2024 *FIRST*® Robotics Competition

KitBot Python Software Guide

1 Contents

2 Document Overview

This document will take you through how to get your 2024 KitBot up and running using the provided Python example code. To avoid content duplication this document frequently links to WPILib and/or RobotPy documentation for accomplishing specific steps along the way. In addition to getting you up and running with the provided code, this document will walk through the structure of that code so you can understand how it operates. Finally, we'll walk through some of the most likely changes you may wish to make to the code and provide concrete examples of how to make those modifications.

To get started with the example code, or to make some of the modifications described, minimal understanding of Python is required. The code and modification examples provided will likely provide enough of a pattern to get you going. To understand the walkthrough, or to make modifications not described in this document, a more thorough understanding of Python is likely required. The Introduction to Python in the RobotPy documentation will get you started, and also has some links to more comprehensive resources.

This document, and the provided example code, assumes the use of the SPARK MAX controllers provided in the rookie Kickoff Kit. The

3 Getting Started with your KitBot code

3.1 Wiring your robot

Use the WPILib Zero-to-Robot wiring document to help you get your robot wired up. Some notes specific to the 2024 Kitbot:

- The 2024 KitBot does not utilize pneumatics. You can skip instructions regarding the Pneumatic Hub/Pneumatics Control Module unless you are adding pneumatics to the design
- In order to use the same IDs for PWM and CAN operation, the 2024 KitBot code does not utilize PWM port 0. Either wire the PWM ports according to the IDs in constants.py (Left = 1,2, Right = 3,4) or modify the constants to reflect your wiring.
- The 2024 KitBot contains two additional motors not included in the basic wiring document. Wire these in the same manner as the drivetrain motors. If using PWM, connect the Feeder motor (closer to the center of the robot) to PWM port 5 and the Launcher motor (the motor closer to the outside of the robot) to PWM port 6.

3.2 Configuring hardware and development environment

Before you are able to load code and test out your robot, you will need to configure your hardware (roboRIO, radio, etc.) and get your development environment set up. Follow the WPILib Zero-to-Robot guide steps 2 through 4 and the RobotPy installation steps (make sure to install the REV package as well if using CAN control) to get everything set up and ensure you can deploy a basic robot project.

If using PWM, make sure all 6 SPARK MAXs are in "Brushed" mode. When powered the LED should blink yellow or blue, not magenta or cyan. To change the mode you can either hold the Mode button down for 3 seconds or use the USB connection and REV Hardware client. You may also wish to check the Idle modes, brake or coast. The Feeder and Launcher motors are recommended to be set to coast mode (blinking yellow). To change the Idle mode, press the Mode button briefly (less than 3 seconds) or use the USB connection and REV Hardware Client. There is no specific recommendation for the drivetrain motors but you likely want all 4 drivetrain motors to match, you may wish to try driving around with each setting to decide what you prefer.

3.3 Opening the 2024 KitBot Example

The 2024 KitBot example code is provided in individual zip files for each language. To open the Python code:

1. Download and unzip the Python example code. Make sure to unzip or copy to a permanent location, not in a temporary folder.
2. Open **WPILib VS Code** using the Start menu or desktop shortcuts
3. In the top left click **File->Open Folder** and browse to the "Python" folder inside of the unzipped example code then click **Select Folder.**

3.4 Changing to CAN control

If you have wired your SPARK MAX motor controllers using CAN, you will need to do some further configuration and code modification before proceeding. If you are using PWM, skip down to Section 3.5 to deploy and test the code.

3.4.1 Configuring the SPARK MAXs

Before using the SPARK MAXs with CAN control, they each need to be assigned a unique ID. Because your SPARKs all start with the same ID you may wish to unplug the CAN bus from each device while you update and assign an ID.

1. Install the REV Hardware Client
2. With the robot powered off, connect a USB cable between the computer and the SPARK MAX USB port. Leaving the robot powered off ensures only the single SPARK MAX is powered and avoids changing the IDs on unintended devices.
3. Update the firmware on the SPARK MAX
4. Set the CAN ID and Motor Type (you can skip the current limit) and save the settings
    a. CAN IDs for each device can be found in constants.py. You can either set the devices to match these IDs, or set the IDs as desired (some teams set the CAN ID = the channel number the device is attached to on the PD) and then update these constants.
    b. Note: If you wish to "Spin the motor" as described on that page, make sure the robot is in a safe state to do so (wheels not touching the ground or table).
5. Repeat for all 6 devices on the robot.

6. While not required, if using the REV PDH you may wish to check that it has the latest firmware at this time as well. Do not change the ID of the PDH off of the default, each device type has a separate ID space and your PDH will not conflict with your SPARK MAX even if set to the same ID.

Now that all your devices are configured, you can do a preliminary check that your CAN bus is wired properly using the REV Hardware client. While plugged into any REV device on your CAN bus with a USB cable, power on the robot and you should see all the other devices listed in the left pane of the REV Hardware Client, under the CAN Bus heading. If you don't see all of the devices, you likely have one or more issues with your CAN bus wiring:

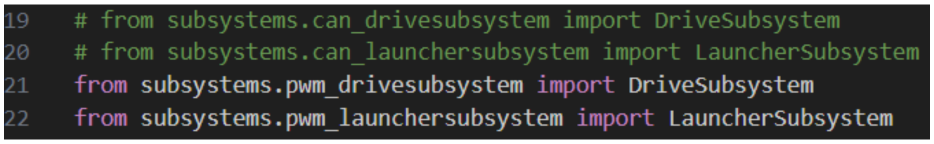
1. Verify that your CAN bus starts with the roboRIO and ends with a 120 ohm resistor, or the built in terminator of a Power Distribution Hub or Power Distribution Panel (with the termination set to On using the appropriate jumper or switch.
2. Check that your CAN bus connections all match yellow-yellow and green-green.
3. Check that all CAN wire connections are secure to each other and that the connectors are securely installed in each SPARK Max
4. If you're still having trouble, moving the USB connection around to different devices and seeing what each device can "see" on the bus can help pinpoint the location of an issue.

