

# Mechatronics Spring 2024 Final Project: JHockey

## Objective

For the final project of 530.421 Mechatronics in Spring 2024, we are hosting a robot hockey tournament. Teams are required to build one robot for this final project. There are no specified roles for the robots a, so each robot is allowed to play both offense and defense.

Revision	Date

## Team, Budget, Parts

- You will form teams of 3-4 people (from within your lab section)
  - If you would like to form a team across lab sections, you need to make a request to the Prof. Brown and the TA's in a Teams message
- Each team will have a budget of \$200. This includes components and manufacturing cost.
  - The following components will not count against your budget
    - 2 DC motors (with encoders)
    - 1 caster wheel & 2 motor wheels
    - 1 8.4V battery (for power)
    - 1 Arduino Mega
    - 1 solderless breadboard (with adhesive backing)
    - 1 Pixy camera
    - 1 IMU
    - 1 Ping ultrasonic sensor
    - 2 IR distance sensors
    - 2 flex sensors
    - 2 12x12in 3/16in acrylic sheet
    - Screws, nuts, and standoffs

- Please see the Budget Tracking Template on Canvas
  - **You are not allowed to use personal manufacturing (i.e. 3D printer at home)**
- You are allowed to use everything that is available in the Mechatronics lab.
  - Must request permission to borrow from RSA cabinet
- Manufacturing capabilities
  - You are allowed to use the laser cutters in Wyman
  - 3D printing will be allowed (using the new Prusa printers in Wyman)
    - Training will be available soon

## The Arena

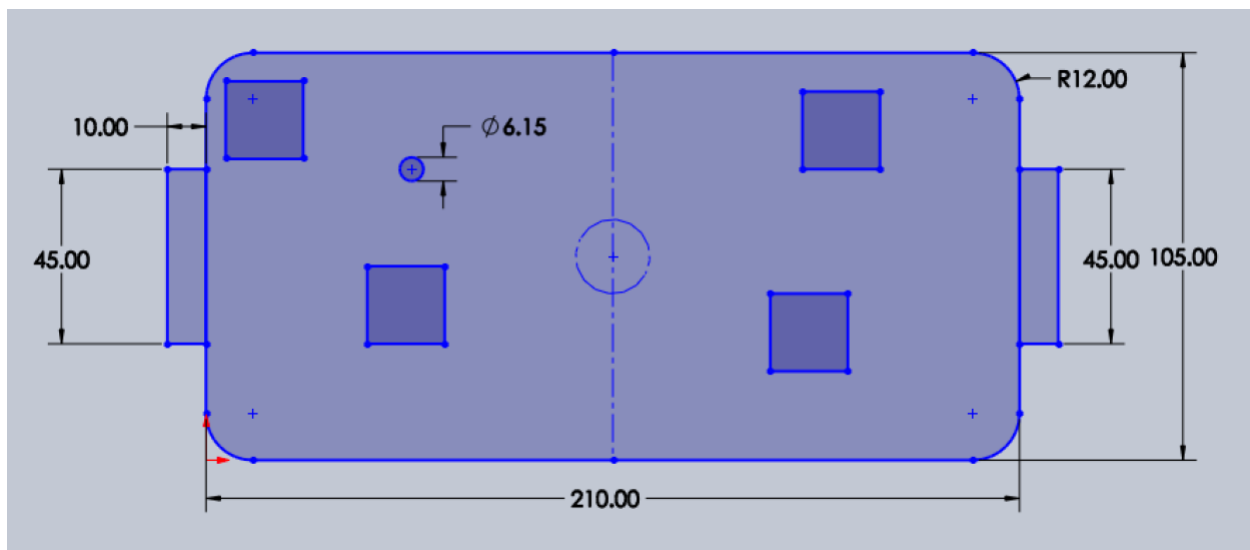


Figure 1: Preliminary arena sketch with mock robots and puck.

