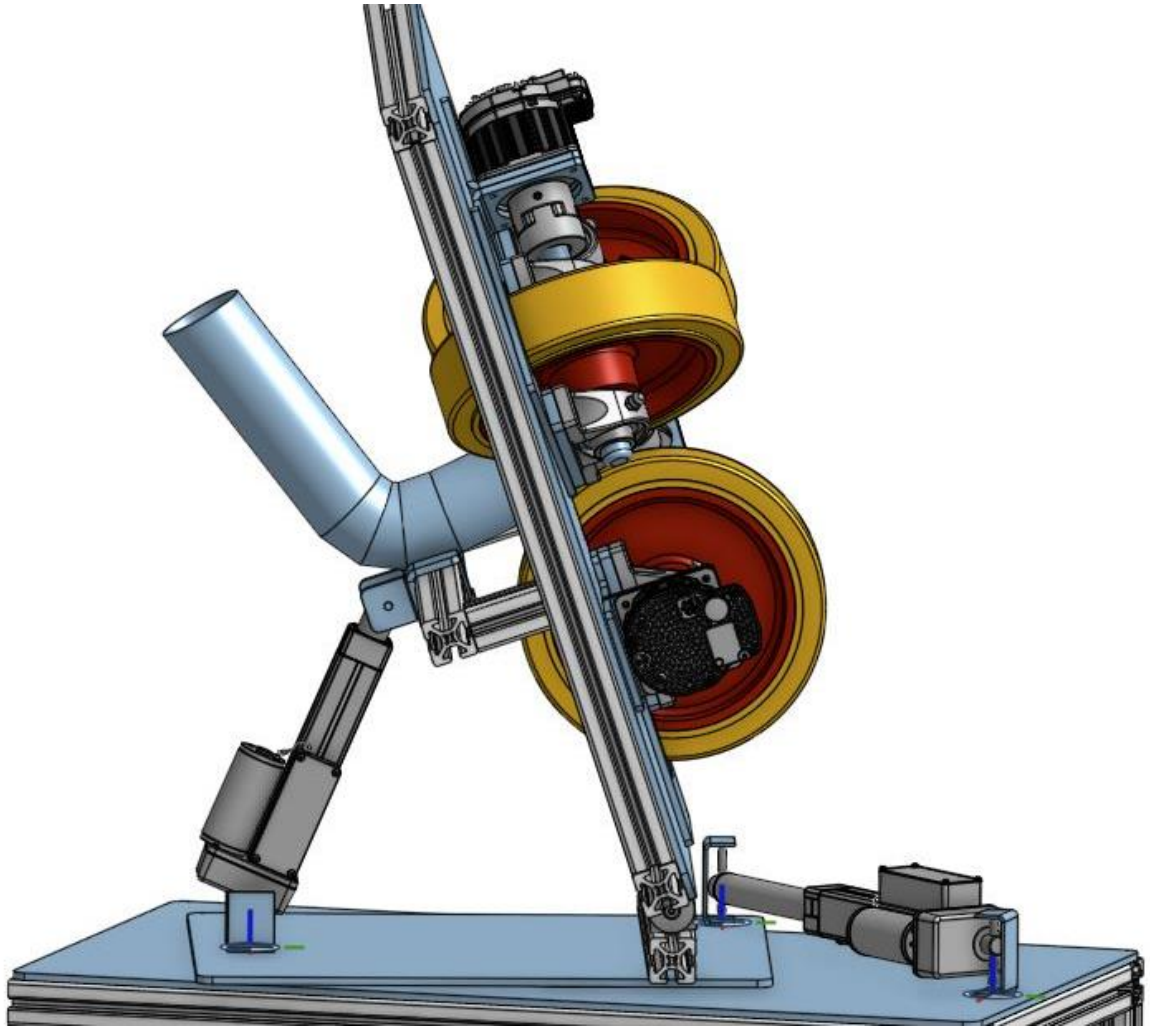


Front view of 2nd aiming mechanism design

Aiming mechanism (yaw and pitch)