3.4.2 Installing REVLib

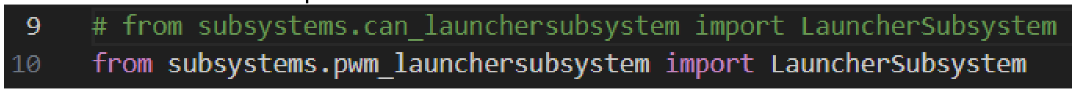
The software library for the SPARK MAX in CAN mode is provided by the vendor (REV Robotics). The 3rd party library configuration is already included in the project, but you will have to install the library itself. To do so, follow the steps in the RobotPy documentation.

3.4.3 Updating the Code

The code is mostly in place in the project to switch from PWM to CAN control, you will just need to make a few edits to switch over.

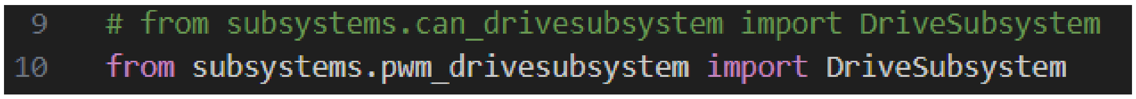
1. In RobotContainer:


```
# from subsystems.can_drivesubsystem import DriveSubsystem
# from subsystems.can_launchersubsystem import LauncherSubsystem
from subsystems.pwm_drivesubsystem import DriveSubsystem
from subsystems.pwm_launchersubsystem import LauncherSubsystem
```

   a. Uncomment the import statements for the CANDrivetrain and CANLauncher. Comment out or remove the statements for the PWM subsystems.
2. In LaunchNote and PrepareLaunch:


```
# from subsystems.can_launchersubsystem import LauncherSubsystem
from subsystems.pwm_launchersubsystem import LauncherSubsystem
```

   a. Uncomment the import for CANLauncher and comment or remove the one for PWMLauncher
3. In Autos:



```python
# from subsystems.can_drivesubsystem import DriveSubsystem
from subsystems.pwm_drivesubsystem import DriveSubsystem
```

a. Uncomment the CANDrivetrain import and comment or remove the PWMDrivetrain import

3.5 Deploying and testing the KitBot Example

To deploy the example to your robot, you will need to follow the [deploy instructions in the RobotPy documentation].

Warning: Make sure you have space in all directions when operating a robot. Even with known code, the robot may move with unexpected speed or in unexpected directions. Be prepared to Disable (Enter) or E-stop (Spacebar) the robot if necessary. The 2024 KitBot code contains a very simple autonomous routine that will move the robot backwards at ½ speed for 1 second when the robot is enabled in Autonomous mode.

3.6 Configuring Gamepads

The code is set up to use the Xbox controller class. The Logitech F310 gamepads provided in the Kit of Parts will appear like Xbox controllers to the WPILib software if they are configured in the correct mode. To set up the controllers, check that the switch on the back of the controller is set the 'X' setting. Then when using the controller, make sure the LED next to the Mode button is off, if it is on press the Mode button to toggle it. When the Mode button is on, the controller swaps the function of the left Analog stick and the D-pad.

3.7 What does the code do?

The provided code implements the following robot controls in Teleoperated:

- Driver controller is an Xbox Controller in Slot 0 of the Driver Station
  - Controls the robot drivetrain using Split-stick Arcade Drive
    - Y-axis (vertical) of left stick controls forward-back movement of drivetrain
    - X-axis (horizontal) of right stick controls rotation of drivetrain
- Operator controller is an Xbox Controller in Slot 1 of the Driver Station
  - Left Bumper – Runs both note launcher wheels inward at different speeds while the button is held. This lets the robot intake a Note
  - A button – Runs a short sequence to launch a Note while the button is held
    - Starts front wheel running to get up to speed
    - Waits 1 second
    - Runs back wheel to feed Note into spinning front wheel

4 Overall Code Structure

The provided code utilizes the Command-Based programming structure provided by WPILib. This structure breaks up the robot's actuators into "subsystems" which are controlled by "commands" or collections of commands (aptly name "command groups"). The Command-Based structure may be a bit overkill for a robot of this complexity, but it scales very well for teams looking to add additional functionality to their KitBot, as well as providing a lot of helpful tools for handling timed actions and sequences as will be seen when looking at the code for the Note Launcher. Additionally, this structure was used by over 60% of teams in 2023, increasing the likelihood that teams around you may be able to provide assistance before or during the event.

To read more about the Command-Based structure, see the Command-Based Programming chapter of the WPILib documentation. You can also reference the API docs for the Python version of the commands library.

4.1 Ways of creating commands

There are multiple ways that you can define commands within the Command-Based structure. This project uses many of these different types in order to provide exposure to what they would look like in a full robot project. If one type feels odd to you or doesn't make a lot of sense, don't fret, you should be able to use the documentation of what the command does combined with the examples of other ways to create commands to re-create it in the form you prefer. The common ways of creating commands that are utilized in this project are:

- Defined as their own class in their own file (e.g. preparelaunch.py and launchnote.py)
- Via a "Command Factory method" in the subsystem (e.g. getIntakeCommand() in *launchersubsystem.py)
- Inline where the command is bound to a button or set as a default (e.g. line 49 of robotcontainer.py)

These same methods are also applicable to Command Groups. This project uses:

- Inline command group where binding occurs. This is done via "decorators", methods you can call on a command to turn it into a command group with specific properties, like "withTimeout" (e.g. line 62 of robotcontainer.py)
- Command Group Factory in its own file (autos.py)

This project does not create any Command Groups in their own file, an example can be seen at the bottom of the Command Groups page linked above as well as on the Organizing Command-Based Robot Project page.

Most teams will not use all these different styles in their code, instead opting to select one or two types that feel best for them.

5 Code Walkthrough

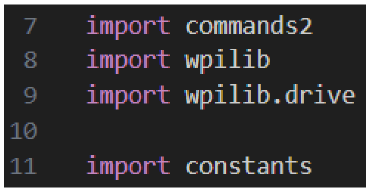
5.1 Subsystems

As described in the What is Command-Based Programming article, "'subsystems' represent independently-controlled collections of robot hardware (such as motor controllers, sensors, pneumatic actuators, etc.) that operate together". For the 2024 KitBot we have grouped the 6 motors into 2 groups, the Drivetrain, and the Launcher. For this robot, these choices were pretty easy, the 4 motors in the drivetrain always need to be working together to move the robot around the field and the 2 launcher motors must always be working together to manipulate Notes. Sometimes the boundaries between subsystems may not be so clear, if you have an arm with a shoulder and wrist joint and a set of motorized wheels on the end, is that all one subsystem or multiple? The general rule of thumb to follow is think about what actions, or commands, you might have to control the subsystems. Do you think you might want the two pieces to be controlled independent of each other (i.e. run the intake in or out while moving the arm or wrist?). If you're unsure, err towards more smaller subsystems; you can always make commands that require multiple subsystems but if you end up wanting separate commands to each control a single subsystem, you'll have to refactor the subsystem to split it up.

