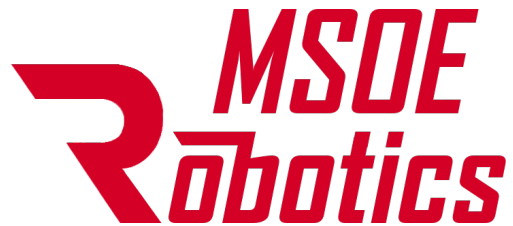




# Raider Robotics Controls Notebook

2024-2025 - VEX High Stakes



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## Meeting Notes - Our Formatting

**Timestamp:** [Date] - Author

**Attending:**

### Meeting Goals

- Goals / Directives for the meeting

### Discussion

Details of the meeting including resources used, implementation details, and meeting setup details.

### Results

- Accomplishments of the meeting

### Action Items

- Todos for next meeting

## Tuesday Strategy Meeting

**Timestamp:** [09/17/2024] - [Luke Gagnon, Leigh Goetsch]

**Attending:** Peter Wolfgramm, Andrew Needham, Miles Trompeter, Landon Van Mersbergen

### Meeting Goals

- Tools for developing robot strategies
- Investigate virtual robot simulation options

### Discussion

Here is an option for virtual robot simulation recently posted to the vex forums. I think looking at options for virtual robot simulation for controls would be a good idea. [bowlerstudio](#)

Here is the pygame repo for testing robot strategies: [repo](#)

## Wednesday Integration Meeting

**Timestamp:** [09/18/2024] - Luke Gagnon, Leigh Goetsch

**Attending:**

### Meeting Goals

- Finish Friday task
- Assemble and test odom systems

### Discussion

We will be finishing the challenge you were given on Friday: program a robot to move autonomously across the field as creatively as possible

Add a copy of the auton program to a text file in the "autons" folder. Please put your name and auton file name here when done!! :D

### Results

name(s)	file name
Andrew	backwards-auton
Miles	swirly-auton

Table 1: Auton files

## Tuesday Strategy Meeting

**Timestamp:** [09/24/2024] - Luke Gagnon, Leigh Goetsch

**Attending:**

### Meeting Goals

- Finish the STEM Center Canvas course for STEM Center Access
- Control Theory: Tracking Robot Position
- Strategy Formulation: Analyzing the Game and Field

### Discussion

Please complete the STEM Center Canvas course for STEM Center Access. This will give you STEM Center access for the rest of the year.

[Here is the page on odometry and tracking robot position](#) from the Purdue VexU team

[Youtube video series on odometry](#)

For the strategy formulation, we will be analyzing the game and field. We will be putting a picture of the field on the board and discussing path planning and autonomous routines. Add any notes you have to the strat folder, please!!!

### Results

- STEM Center Canvas course completed
- Watched youtube video series on odometry
- Analyzed the game and field



## Monday Controls Group Meeting

**Timestamp:** [9/30/24] - Landon & Hunter

**Attending:**

### Results

- Odometry pods are working and calculations appear to be accurate. More precise offset measurements will be needed to improve accuracy.
- Square root input curve on drive is working using voltage control.
- Voltage control allows motors to drive above max speed.
- Due to uneven friction, voltage control adds slight drift and may need to be removed.

### Action Items

- SD card for differentiation between bots, images, odometer.
- Implementing path gen for usable auton paths in competition.

## Friday Controls Group Accomplishments

**Timestamp:** [10/04/24] - Landon & Hunter

**Attending:**

### Results

- Added control to toggle claw in op and autonomous control.
- Practiced autonomous routes with claw mechanisms.

### Action Items

- Research pros tasks to run processes in parallel.
- Research odometry for autonomous routes.
- Plan autonomous routes for skills and competition.

## Strategy Meeting - Project Updates

**Timestamp:** [10/08/2024] - Luke Gagnon, Leigh Goetsch

**Attending:** Peter Wolfgramm, Andrew Needham, Miles Trompeter, Landon Van Mersbergen

### Meeting Goals

- Review progress on current project objectives
- Discuss next steps for each project area
- Identify any roadblocks or challenges
- Plan for future strategy meetings

### Project Updates

The following is a summary of the progress made in each project area and the next steps planned for each group:

#### Leblib Path Planning

**Group:** Andrew, Peter, Salvin

**Objective:** Set up the Leblib path planning library and begin integrating it with autonomous navigation and odometry.

**Plan:**

- Successfully set up the path planning library on the development environment.
- Initial testing was not conducted yet; plan to test integration with the robot's autonomous systems and odometry tomorrow.