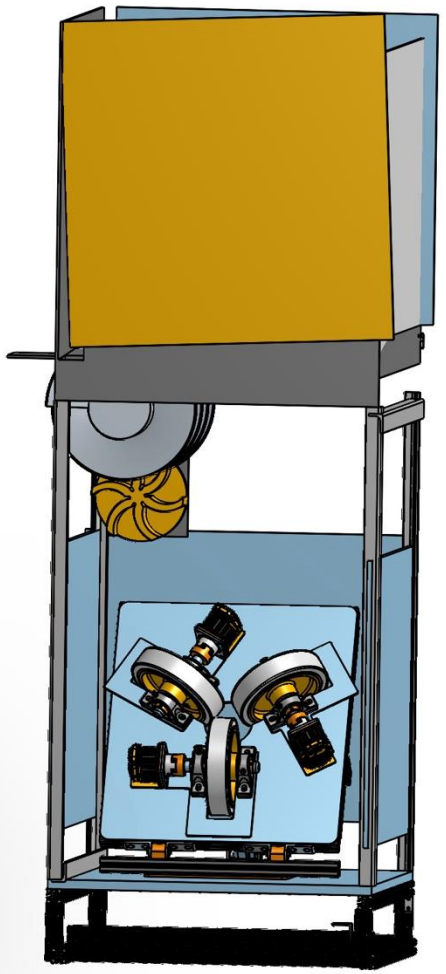
Initial concept:

- 2x linear actuator (6 in stroke)
- Turntable



Side view of aiming mechanism (initial concept)

Housing



- The first design of the housing was based on the initial design of the pitching mechanism and the ball feeder.
  - The L-angles are used for framing while sheets of metal are used for walls
- This ensures that there’s enough space for the pitching mechanism to move, and for the balls to fall down to the aiming mechanism.

Components Interfaced with Microcontroller

- **Motors and Motor Drivers**:
  - Control pitching speed, oscillation, and pitch rate using PWM signals from the Raspberry Pi Pico.
- **Feedback Sensors**:
  - IR sensors detect balls, LEDs to indicate system status (e.g., "Ready," "Error") the beeper for alerts.
- **LCD Control Panel**:
  - Displays settings and status; accepts input via keypad/buttons.
- **Remote Control**:
  - Communicates wirelessly with the Pico to allow play/pause, adjust settings, and toggle oscillation modes
- **Power Supplies**:
  - 36V for motors and actuators.
  - 24V for actuator, ball feeder
  - 5V for control electronics including microcontroller

User Instruction Manual

- **Purpose**: Guide for setup, operation, and maintenance.
- **Key Sections**:
  - Setup instructions.
  - Operating the machine (speed, rate, spin, oscillation).
  - Troubleshooting common issues.
  - Safety guidelines.
- **Highlights**:
  - Diagrams of the control panel and components.
  - LCD message examples.
  - Maintenance tips.

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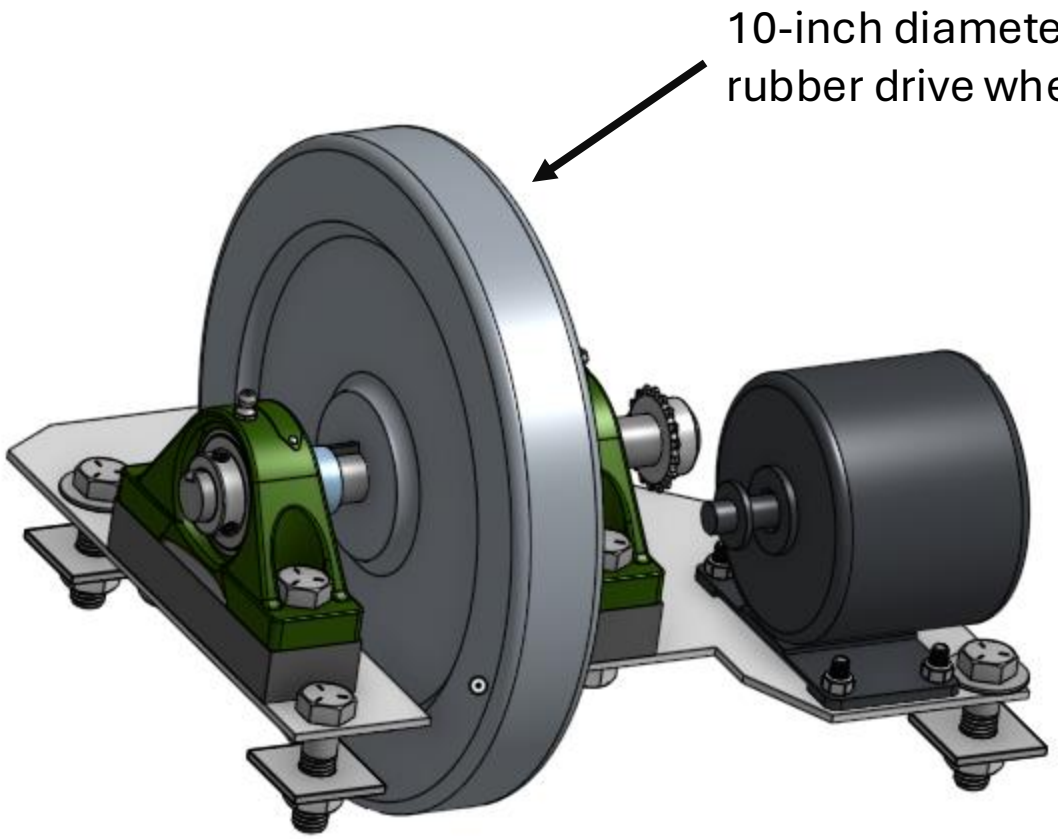
Pitching Mechanism