5.1.1 Pwm_drivesubsystem

This class is the subsystem for the drivetrain if you have wired your motor controller using PWM. If you have wired your motor controller signaling using CAN, see Section 3.4 for information on commenting out the usage of this class and replacing it with the CANDrivetrain class.

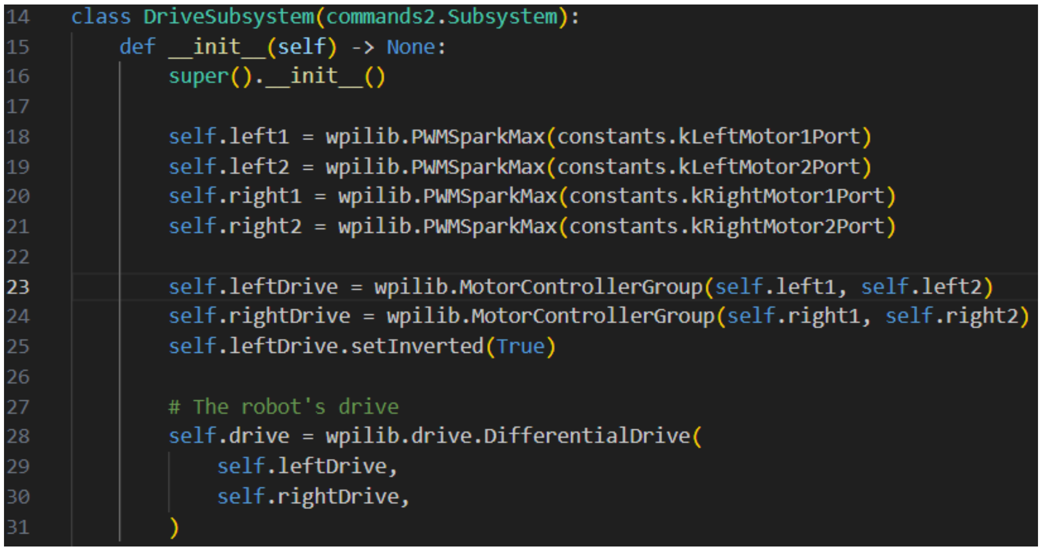
5.1.1.1 Imports



```
import commands2
import wpilib
import wpilib.drive

import constants
```

This section declares what other modules we need to reference within this code (imports). A common practice is to add imports as you go; as you find yourself referencing a module you have not yet imported, you can add an import for that class. In this subsystem we import the commands2 library, the WPILib library, and specifically the drive module in WPILib. The last thing we import is the "constants" module from this project where we declare things like port numbers and timings specific to the KitBot.

5.1.1.2 Class declaration and Constructor

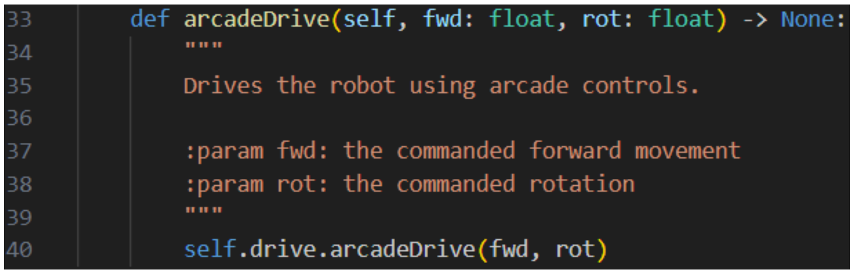


```python
class DriveSubsystem(commands2.Subsystem):
    def __init__(self) -> None:
        super().__init__()

        self.left1 = wpilib.PWMSparkMax(constants.kLeftMotor1Port)
        self.left2 = wpilib.PWMSparkMax(constants.kLeftMotor2Port)
        self.right1 = wpilib.PWMSparkMax(constants.kRightMotor1Port)
        self.right2 = wpilib.PWMSparkMax(constants.kRightMotor2Port)

        self.leftDrive = wpilib.MotorControllerGroup(self.left1, self.left2)
        self.rightDrive = wpilib.MotorControllerGroup(self.right1, self.right2)
        self.leftDrive.setInverted(True)

        # The robot's drive
        self.drive = wpilib.drive.DifferentialDrive(
            self.leftDrive,
            self.rightDrive,
        )
```

The first line of this image is the class declaration. This declares the name of our class and says that it's an extension of the Subsystem class. All subsystems should extend this class which provides some utility functions regarding setting the name of the subsystem, registering it with the scheduler, and sending information about it to the dashboard.

The next section is the constructor. Here we initialize any variables contained in the subsystem. In the case of our drivetrain, we initialize the 4 motor controllers, put them into a group for left and right, invert the left group so that a positive output moves both sides forward, and collect both sides into a WPILib DifferentialDrive object which describes the whole drivetrain.

5.1.1.3 Methods



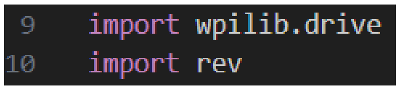
```python
    def arcadeDrive(self, fwd: float, rot: float) -> None:
        """
        Drives the robot using arcade controls.

        :param fwd: the commanded forward movement
        :param rot: the commanded rotation
        """
        self.drive.arcadeDrive(fwd, rot)
```

The remainder of the subsystem class is methods. Here we define any methods that commands may need to call to get status from or perform actions on the subsystem. For our simple drivetrain, the only method we need is the arcadeDrive method which simply passes the parameters through to the same method on the DifferentialDrive object.

5.1.2 Can_drivesubsystem

This class is the subsystem for the drivetrain if you have wired your motor controller using CAN. If you have wired your motor controller signaling using CAN, see Section 3.4 for information on commenting out the usage of PWM drivetrain and replacing it with the CAN drivetrain class. Most of the code is the same as the PWM drivetrain class described above. Differences are described below.