#### Next Steps:

- Tomorrow, test the library with the robot's autonomous functionalities and odometry data.
- Identify any adjustments or customizations needed for better integration.

#### Robot Communication

**Group:** Luke, Leigh, Miles

**Objective:** Establish a communication protocol between robots and test message reception.

**Plan:**

- Set up a basic test environment to verify correct message reception between robots.
- Began discussing the communication protocol for inter-robot messaging, focusing on what specific data needs to be shared.

#### Key Considerations for Communication Protocol:

- Location data: Essential for coordinating movements between robots.

- Object detection data: Could be useful in determining shared understanding of obstacles or objectives.
- Game state: Related to object detection, the state of the game (such as target detection or task progress) may need to be shared.
- Help signal: To allow one robot to request assistance from another if necessary.

### Next Steps:

- Finalize the communication protocol, specifying the exact data types to be transmitted.
- Implement and test the protocol between the robots.

### Task Abstraction

**Group:** Not assigned yet

**Objective:** Develop a task management system for handling asynchronous tasks during autonomous robot operation.

**Plan:**

- Research two potential approaches: creating a custom task system vs. leveraging the PROS library's task management system.
- Determine how events can be triggered within the system to better manage robot actions.

### Next Steps:

- Research both options: creating a custom task system vs. leveraging PROS.
- Determine how events can be triggered within the system to better manage robot actions.

### Web Dashboard

**Status:** Paused / Peripheral

**Objective:** Update and integrate the internal path planning interface to export JSON data.

**Plan:**

- The web dashboard interface, developed a few years ago, needs updates to ensure compatibility with our current system.
- Initial review of legacy code has not yet been conducted.

### Next Steps:

- Review the legacy code to assess the current implementation.
- Ensure the dashboard can export JSON data for use in other areas of the project.

### Website Maintenance

**Group:** Salvin, Andy

**Objective:** Modernize the website and update the content.

**Plan:**

- The website is outdated and has dependency issues with npm, preventing updates in its current state.
- Initial steps will involve resolving these dependency issues to make the site functional in modern environments.

### Content Updates Considered:

- Sponsor list.
- Links to relevant GitHub repositories (pneumatic reverse engineering, senior design projects, web dashboard, website).
- Past engineering notebooks, Onshape designs (past robots), and updated tournament statistics.
- Contact information update.

### Next Steps:

- Fix the dependency issues.
- Begin content updates as discussed, starting with sponsor lists and repository links.

## Wednesday Integration Meeting

**Timestamp:** [10/09/2024] - Luke Gagnon, Leigh Goetsch

**Attending:** Miles,

### Meeting Goals

- Implement a simple program for exploring VEXlink communication

### Discussion

Using the VEXlink communication protocol, we can send signals to the robot. However, we are unable to send signals when the remotes are connected. We wrote some basic tests to try to get the remotes connected.

### Results

- Wrote a simple program to test VEXlink communication
- We can send signals, but not with remotes connected
- Wrote some basic tests to try to get to connected

## Tuesday Strategy Meeting

**Timestamp:** [10/22/2024] - Luke Gagnon, Leigh Goetsch

**Attending:** Peter Wolfgramm, Andrew Needham, Miles Trompeter

### Meeting Goals

- Try to figure out the reason behind VEXlink issues
- VEXlink documentation reading
- Get VEX AI team members GHOST project setup and running

### Discussion

- [VEXlink Docs](#)
- Excerpts:
  - When multiple radios are connected to a V5 brain, the radio in the highest numbered smart port will be used for the controller VEXnet connection, to avoid errors
  - Data Rate:
    - \* Maximum data rate for manager to worker robot is 1040 bytes/second.
    - \* Maximum data rate for worker to manager robot is 520 bytes/second.