Motor assembly



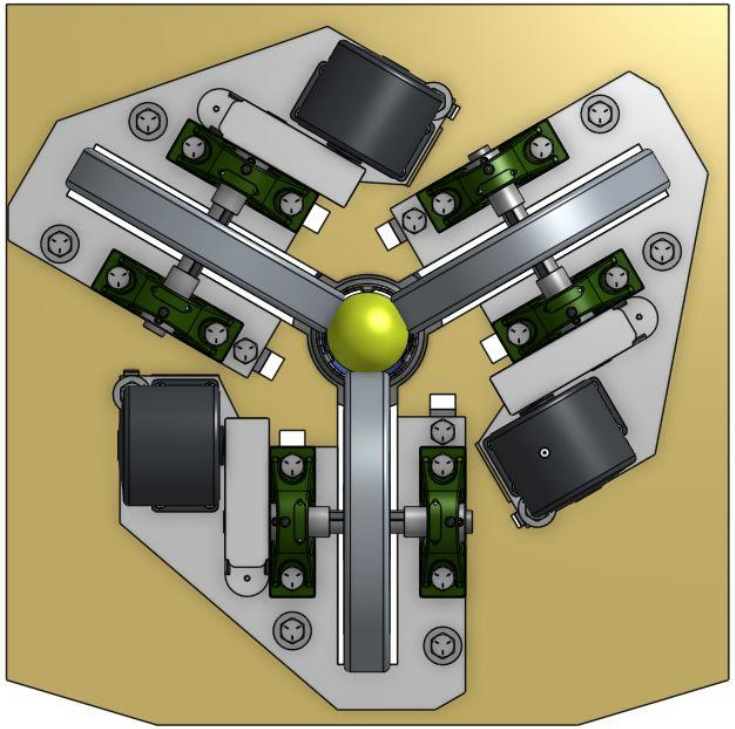
Isometric view of motor assembly

Max RPM:

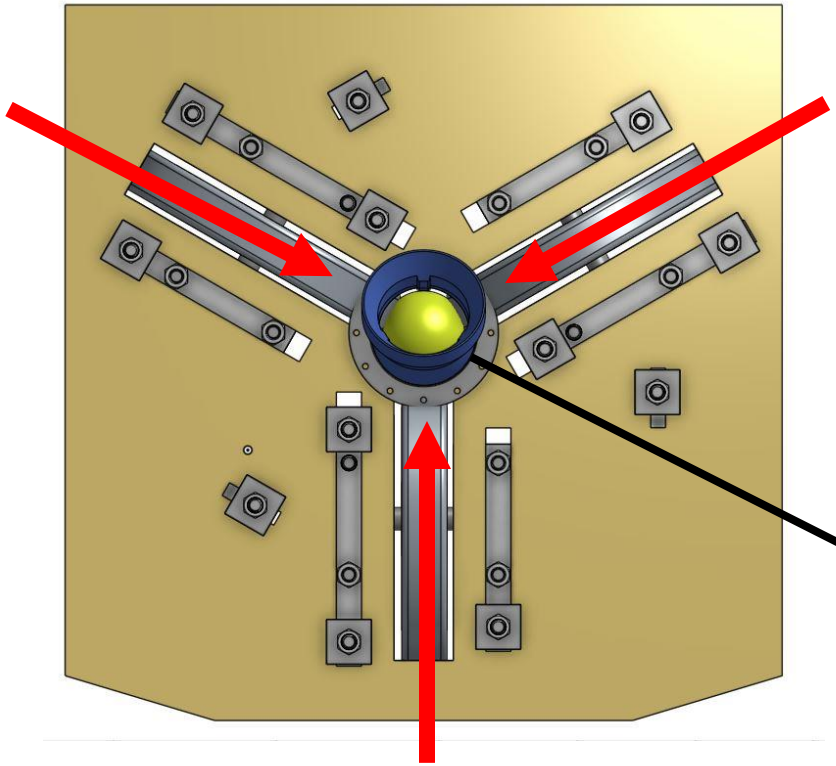
$$\frac{driven\ sprocket}{driving\ sprocket} = \frac{18\ tooth}{11\ tooth} = \frac{3068\ RPM}{5020\ RPM}$$