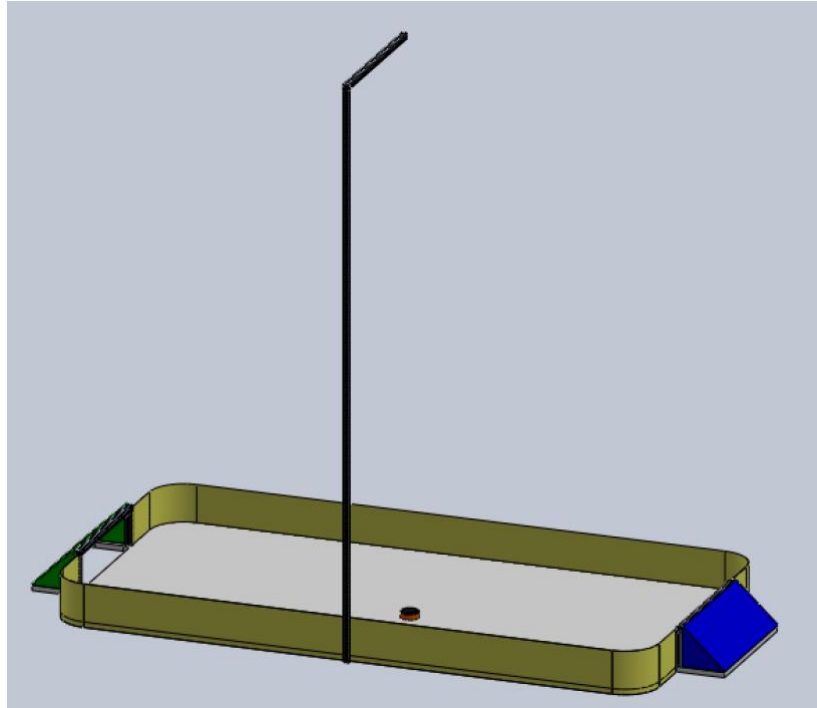


Figure 2: 3D render of the field.

- The size of the arena will be roughly 210 cm by 105 cm (excluding the goals).
- Each goal will be 45 cm wide and 10 cm high. They will have enough depth to catch the puck and will stick out from the back of the arena. Each goal will be centered on the width of the arena. Robots should never enter the footprint of any goal. A colored target will be used to localize each goal (details to be updated).
- The arena will consist of an overhead computer vision camera, which will track robots using ArUco tags. The robot's position will be communicated at coordinates using a ZigBee IoT protocol. We will utilize lab time to introduce ZigBee communication. You will not communicate with the camera directly, nor will you be responsible for tuning/calibrating it. Consider the overhead camera a rough ground-truth or GPS system. The robot localization may have some small inaccuracy and latency, to be characterized.
- The arena walls will be colored YELLOW as to help distinguish robots from walls if using a Pixy camera. (Note, this color may be updated to improve contrast with the puck)
- Arena will have a smooth surface.
- The arena may be elevated from the ground.
- The walls of the arena will resemble the shape of an ice hockey rink (the edges will be curved).

- The halfway line will be marked with black tape on the floor.

## The Puck

- The puck will be roughly 61.5 mm in diameter and 76 mm tall.
- The puck will be plastic, mostly hollow, and light and will have a cylindrical foam structure on top (see below).
- The puck will have a single color (color code: **ORANGE**) surrounding it on the sides.
- The puck will not move by itself (not be powered by motors), however, the puck will utilize a small, motorized fan to reduce its sliding friction (think air hockey puck).

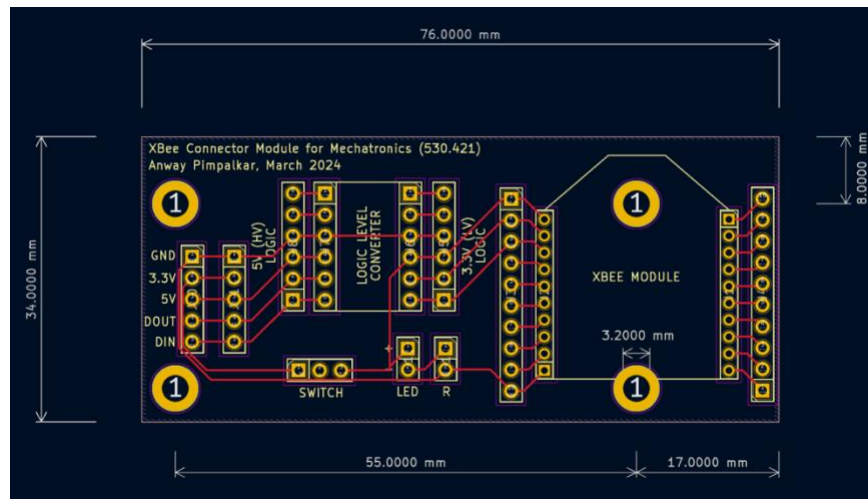
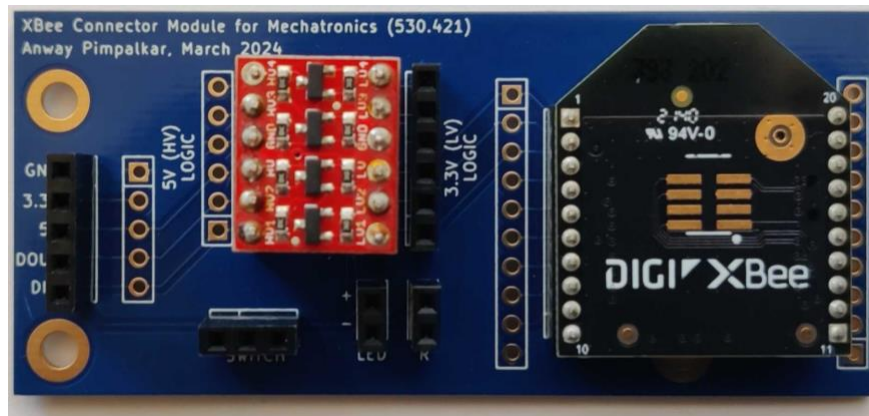