### Results

- VEXlink issues are likely due to the order of the controller and the VEXlink device ports

### Action Items

#### **VEXU Team Tasks**

- VEXlink  
**Leigh, Miles**
- LebLib  
**Andrew**

#### **VEX AI Team Tasks**

- Nano -> V5 microcontroller communication:
  - How is the nano and the V5 microcontroller working together?
  - What is being processed on what?
  - Create a simple program to send a message from one to the other
- ROS2 serial robot messaging
  - How is ROS architected?
  - How is this useful in our use-case?
  - Write a publisher and subscriber script (or run the one in GHOST's example)

- robot -> robot messaging (VEXlink)
  - What messages should robots send each other
  - What message protocol do robotic systems usually use?
  - What message protocol should we use?
  - Use VEXlink PROs API to write a simple program to send a message from one robot to another.
- Simulation - GHOST  
**Evan, Salvin, Leigh**
  - The sim software that GHOST uses is called Gazebo Sim
  - The python that the bash file `./scripts/launch_sim.sh` runs can be found at `04_Sim/ghost_sim/launch/`
  - There is a typo that causes the world to not load in the sim env, will post the fix later tonight.
  - What information can the sim env store?
  - What is the filetype of the world and the model files?
- Path planning - GHOST
  - GHOST uses <https://web.casadi.org/> for path planning
  - What does this library do?
  - What are the input and outputs for their algorithm?
- MSOE Senior Design - Adversarial Strategy VEX Robot Program
  - This is a senior design project from two years ago using RL
  - If you are itching for more project setup, load up this project
  - How does this project represent a robot?
  - What information does the robot store?
  - How does the robot choose actions?

### Specific People:

- Nano Setup  
**Evan, Salvin**
  - Try following the instructions in this repo to setup your nano and run the example code
- Rosie Newbie  
**Andrew**
  - Go to the AI Club Learning Tree and follow the instructions to practice requesting rosie and running jobs
  - I will have some files for you in the next couple days for this



## Wednesday Controls Group Accomplishments

**Timestamp:** [10/23/24] - Luke Gagnon

**Attending:** Miles, Gideon

### Discussion

#### port maps:

- left drive: 11, 12, 13
- right drive: 14, 15, 16
- tandem motor: 17, 18
- solo motor: 19

### Results

- Library Research project (Luke)
  - Continued investigation of pros vs. custom libraries
- Main Robot project (Luke)
  - Started getting code set up for the current robot project
- Vex Link project (Miles, Gideon)
  - Continued research for vex link for use in Vex AI

### Action Items

- Library Research project: Continue to investigate pros vs. custom libraries  
**Luke**
- Main Robot project: Do whatever design needs  
**Luke**
- Vex Link project: Continue vex link work  
**Miles, Gideon**

## Friday Controls Group Accomplishments

**Timestamp:** 10/25/24 - Luke Gagnon

**Attending:**

### Results

- Main Robot project (Luke)
  - Fixed some problems with the current robot project
  - Got pneumatics working on the current robot
  - Looked into setting up odom

### Action Items

- All project
  - Touch base with everyone to see what's happening with teams and members who have been busy and might not have been at all meetings

## Friday Controls Group LemLib Accomplishments

**Timestamp:** 11/08/24 - Andrew Needham

**Attending:**

### Results

- LemLib (Andrew)
  - Figured out the old version of LemLib was causing problems when calculating robot position
  - Created a new PROS project with the latest version of LemLib which worked correctly
  - Created constants to initialize EZTemplate and LemLib robot configurations **LemLib Test Project**

---

```
const vector<int> leftMotorPorts = {-5,8,-9};
const vector<int> rightMotorPorts = {-3,4,-11};
const int motorRPM = 600;
const pros::motor_gearset_e_t motorGearSet =
    pros::motor_gearset_e_t::E_MOTOR_GEAR_600;
const int imuPort = 16;
const float driveWheelDiameter = 3.25;
const float trackingWheelDiameter = 2;
const float driveRPM = 360;
const float driveTrackWidth = 10.75;
const float verticalTrackingWheelOffset = 1.625;
const float horizontalTrackingWheelOffset = 2.75;
const int verticalEncoderPortTop = 3;
const int verticalEncoderPortBottom = 4;
const int horizontalEncoderPortTop = 2;
const int horizontalEncoderPortBottom = 1;
```

---

- Created a PROS task to control the claw without interrupting the main leftMotorPorts **LemLib Test Project**