Max velocity of 10-inch Wheel = 91.3 mph

Pitching Mechanism



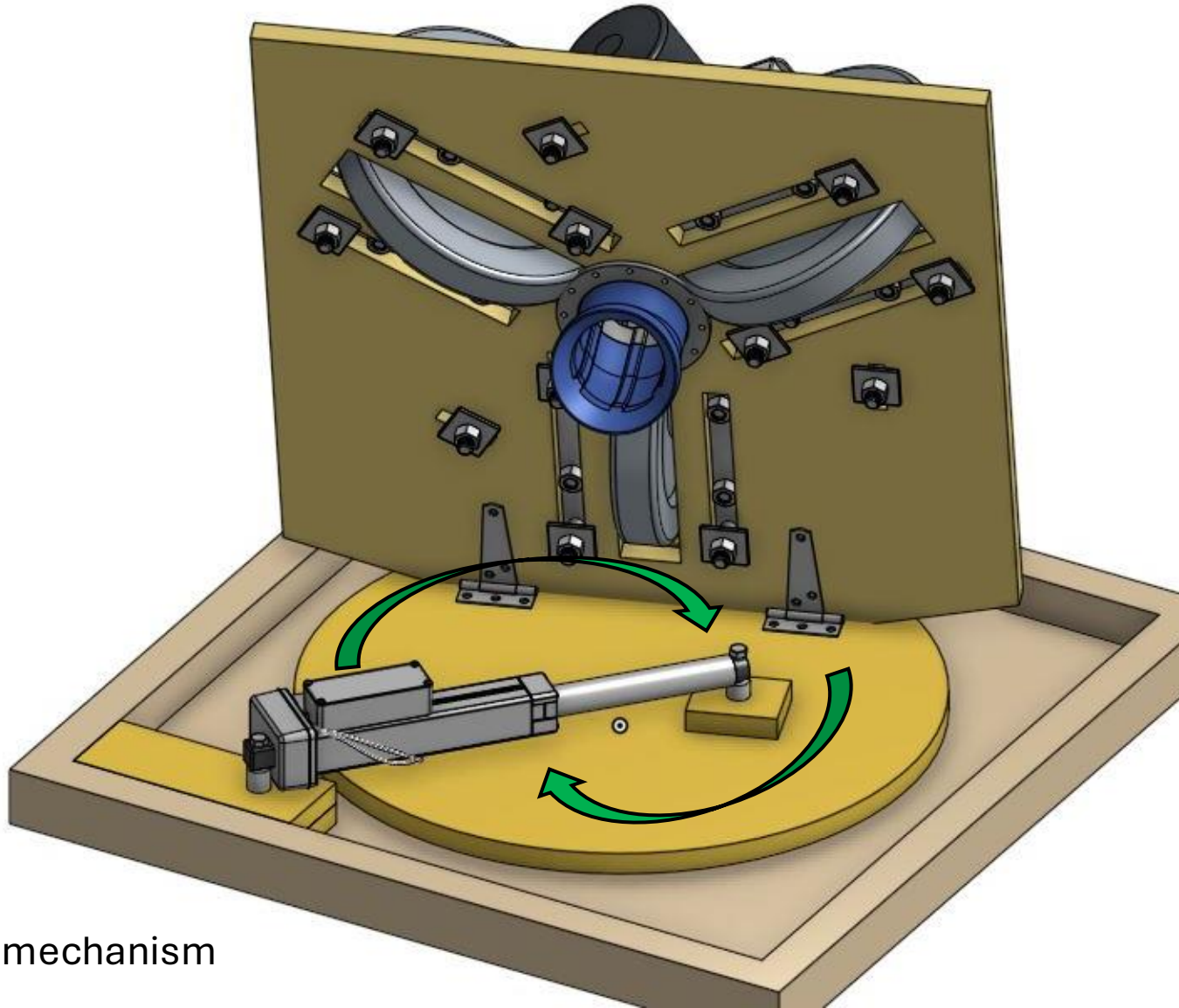
Front view



Rear view

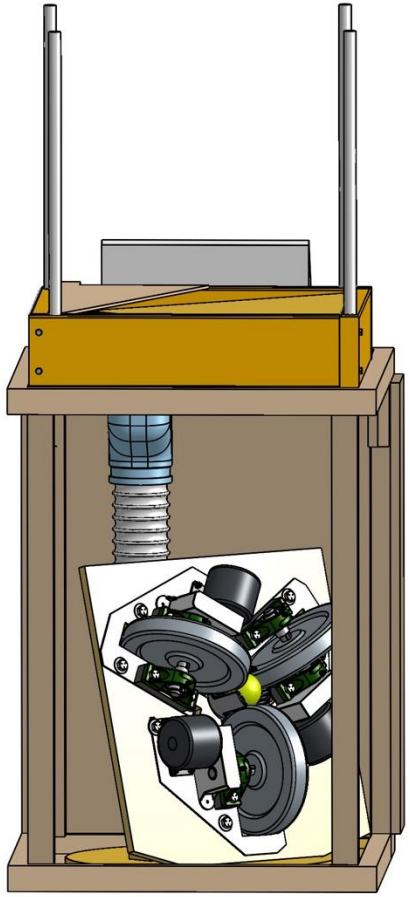
Aiming Mechanism (yaw)