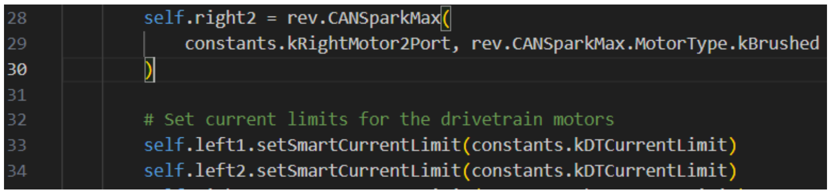
5.1.2.1 Imports



```python
import wpilib.drive
import rev
```

In addition to the imports in the PWM drivetrain class, an additional import is needed for the REV Robotics third party library. This module provides the functionality for controlling SPARK Maxs over CAN. You can find information about the objects and methods available from the "rev" module in the RobotPy documentation.

5.1.2.2 Constructor



```python
        self.right2 = rev.CANSparkMax(
            constants.kRightMotor2Port, rev.CANSparkMax.MotorType.kBrushed
        )

        # Set current limits for the drivetrain motors
        self.left1.setSmartCurrentLimit(constants.kDTCurrentLimit)
        self.left2.setSmartCurrentLimit(constants.kDTCurrentLimit)
```

Most of the constructor is the same, with two main differences. The first difference is that the controllers are instantiated using "rev.CANSparkMax" instead of "wpilib.PWMSparkMax". The CAN class requires specifying the motor type, which for the CIM motors used in the KitBot is "Brushed". The other difference is the addition of setting current limits on each of the motors. A current limit can help reduce the likelihood of slipping the wheels on the carpet as well as helping prevent the motors overheating.

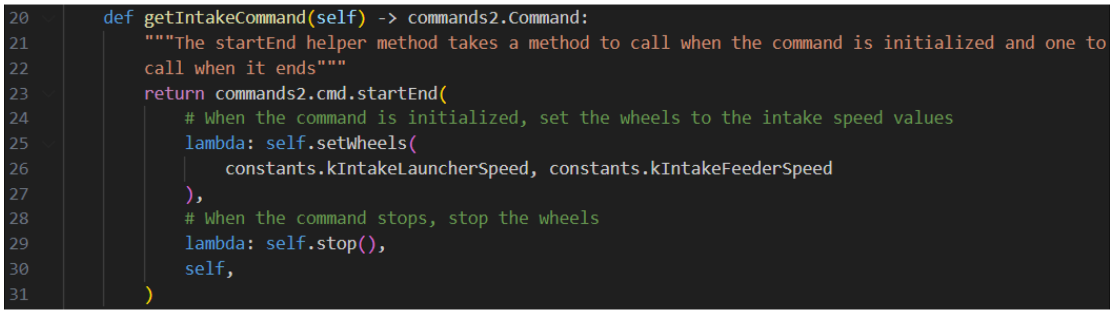
5.1.3 Pwm_launchersubsystem

This class is the subsystem for the launcher if you have wired your motor controller using PWM. If you have wired your motor controller signaling using CAN, see Section 3.4 for information on commenting out the usage of this class and replacing it with the CAN Launcher class.

5.1.3.1 Package, Imports, Class Declaration, Member Variables, and Constructor

The first sections of this subsystem are very similar to the PWM Drivetrain subsystem. See that section for more detailed description of each of these parts of the code. For the launcher, the two motors are created and controlled independently, no motor controller group or drivetrain object is used.

5.1.3.2 Methods – Command Factory



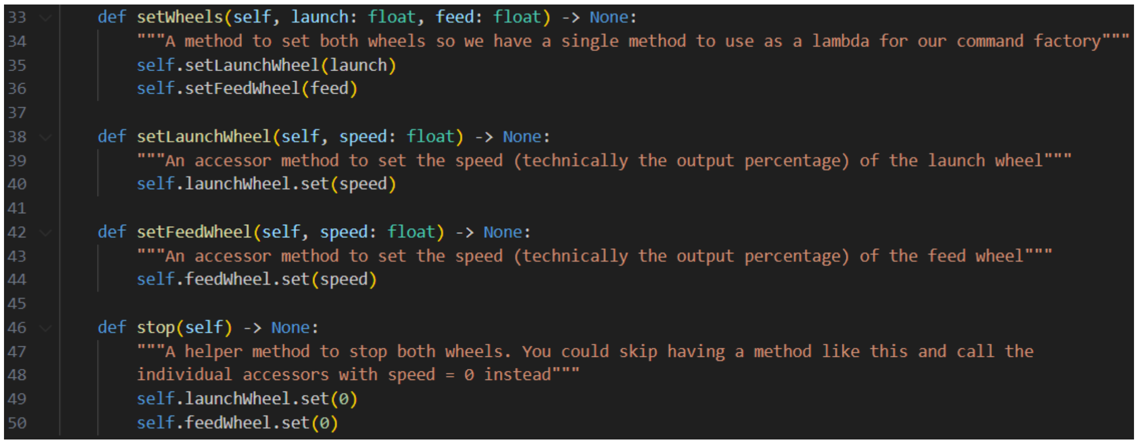
```python
    def getIntakeCommand(self) -> commands2.Command:
        """The startEnd helper method takes a method to call when the command is initialized and one to
        call when it ends"""
        return commands2.cmd.startEnd(
            # When the command is initialized, set the wheels to the intake speed values
            lambda: self.setWheels(
                constants.kIntakeLauncherSpeed, constants.kIntakeFeederSpeed
            ),
            # When the command stops, stop the wheels
            lambda: self.stop(),
            self,
        )
```

This method is what is called a "Command factory" because it creates instances of a command. We can call this method from wherever we are setting up buttons, creating command groups, etc. to get an instance of this command. The command itself is created using one of the inline command helpers (in this case startEnd). To see the different options available, check the API Doc for the Subsystem class and look for the methods that return a Command object (other than the first two).

In this case we use startEnd() which calls the first parameter when the command starts and the second parameter when the command is interrupted (e.g by a new command being scheduled or a button being released). When the command starts we want to start spinning both wheels inward at a specific speed to pull in a Note and when it ends we want to stop the wheels. The last parameter is the subsystem the command requires, which is passed using the keyword 'self' to indicate that it's this subsystem.