---

```
bool clawOn = false;
void toggleClaw(){
pros::Task claw_task([&]() {
    if(clawOn){
        Claw2.set_value(0);
        pros::delay(100);
        Claw1.set_value(0);
    }else{
        Claw1.set_value(1);
        pros::delay(100);
        Claw2.set_value(1);
    }
    clawOn = !clawOn;
});
}
```

---

### Action Items

- All project
  - Continue development of the new PROS project OR update the current vex-base to new version of LemLib
  - Create a GitHub repo for the new project

## LemLib implementation

**Timestamp:** [11/01/24] - Andrew Needham

**Attending:**

### Goals

- Get LemLib odometry values to read the robot position on the field

### Methods

LemLib odometry values all read as NaN Troubleshooted by checking to see what values the encoders read and then checked where the problem first started occuring

### Results

- Motor encoder values read correctly, around 1000 units per rotation
- Values from the tracking wheel objects are not reading correctly, will jump between 1000000, -1000000 and 0 seeminly randomly
- Found source code for LemLib TrackingWheel

#### TrackingWheel.getDistanceTraveled

---

```
float lemlib::TrackingWheel::getDistanceTraveled() {
    if (this->encoder != nullptr) {
        return (float(this->encoder->get_value()) * this->diameter * M_PI /
                360) / this->gearRatio;
    } else if (this->rotation != nullptr) {
        return (float(this->rotation->get_position()) * this->diameter * M_PI
                / 36000) / this->gearRatio;
    } else if (this->motors != nullptr) {
        // get distance traveled by each motor
        std::vector<pros::MotorGears> gearsets =
            this->motors->get_gearing_all();
        std::vector<double> positions = this->motors->get_position_all();
        std::vector<float> distances;
        for (int i = 0; i < this->motors->size(); i++) {
            float in;
            switch (gearsets[i]) {
                case pros::MotorGears::red: in = 100; break;
                case pros::MotorGears::green: in = 200; break;
                case pros::MotorGears::blue: in = 600; break;
                default: in = 200; break;
            }
            distances.push_back(positions[i] * (diameter * M_PI) * (rpm / in));
        }
        return lemlib::avg(distances);
    } else {
        return 0;
    }
}
```

---

### Action Items

- Will try to use old VEX encoder to see if the precision of the encoders are leading to position calculation issues
- Try to find what “TrackingWheel.getDistanceTraveled()” does to figure out why it’s not working

## CasADi Test Program

**Timestamp:** [11/05/24] - Andrew Needham

**Attending:**

### Goals

- Create a basic Python program to get familiar with using the CasADi library to generate robot path trajectories

### Methods

- Use ChatGPT to generate a basic test program and iterate from there to fit our use case
- Use the CasADi documentation to figure out what inputs and outputs are needed

### Results

- Was able to get a basic program that minimizes the distance traveled between two points given a list of obstacles to avoid
- The program optimizes the objective function given a set of constraints and plots the path on a graph
- GitHub repo for CasADi test program: <https://github.com/msoe-vex/CasADi-Test.git>

### Action Items

- Will update the program to minimize the amount of time used to travel from one point to another
- After that, will work on converting the Python program to a C++ implementation

## CasADi Test Program

**Timestamp:** [11/08/24] - Andrew Needham

**Attending:**

### Goals

- Update the python test path program to minimize the amount of time to traveled instead of just the path length

### Methods

- Use ChatGPT to generate a basic test program and iterate from there to fit our use case
- Use the CasADi documentation to figure out what inputs and outputs are needed
- Find other existing programs to build off of

### Results

- Was able to get a solver working that minimizes the amount of time
- The solver also has constraints for maximum velocity and acceleration
- The robot starts and ends at a complete stop
- The program is very finicky at the moment, any small change in the constraints or starting values can cause the solver to not be able to find a solution
- GitHub repo for CasADi test program: <https://github.com/msoe-vex/CasADi-Test.git>
- GitHub repo for another users implementation: <https://github.com/tianchenji/path-planning.git>

### Action Items

- Will use the tianchenji/path-planning.git repo to learn how to better implement CasADi
- After that, will work on converting the Python program to a C++ implementation