- Yaw mechanism closely follows the initial concept design
- Due to time constraints, pitch mechanism was not able to implemented



Final protype of aiming mechanism

Housing



- The new housing is made entirely of wood due to the metal sheets being too expensive.
  - A space in the back is built for the electronics to be mounted in.
  - The updated housing does not have any walls to ensure that there is maximum space for the pitching mechanism to move.
  - A 3D printed control panel is added on the backside for easy access for the user.
  - The funnel is also 3D printed and attached to a tube to another funnel that is on the pitching mechanism.
  - Major change to the ball feeder.

Ball Dynamics

- With our 3-wheel design, we will be able to create different ball pitches that fits the needs of tennis players.

- The types of pitches that our machine will additionally have is a flat throw, top spin, back spin, left curve and a right curve.

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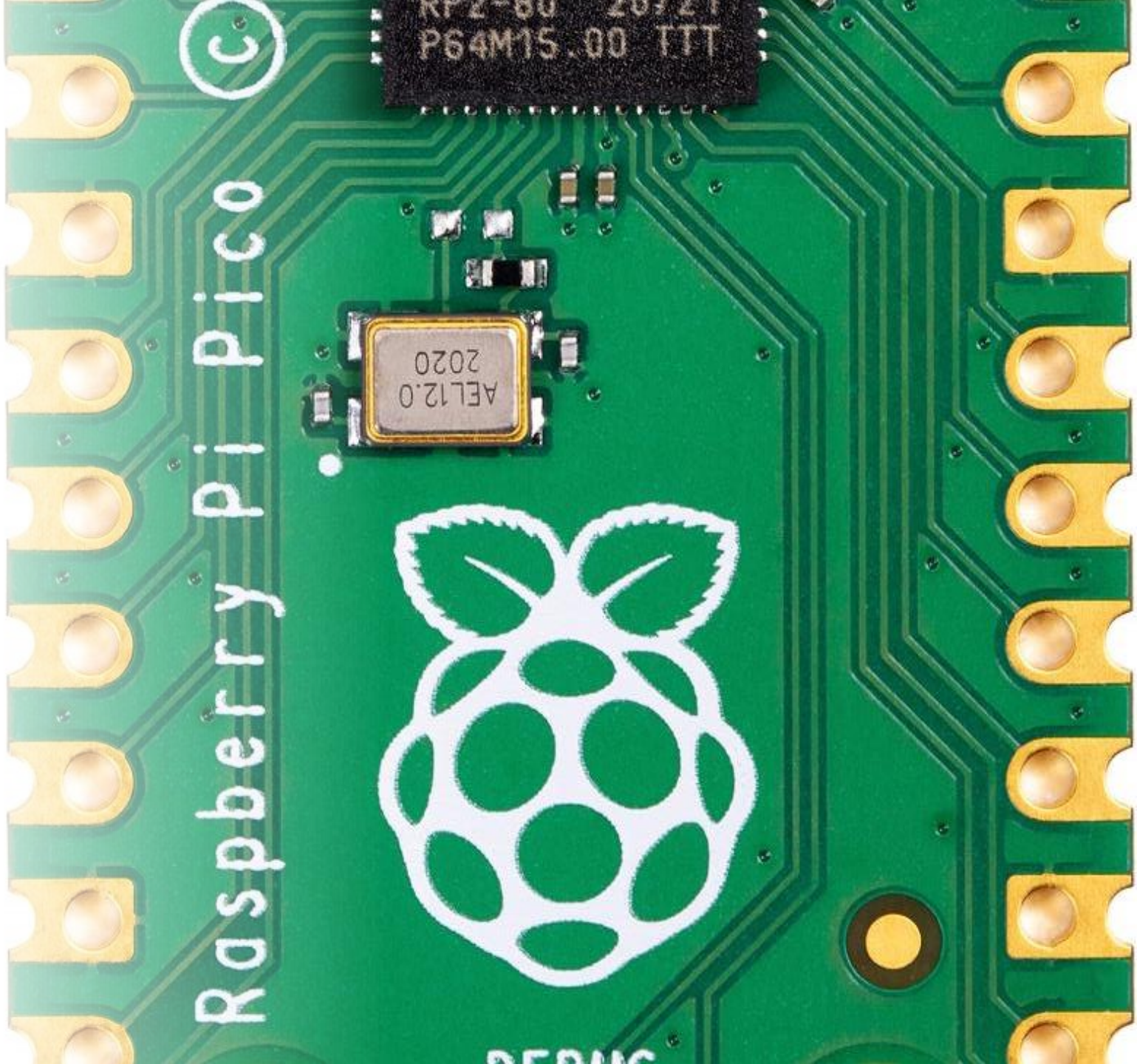
Control System