The programming technique used here is called a "lambda expression". To learn more about lambda expressions, check out this article about Python lambdas.

5.1.3.3 Methods – Hardware Control



```python
    def setWheels(self, launch: float, feed: float) -> None:
        """A method to set both wheels so we have a single method to use as a lambda for our command factory"""
        self.setLaunchWheel(launch)
        self.setFeedWheel(feed)

    def setLaunchWheel(self, speed: float) -> None:
        """An accessor method to set the speed (technically the output percentage) of the launch wheel"""
        self.launchWheel.set(speed)

    def setFeedWheel(self, speed: float) -> None:
        """An accessor method to set the speed (technically the output percentage) of the feed wheel"""
        self.feedWheel.set(speed)

    def stop(self) -> None:
        """A helper method to stop both wheels. You could skip having a method like this and call the
        individual accessors with speed = 0 instead"""
        self.launchWheel.set(0)
        self.feedWheel.set(0)
```

The remainder of the subsystem class is hardware access methods. Here we define any methods that commands may need to call to get status from or perform actions on the subsystem. For our launcher this includes methods to set the speed of each wheel and a method to stop both wheels at once. Because Python lambdas must be a single expression, a method to set both wheels at once is also used.

5.1.4 Can_launchersubsystem

This class is the subsystem for the launcher if you have wired your motor controller using CAN. If you have wired your motor controller signaling using CAN, see Section 3.4 for information on commenting out the usage of the PWMLauncher class and replacing it with the CANLauncher class.

5.1.4.1 Package, Imports, Class Declaration, Member Variables, and Constructor

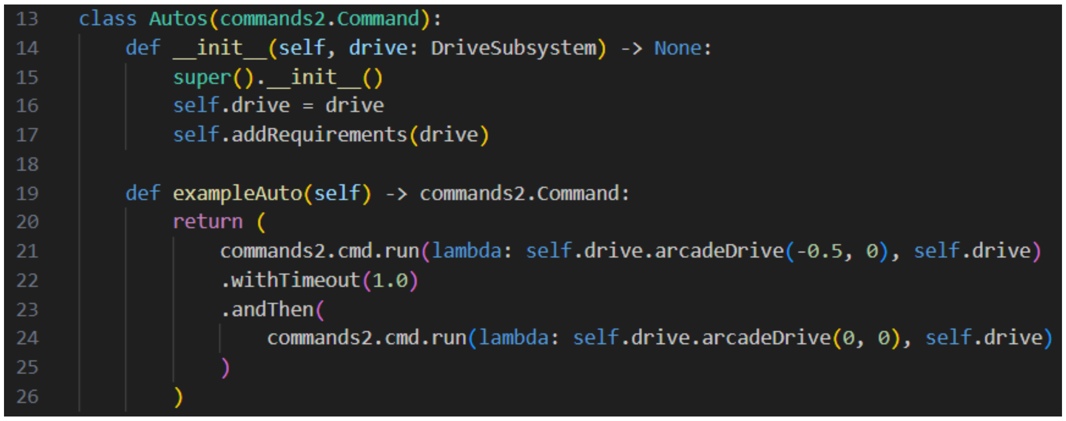
The subsystem contains elements of the CAN Drivetrain and the PWM Launcher mixed together, see those sections for descriptions of the various elements. The current limit is set to 80 amps, the SPARK Max default, to handle the short duration current surge when the Note hits the wheels.

5.2 Commands

This section will cover the 3 command files in the commands folder. Additional inline commands are defined in the RobotContainer file, they will be covered in the next section.

5.2.1 Autos

The Autos file is a slightly different example of a command factory. By separating the factory into a separate file it represents one of the ways to define complex groups that involve multiple subsystems (though our example here is not complex and requires only a single subsystem).



```python
class Autos(commands2.Command):
    def __init__(self, drive: DriveSubsystem) -> None:
        super().__init__()
        self.drive = drive
        self.addRequirements(drive)

    def exampleAuto(self) -> commands2.Command:
        return (
            commands2.cmd.run(lambda: self.drive.arcadeDrive(-0.5, 0), self.drive)
            .withTimeout(1.0)
            .andThen(
                commands2.cmd.run(lambda: self.drive.arcadeDrive(0, 0), self.drive)
            )
        )
```

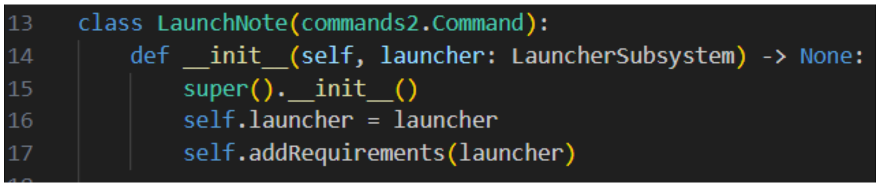
Our example file only has a single autonomous routine to get. You could easily extend this pattern by adding additional methods to define more autonomous routines and you could select between them using a SendableChooser on the dashboard.

This simple autonomous routine instructs the robot to drive backwards for 1 second at 50% power by using the withTimeout decorator to set a timeout of 1 second on the driving command. It uses the andThen decorator to tell the robot to stop moving after the first command is complete. The different types of command compositions that are built-in via decorators and factory methods are described on the Command Compositions page. You can find Python documentation for them on the API Doc page for the Command class.

5.2.2 LaunchNote

The LaunchNote command is the first of two examples in this project of a command as a standalone class defined in its own file. This structure is generally quite useful for complex commands but can be used for simple commands as well, as shown here, depending on preference. The LaunchNote command runs both wheels of the Launcher to eject the Note from the robot.

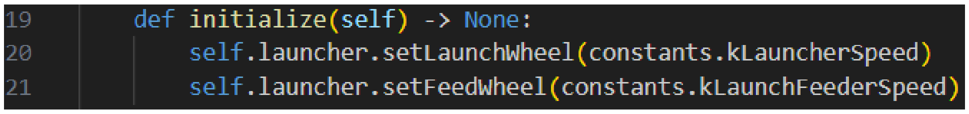
5.2.2.1 Class Definition and Constructor



```python
class LaunchNote(commands2.Command):
    def __init__(self, launcher: LauncherSubsystem) -> None:
        super().__init__()
        self.launcher = launcher
        self.addRequirements(launcher)
```

The first line in this section defines the class as an extension of Command. This base class defines many of the helper methods used to manage getting and setting requirements, interacting with the Scheduler, and handling decorators that modify the command or collect it into a group.