## CasADi Test Program

**Timestamp:** [11/11/24] - Andrew Needham

**Attending:**

### Goals

- Update the python test path program to follow the laws of physics and come to a complete stop at start and end points

### Methods

- Iterate the path planning repo to fit our use case
- Use the CasADi documentation to figure out what inputs and outputs are needed
- Utilize ChatGPT to quickly develop the program

### Results

- Was able to get a solver working that follows a smooth path and limits the maximum speed and velocity
- The solver works in about 0.1 seconds so it will be able to calculate paths in real time during the match
- Currently the program has a static time interval and a variable amount of steps to look into
- GitHub repo for CasADi test program: <https://github.com/msoe-vex/CasADi-Test.git>
- GitHub repo for another users implementation: <https://github.com/tianchenji/path-planning.git>

### Action Items

- Will update the program to change the units to inches so that it can be used with LemLib
- Will research how LemLib controls the robot based on a list of points
- The program can be updated to use a set number of steps and a variable amount of time in between them
- After that, will work on converting the Python program to a C++ implementation

## LemLib Test Program

**Timestamp:** [11/14/24] - Andrew Needham

**Attending:**

### Goals

- Create a LemLib PROS project to control the robot in auton and opcontrol

### Methods

- Create a new PROS project
- Install LemLib depot
- Update the program to control the robot in auton and opcontrol

### Results

- Was able to get a program working that calculates the position of the robot based of the inputs of tracking wheel encoders
- Added classes to allow selection of auton during the initialize part of the match

### Action Items

- Confirm that the auton selector works in a match
- Create a split arcade drive configuration to control the robot in opcontrol
- Tune PID constants and make sure the chassis configuration is correct and tracks robot position correctly

## Appendices

This section contains additional information that may be useful for understanding the contents of this notebook. This includes code snippets, data tables, and other supplementary information.

## AI Research Meetings Findings

## CasADi and GHOST Path planning

**Timestamp:** [10/29/24] - Andrew Needham

**Attending:**

### Research CasADi library and GHOST implementation of path planning

The goal for this exploration is to determine how to use the CasADi library to generate path trajectories for the robot

### Questions Explored

- What is CasADi and what does it do?
- How does GHOST do path planning?
- What are the inputs and outputs of the algorithm?
- How can CasADi be used to generate path trajectories

### Methodology

1. Reading through CasADi documentation
2. Checking GHOST public repo for CasADi implementation and path planning code
3. Create a test program to generate path and become familiar with the library

### Code Locations

- GHOST VEX-U Repository: [link](#)
- GHOST Swerve drive trajectory generation [link](#)
- Test program repo: [link](#)
- CasADi Robot Path Planning example: [link](#)

### Findings

- CasADi is a general purpose library with the focus of solving optimization problems given a set of constraints
- Inputs of CasADi is a function of multiple variables and a number of constraints for the function
- The GHOST systems uses serialized messaging to communicate between different classes and parts of the robot

### Issues

- Unable to locate where in the GHOST repo CasADi was implemented for a tank drive
- Unable to consistently generate a path that minimizes the time taken to get to the target point

### Code Snippets / Commands Used

---

## LemLib implementation

**Timestamp:** [11/06/24] - Andrew Needham

**Attending:**

Research LemLib library

Questions Explored

- What is LemLib and what does it do?
- How can odometry be used to control the robot?

Methodology

1. Reading through LemLib documentation to configure the robot
2. Use Jerry.io and/or CasADi to plan paths to be used with LemLib

Code Locations

- LemLib source code repository (stable): [link](#)
- LemLib documentation: [link](#)
- Test program repo: [link](#)

Findings

- LemLib supports odometry that tracks the position of the robot
- PID tuning can be used to get accurate measurements
- LemLib also supports pure pursuit which can be used to create complex paths for the robot to follow

Issues

- Unable to get TrackingWheel values to read correctly

Code Snippets / Commands Used

---

## Beginning With Gazebo

**Timestamp:** [11/4/24] - Evan Roegner

**Attending:**

### Objective / Focus

The goal for this was to explore the gazebo simulation to determine what its components are, and what role they serve and can do.

### Questions Explored

- What information can the sim environment store?
- What is the filetype of the world and model files?