- Purpose
  - Manage all machine functions (the brain).

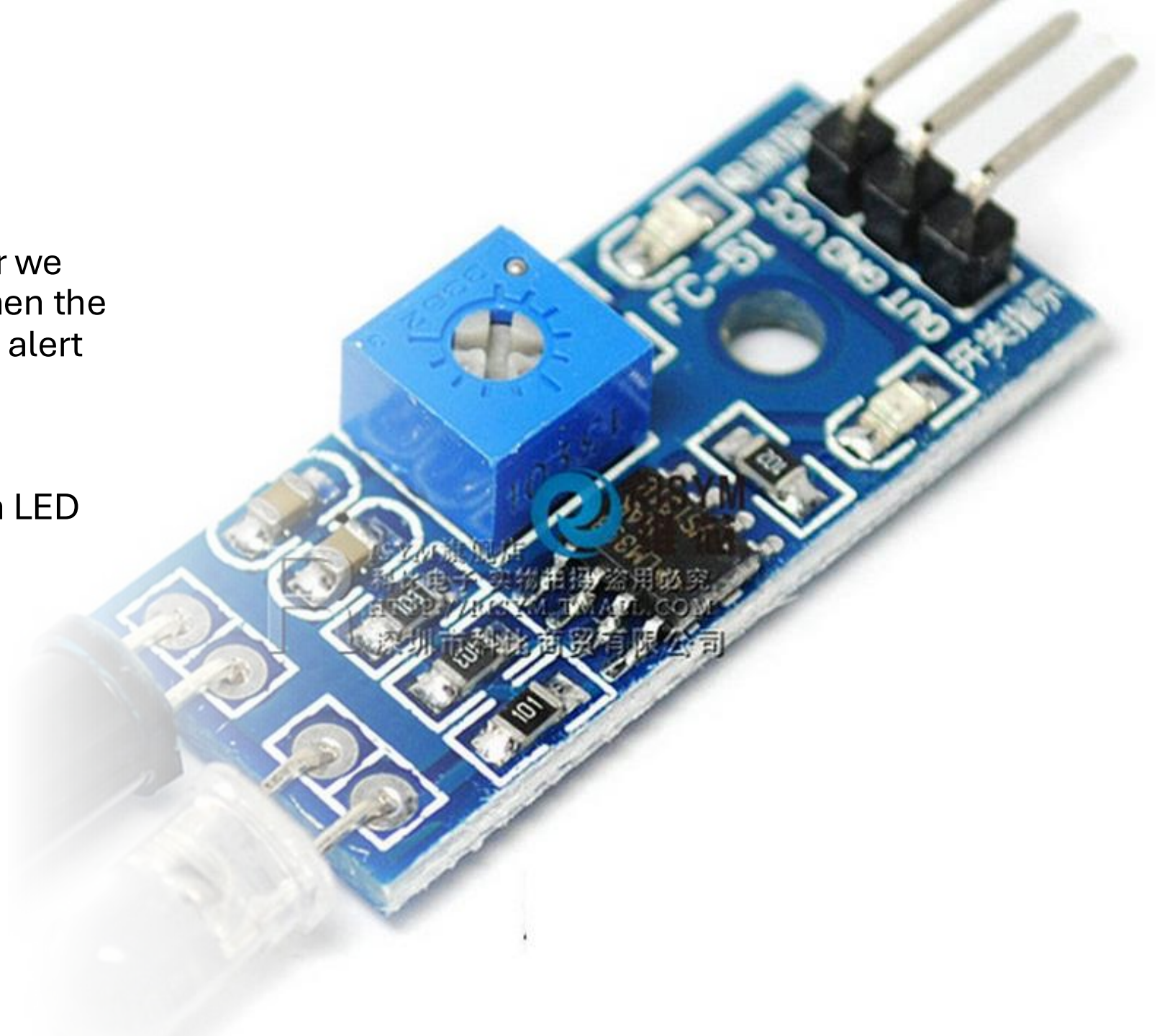
- Components
  - Microcontroller
    - Raspberry Pi Pico
  - Input Devices
    - Potentiometers
    - LCD Display
  - Wireless Receivers
    - Remote Control



Sensors

- Using a proximity sensor we will be able to detect when the ball feeder is empty and alert user.