Puck (foam will be painted orange)

## Robots

- The robot frame perimeter (i.e., the perimeter of the best fit polygon at the robot's largest point) should be no greater than 80 cm. The robot should be no more than 20 cm tall. It should be taller than the goal post at all times (height of goal post in "the arena" section above). The robot should be no more than 22 cm wide (covering no more than half the goal at any time).
- The robots will need to carry a "team jersey", which is an ArUco tag placed on top of the robot (for tracking). We will provide the "jerseys" with Velcro, it is your job to attach them to your robot during the game. The dimensions and height of these jerseys will be confirmed by 3/29/24.
- The robot cannot have any part of it cross the goal line or the score will not count.
- A robot cannot block more than half the width of the goal at any time.

- The robots cannot extend in size after the game starts. The only exception to this rule is if your robot has a mechanism to shoot the puck into the goal, in which case the robot can exceed in dimension in one horizontal axis at time (5 cm max).
- To utilize the CV camera tracking system, your robot will need to accommodate a custom PCB that features a ZigBee transceiver module and logic level converter (see picture below) which will be provided the week of 4/1.



## System Requirements

1. The robots need to be fully autonomous, run on batteries, and not be tethered.
2. There is no extra limit regarding sensors besides the one specified above. You are therefore allowed to use any sensors you like including IR sensors, ultrasound sensors, sound sensors, PixyCam, etc.
3. Robots needs to remain inside the rink throughout the duration of the game.
4. Robots cannot fly or be airborne or contain liquid.
5. The puck will and needs to stay on the ground at all times.

6. The hockey match will begin when the ZigBee communication system sends a start signal. Your system cannot start until this signal is given. The puck will start in the center of the arena. You will be penalized if either of your robots moves or generates signals of any kind before the start signal is given.
7. The robots must leave at least half of the puck exposed from the side and top views. Your robot cannot “consume” the puck, meaning the color code must be visible by the opponent’s robots and the arena PixyCam on top. Robots are not allowed to rigidly connect with the pucks. In general, a robot cannot control the puck in a way that definitively prevents the other team from accessing or manipulating the puck.
8. Your robots cannot destroy the puck.
9. Your team will not have any consecutive games. There is no constraint regarding repairs and modifications between games.
10. The puck must always be able to enter the goal (i.e., your robot cannot completely block the goal. It can attempt to block the puck from going into the goal.) but cannot cover more than half the goal width at a time.
11. You are **NOT ALLOWED** to use and purchase subsystems or pre-assembled structures. Please check with the TAs before adding certain components to your robot. Any violation will automatically disqualify your team.
12. You are allowed to carry spare parts for your system in the event of a part malfunction.
13. Your systems cannot have any pieces that are not physically attached to your robot on the field. Any debris created during the competition will be removed by the referee.
14. You are not allowed to intentionally damage your opponent’s robot (i.e., no battlebots) nor interfere with their communication (e.g., no RF jamming). **Any strategy meant to subvert other rules or otherwise disrupt game flow will not be allowed, by judgment of the teaching staff.**

## **Valid Assumptions to Make**

1. If any information presented contradicts future correspondences, the latter information shall supersede.
2. The referees’ rulings within the competition are final and non-reversible. Teams cannot challenge the final decisions of the referees.