### Steps Taken / Methodology

1. Fixed the typo in the start\_sim\_launch file.
2. Found what files were being used to create the world and the objects/robots in it
3. Looked into those files to determine exactly what they actually were
4. Changed the filepath being used in start sim launch to accept files from a local directory

### Paths to Key Files / Code Locations

- start\_sim\_launch: scripts -> start\_sim\_launch.py, run from VEXU\_GHOST directory with ./scripts/launch\_sim.sh
- World files: 04\_Sim -> ghost\_sim -> worlds
- Robot xacro files: 04\_Sim -> ghost\_sim -> urdf
- Macro xacro files: 04\_Sim -> ghost\_sim -> urdf -> macros
- Typo, local directory change, world selection: start\_sim\_launch Line 70
- Robot selection: start\_sim\_launch Line 20

### Findings / Insights

- Typo and local directory line should be changed to world\_file = os.path.join(home\_dir, "VEXU\_GHOST", "04\_Sim", "ghost\_sim", "worlds", **\*\*INSERT WORLD NAME HERE\*\***)
- start\_sim\_launch.py launches the simulation when run. launch\_setup method contains a single variable that can be changed to switch the robot that is being simulated. This means that robots are not defined in the world, but as their own file which is placed in an existing world by this script. This would be used to change the world the robot is being loaded into (line 70) as well as the robot being loaded (line 20). Also allows you to specify a joystick to use in the simulation.

- .world files are XML files which contains all of the information about a given environment a robot can be placed into. Contains the placement and state of all objects in the environment. Editing these files allow you to add physical objects into the simulation as well as change various attributes about the simulation (gravity, kinematics, etc). Many attributes in the world file can be modified while the program is running (this does not change the actual file, it just changes it in the simulation). This is used in start\_sim\_launch to create the environment the robot will be placed into.
- xacro files are used to define various macros and the robots that they make up. There are xacro files for robots and separate files for the macros. The macros are xml representations of robot parts
- Macro xacro files Contain information about the various parts of the robot, by default there are 2 types: actuators and sensors. Sensors are anything the robot can use to learn things about its environment and actuators are types of motors. The sensors macro file contains the following:
  - lidar\_macro - A simulation of a lidar sensor which shoots raycasts in a circle
  - imu\_macro - A simulation of a sensor that gives a robot's acceleration and velocity with simulated uncertainty

The actuators macro file contains the following:

- v5\_motor\_macro - A generic motor with a number of settings similar to an actual motor
- joint\_pid\_macro - A generic motor with a PID loop, with settings similar to an actual PID motor

## Code Snippets / Commands Used

---

---

```
./scripts/launch_sim.sh
```

```
world\_file = os.path.join(home\_dir, "VEXU\_GHOST", "04\_Sim", "ghost\_sim",  
    "worlds", "**INSERT WORLD NAME HERE**")
```

---



# Powering Jetson Orin Nano Over Battery

**Timestamp:** [11/14/24] - Evan Roegner

**Attending:**

## Objective / Focus

The goal for this was figure out a method of powering the Jetson Orin Nano off of a 5V USB Power bank

## Questions Explored

- What ports on the nano accept power?
- What connectors or cables are needed?
- How much power does the Nano need?
- How can USB-A/USB-C power out be converted to a standard that the nano accepts?

## Steps Taken / Methodology

1. Nano usb-c plugged into 15V=3A power
2. Watched NVIDIA Jetson on Battery Power video
3. Searched for 5V to 19V step-up converter
4. Looked into potentially using POE

## Findings / Insights

- Our battery outputs at 5V, but the nano needs 9V-19V
- We can convert between voltages with a step-up converter
- Most step-up converters on the market that convert from 5V usb to 9V-19V barrel only provide up to 10 watts, which is not enough
- If we get an expansion board, Power over Ethernet is possible, but likely impractical
- Absolute minimum amount of power would be 15 Watts, but more is recommended
- Inner barrel positive, outer is negative

## Items needed

- 5V USB -> 9V-19V 5.5mmx2.5mm Barrel, >= 20 Watt output
- Alternatively, generic 5V->9V-19V step-up adaptor with correct connections soldered on would work

## Challenges / Issues

- Need to find an applicable power adaptor, or potentially create our own with a generic step-up adapter.