- User will be alerted via a LED and a buzzer sound.



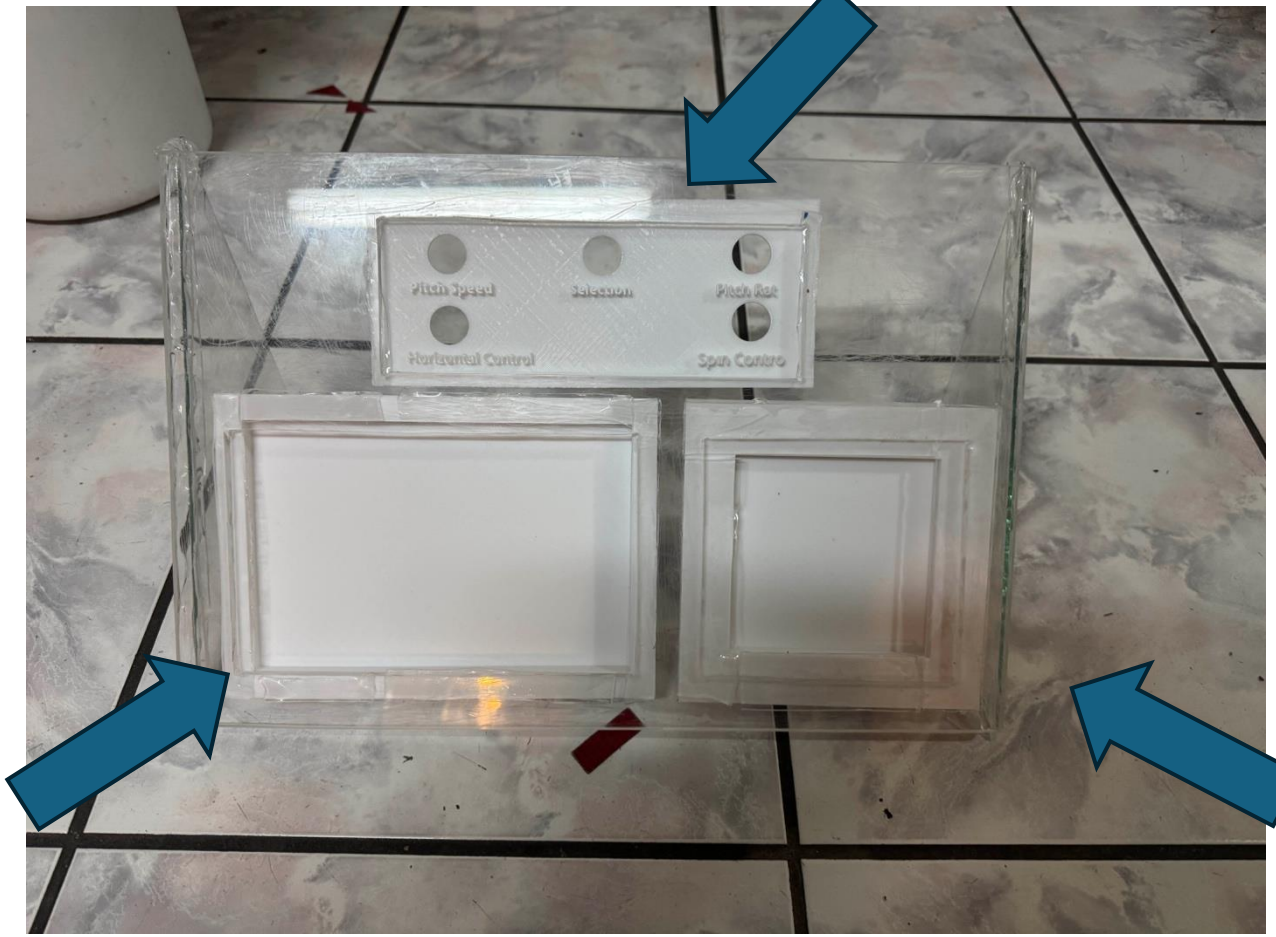
Remote controller

- Using a remote we will be able to control the pitch speed of our machine.

- We will also be able using our controller to be toggle our machine to stop or start pitching balls.