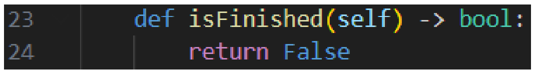
Next, we have the constructor. This constructor takes the subsystem as a parameter so it can be saved locally. We need to save the subsystem internally in order to call methods on it when the command is running. The last line of the constructor indicates that this command requires this subsystem. This requirements declaration is the glue that holds the Command-Based architecture together. Any command that performs any output actions on a subsystem must "require" that subsystem to help the Scheduler maintain only a single command controlling a subsystem at once.



```python
    def initialize(self) -> None:
        self.launcher.setLaunchWheel(constants.kLauncherSpeed)
        self.launcher.setFeedWheel(constants.kLaunchFeederSpeed)
```

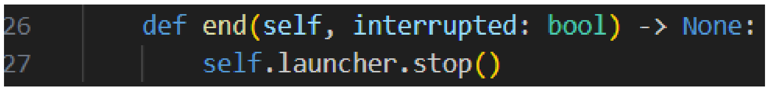
Next are the "lifecycle" methods of the command. These are the methods that are called when the command is scheduled (initialize), while it is running (execute, isFinished) and when it is done or interrupted (end). These methods are stubbed out in the base command class and are generally overridden by child classes. For the LaunchNote class, we set the wheels to a speed when the command is initialized. We can do this because the desired speed doesn't change while the command is running. If you wanted to change the speed while the command was running (based on a joystick input for example), setting these speeds in execute would be more appropriate.

Because our LaunchNote command uses a single speed set during initialize(), we don't have anything to do in the execute method so it's ommitted from the code. The empty method from the base class will be called for us. This method is called each scheduler run (generally every 20ms) while the command is running.



```python
    def isFinished(self) -> bool:
        return False
```

The isFinished() method is also called each run of the scheduler, after execute() to check if the command is finished running. In this case, we want the wheels to keep running as long as the operator is holding the button so we always return False to indicate the command is not finished. The Scheduler will handle canceling the command when the operator releases the button (covered more in the next section on RobotContainer).

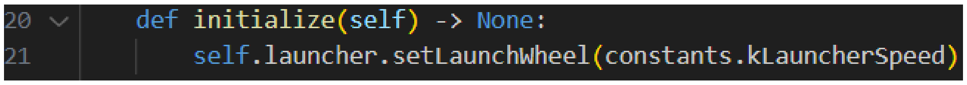


```python
    def end(self, interrupted: bool) -> None:
        self.launcher.stop()
```

The end() command is called when the command is being removed from the scheduler. You should perform any "clean-up" needed on your mechanism here. Often, but not always, you will want to stop the mechanism in this method, as is the case here. The scheduler passes in a boolean to indicate whether the command was interrupted or not (not interrupted = ended on it's own by returning True from isFinished()). In this case, we don't care whether the command was interrupted or not, we want to stop the wheels when the command ends.

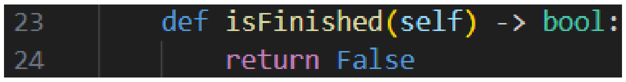
5.2.3 PrepareLaunch

The PrepareLaunch command is the second of two examples in this project of a command as a standalone class defined in its own file. The PrepareLaunch command spins just the outside wheel of the launcher to allow it to get up to speed before launching. The PrepareLaunch command code is almost identical to LaunchNote with two main exceptions.



```python
    def initialize(self) -> None:
        self.launcher.setLaunchWheel(constants.kLauncherSpeed)
```

In the initialize() method, the speed of the launch wheel (outside wheel) is set but the feed wheel is left alone so the Note is not yet fed into the launch wheel.



```python
    def isFinished(self) -> bool:
        return False
```

In the end() method we do not stop the wheels because we need the launch wheel to keep running as part of the launching sequence. This does mean that we have to handle stopping the wheel if the sequence is interrupted while running this command which we will cover in the RobotContainer section below.

5.3 Constants

This class contains named constants used elsewhere in the code. Sections are used to organize the constants into distinct groups delineated by comments.

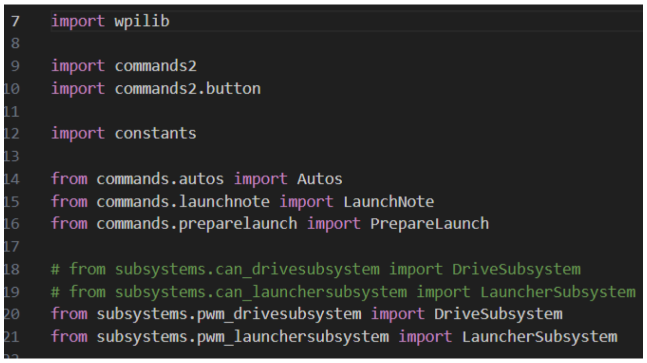
5.4 Robot

This file is identical to the default Command-Based template. You can find a description of the elements in the Robot class in the Structuring a Command-Based Robot Project article. While that article provides examples in Java, that should be pretty easily mapped to the Python equivalents.

5.5 RobotContainer

The RobotContainer class is where instances of the robot subsystems and controllers are declared and where default commands and mappings of buttons to commands are defined.