3. The starting position of each robot will be set by the referees.
4. Your robot cannot contain any **YELLOW**, **ORANGE**, , **GREEN** colors so that the opponent's robot will not get confused (will be updated).
5. The arena is flat, smooth, and free of debris.
6. The lighting will be similar to lab conditions but will inevitably vary somewhat.
7. The arena will be fixed and have walls. The goal position will be fixed as well and may not be visible from field of view of overhead Pixy.
8. You can make contact with the other robots when playing the game; however, you will be disqualified if your robot intentionally damages other robots.
9. None of the robots will start the game with the puck.
10. There will be no other obstacle in the arena.
11. There is no weight limit for your robot.
12. We will provide one Arduino Mega 2560 microcontroller. If you choose to use more than one Arduino, you will need to purchase the additional Arduinos using your team budget. You may use a microcontroller other than Arduino, however, we will only be providing support (which includes IR tracking over I2C) for Arduino.
13. We will provide a pair (2) of rechargeable 8.4 V, 2200 mA-H NiMH batteries. The cost of these batteries, if you chose to use them, will not be included in your overall budget. If you want to use different batteries, you are on your own.
14. We will provide one (1) MAX 14870 Arduino ready motor controllers. The cost of these motor controllers, if you chose to use them, will not be included in your overall budget.
15. Your system does not need to keep track of the time of the competition.
16. If your design does not violate any rule specified in the final version of this document, you are good to go. Please note that this document will get updated with minor changes and finalized by **April 15th**.

### **Competition Criteria and Rules (Subject to Change)**

1. No user interference is allowed once you put both of your robot in the arena.
2. Each team will play one match each round.

3. You will know the side of the goal you are on at the beginning of each round. The first match of the first round will have an extra 5 minutes to prepare (aka to hard code in the correct direction).
4. The entire puck must be inside the goal to be counted as a goal.
5. Each hockey game will last for 4 minutes, with 1 timeout for each team. For every timeout, the team is allowed to pick up their robots and make hotfixes. The clock will not reset after the timeout. Each timeout will last for 90 seconds. After 90 seconds, if the team is not ready, the team is disqualified from the match.
6. For each game, a team will get 3 points for a win, 1 point for a draw, 0 point for a loss.
7. If two teams have the same score at the end of the competition, we will take into account goal differential (number scored minus number given up).
8. If two teams have the same goal differentials, we will take into account head-to-head score
9. If two teams have the draw for head-to-head, we will organize a shootout, 3 turns for each team. The shootout only happens at the end of the competition.
10. **The Shootout:** The referee will put the puck at the halfway line. One robot will start on its own half, “possessing” the puck and have 10 seconds to move around and make a shot. There is no restriction on what the opponent robot can do. The time for the shootout will start after the start signal begins.
11. Disqualified team will get -1 point for that match. The other team in this disqualified match will get 0 point if they are losing (goal differential will not be recorded), 1 point if it is a draw, and 3 point if they are winning (goal differential recorded).

## **Deliverables & Timeline (Subject to Change)**

**Week of March 25th:** The initial project released and team formation. All questions, complaints, comments regarding the project need to be submitted by the end of lab (on the Teams #project channel). Teams can request a Trello workspace for ordering (details provided in lecture and on Canvas). Once Trello is confirmed, teams can begin to order components.

**Week of April 1st:** Teams will be introduced to the ZigBee communication protocol and will need to demonstrate utilization in-lab (a detailed set of instructions and deliverables will be provided). Teams continue to work on robot design and must show TAs progress.



***Week of April 8th:*** Milestone 1- Robot Testing (expected tasks: navigate and track the puck)- progress report due on Canvas.

***Week of April 15th:*** Milestone 2 - Robot Testing (expected tasks: attempt to score a goal) - progress report due on Canvas.

***Week of April 22th:*** Milestone 3 - Robot Testing (expected tasks: navigate the arena and attempt to score a goal, with opponent present).

***April 26th:*** Last day to order materials!

***April 28th:*** Final reports and peer evaluation due (by midnight). You will receive a 0% for the final report individually if you do not finish the peer evaluation. Teams must also submit a video demonstration of their robot performing milestone 1, 2, and 3 for a final grade.

***Week of April 29th:*** Reading Period - Teams are allowed (not required) to come in lab and continue to work on their robots.

***May 6th 6:00pm – 9:00pm:*** Final Tournament (no grades, just fun and food)

## **Tips and Suggestions**

1. Teamwork will be the key to success.
2. Keep it SIMPLE, innovation doesn't have to be complex and in most cases, it is NOT.
3. Do not make assumptions prior to the competition. If you think your design is valid, make sure you can argue for your case, else your "innovation" can get you disqualified.
4. The only dumb question is the one you don't ask.
5. Perfect is the enemy of good.
6. Meeting the requirements does not guarantee winning the competition.
7. Use your time wisely. Don't leave it the night before to finish all the work!
8. Don't leave your robot unattended on the lab benches at any time. Your 6-week project may get destroyed in 2 seconds.