Control Panel

Control Plate



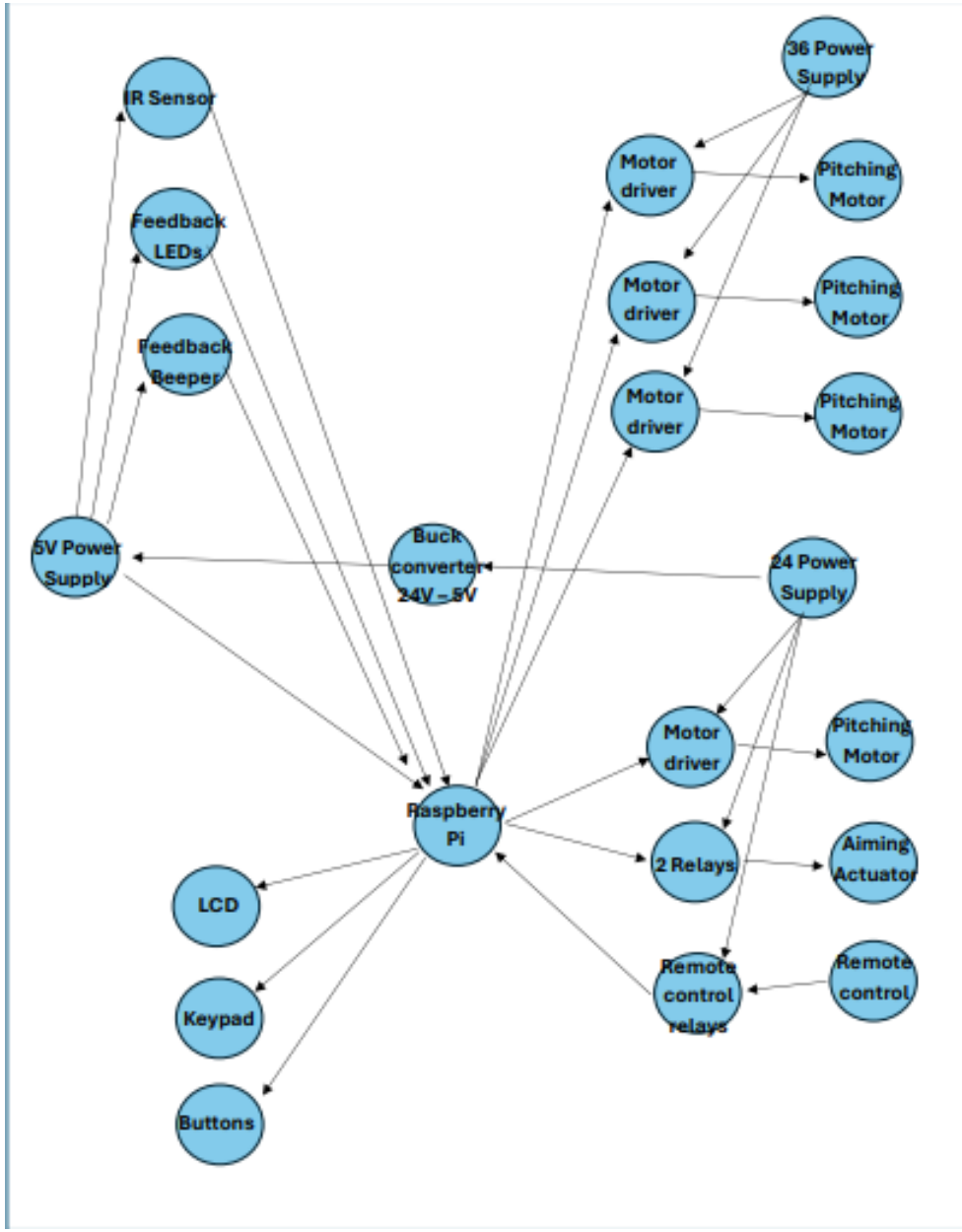
LCD

Number Pad

Power Supply System

36V Power Supply	24V Power Supply	5V Buck Concertor	AC Input
• Powers three pitching motors	• Powers linear actuator and ball feeder motor	• Steps down from 24V to power Rasberry Pico, sensors, LCD, LEDs, beeper.	• DC power feeds them via single AC source

Interface block diagram



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Testing to Consider

- We will test to see if the code implements correctly what we want it to do for our machine.
  - This includes having the ball pitch at the right speed we wanted and location.
  - We also want the actuator to pitch at a certain spot for the ball to be aimed correctly.

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Conclusion

- We have built a tennis ball pitching machine based on our 3D model on OnShape and used mechanical analysis to choose the correct motor for the pitching mechanism.

    - In the future, testing can be conducted to see if the code is implemented correctly in the motors, linear actuator, and ball feeder motor based on the control panel from the user inputs.