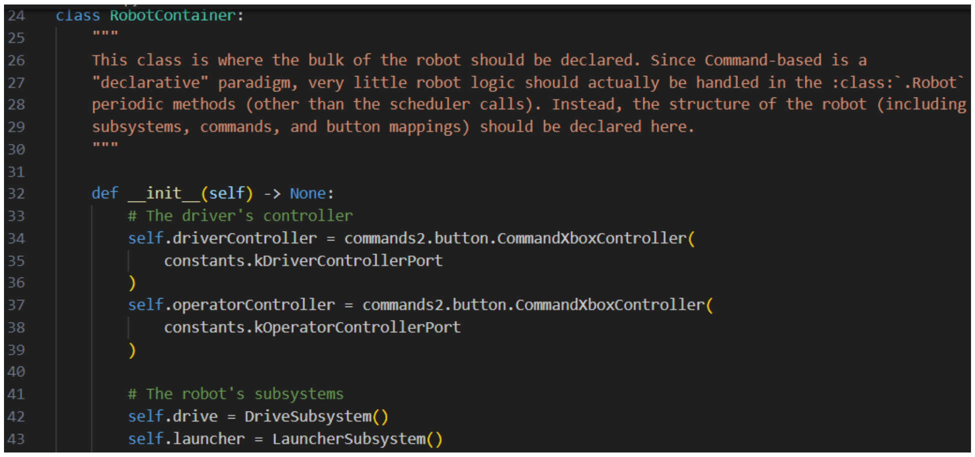
5.5.1 Imports



```python
import wpilib

import commands2
import commands2.button

import constants

from commands.autos import Autos
from commands.launchnote import LaunchNote
from commands.preparelaunch import PrepareLaunch

# from subsystems.can_drivesubsystem import DriveSubsystem
# from subsystems.can_launchersubsystem import LauncherSubsystem
from subsystems.pwm_drivesubsystem import DriveSubsystem
from subsystems.pwm_launchersubsystem import LauncherSubsystem
```

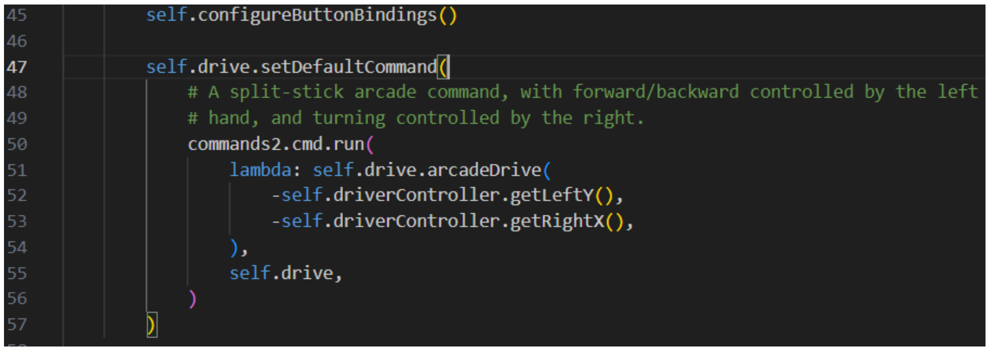
The first section of code is the imports. In this case we need to import wpilib, some elements from the commands module, the constants file from our project, and then all of our commands and subsystems.

5.5.2 Class definition and Constructor



```
class RobotContainer:
    """
    This class is where the bulk of the robot should be declared. Since Command-based is a
    "declarative" paradigm, very little robot logic should actually be handled in the :class:`.Robot`
    periodic methods (other than the scheduler calls). Instead, the structure of the robot (including
    subsystems, commands, and button mappings) should be declared here.
    """

    def __init__(self) -> None:
        # The driver's controller
        self.driverController = commands2.button.CommandXboxController(
            constants.kDriverControllerPort
        )
        self.operatorController = commands2.button.CommandXboxController(
            constants.kOperatorControllerPort
        )

        # The robot's subsystems
        self.drive = DriveSubsystem()
        self.launcher = LauncherSubsystem()
```

The first section of the constructor sets up some member variables in the class. For RobotContainer this generally includes all of your subsystems and control devices. This code uses the CommandXboxController class to represent the gamepads as it contains a number of helper methods that make it much easier to connect commands to buttons.

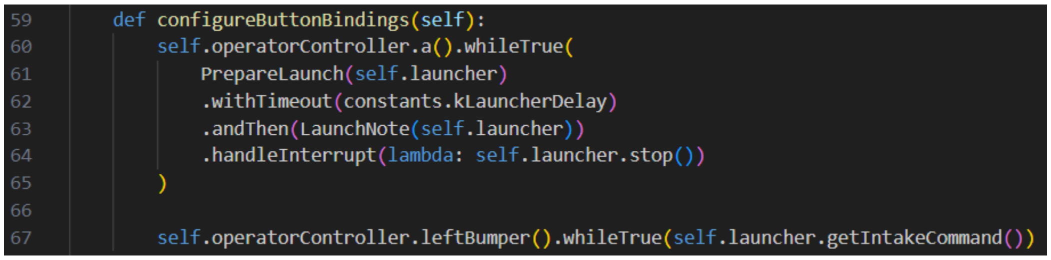


```
        self.configureButtonBindings()

        self.drive.setDefaultCommand(
            # A split-stick arcade command, with forward/backward controlled by the left
            # hand, and turning controlled by the right.
            commands2.cmd.run(
                lambda: self.drive.arcadeDrive(
                    -self.driverController.getLeftY(),
                    -self.driverController.getRightX(),
                ),
                self.drive,
            )
        )
```

Next is a call to configureBindings() which we will cover below. This method is used to set up button bindings and default commands. Finally, the constructor sets up the default command for the drivetrain using an inline command construction. We want a command to run on our drivetrain to allow us to drive the robot with joysticks whenever we don't have some other command using the drivetrain (like the exampleAuto command). To do this we use the setDefaultCommand() method of the subsystem. This sets the command that will run whenever the Scheduler sees nothing else running on that subsystem.

The inline command is defined using the run method from the [cmd package](). That package contains some helper methods for constructing groups from multiple commands as well as some methods to create inline commands. The run method is used to turn a single method call into a command. The method we pass to the run is inserted into the execute() section of the command lifecycle discussed in the LaunchNote section, meaning it will be called repeatedly while the command is scheduled.

In this code, the method we want to call is the arcadeDrive method of the drivetrain subsystem. For the forward/back movement we pass in the value from the Y-axis (vertical) of the left stick of the controller, but we negate it. This is because joysticks generally define pushing the stick away from you as negative and pulling the stick towards you as positive (a result of the original use being flight simulators). We want pushing the stick away from us to drive the robot forward so we negate the value. Similar for the turning value where we negate the X-axis (horizontal) of the right stick of the controller. The joystick considers pushing this to the right as a positive value, but the WPILib classes consider clockwise rotation (what would be expected when pushing the joystick right) as negative.



```
    def configureButtonBindings(self):
        self.operatorController.a().whileTrue(
            PrepareLaunch(self.launcher)
            .withTimeout(constants.kLauncherDelay)
            .andThen(LaunchNote(self.launcher))
            .handleInterrupt(lambda: self.launcher.stop())
        )

        self.operatorController.leftBumper().whileTrue(self.launcher.getIntakeCommand())
```

The configureBindings() method is where we put all of the glue code that tells commands when to run. The first section here is for the drivetrain.

First, we set up an inline command group to run a launch sequence while the operator holds the A button on the controller. We first use the a() helper method on the controller to get a Trigger and then use the whileTrue() method to run the command while the button is held, canceling it when the button is released. You can see other options available for Trigger methods on the Trigger API doc page or on the WPILib doc page about Binding Commands to Triggers.

The first command in our sequence is preparelaunch(). We then use the withTimeout() decorator to have this command run for a fixed time before ending. The andThen() decorator is used to run the launchnote command after the timeout expires. Finally, the handleInterrupt() decorator is used to provide a method to run if the command is interrupted; this is needed to make sure the wheels stop if the operator lets go of the button while the preparelaunch command is running as the end() method of that command won't stop the wheels by itself.

Next, we set up a binding to run the intake command while the Left Bumper button is held.

6 Making Changes

This section details some common possible changes you may want to make to the KitBot code and provides some references for how to approach making those changes.

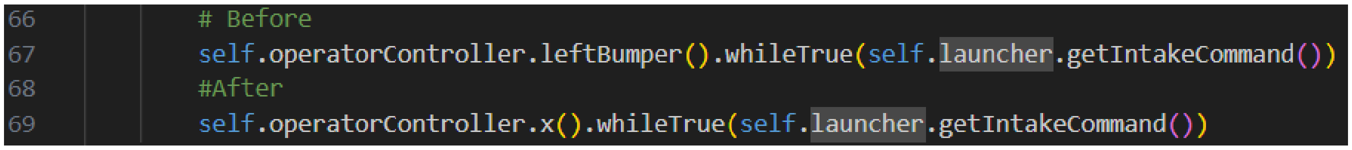
6.1 Changing buttons for actions

One of the easiest changes to make to Command-Based robot code is to switch what buttons or button behaviors control a command. The commands used in the 2024 KitBot do not end (isFinished always returns false) so they should generally only be used with the whileHeld() behavior, but changing which buttons they map to can be done very simply.

The button mappings in the example code are done near the end of the configureBindings() method inside the RobotContainer file. The bindings used for this project are made using the helper methods of the CommandXboxController class. These helper methods exist for each button on the controller and return a Trigger object which can then be used to specific a behavior for the binding.

As provided the code connects the **a** button to the launch sequence and the **leftBumper** to intaking a Note. To change these, simply change the a() or leftBumper() helper methods, to the method for any of the other buttons! You can see all of the available options by looking through the CommandXboxController APIDoc for methods which return a Trigger object.

For example, to change the intake command from the left bumper to the x button, simply replace the leftBumper() with x()



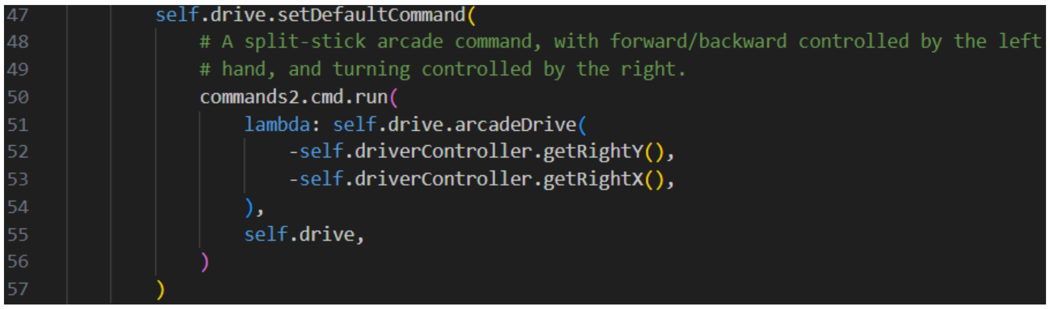
```
        # Before
        self.operatorController.leftBumper().whileTrue(self.launcher.getIntakeCommand())
        #After
        self.operatorController.x().whileTrue(self.launcher.getIntakeCommand())
```

6.2 Changing Drive Axis Behavior

Another easy change to make is to modify which axes of the controller are used as which part of the robot driving and how. The provided code does this mapping when setting up the drivetrain default command at the end of the constructor in RobotContainer.

The example code uses the Y-axis of the left stick to drive forward and back and the X-axis of the right stick to rotate. These can easily be swapped to the opposite sticks, or move just one so they are on the same stick! To review the available options, look for methods that return a **float** in the XboxController API Doc. To make this type of modification, locate the method call you wish to change, such as getLeftY(), and replace it with the new desired method, such as getRightY()

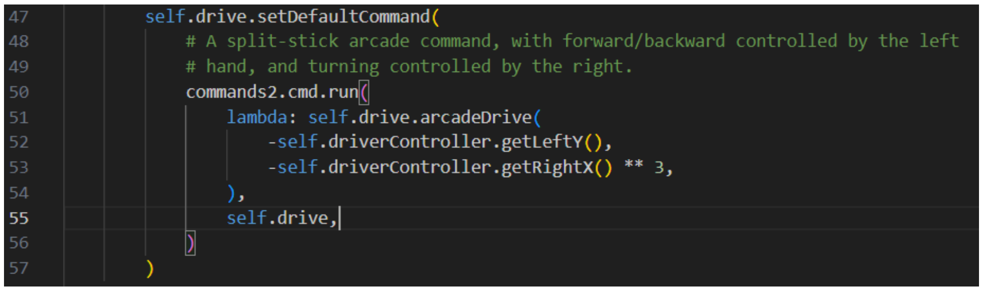
Example: changing the forward-back driving to the right stick Y-axis and leaving the rotation on the right X-axis



```
        self.drive.setDefaultCommand(
            # A split-stick arcade command, with forward/backward controlled by the left
            # hand, and turning controlled by the right.
            commands2.cmd.run(
                lambda: self.drive.arcadeDrive(
                    -self.driverController.getRightY(),
                    -self.driverController.getRightX(),
                ),
                self.drive,
            )
        )
```

You can also modify the axis values. One common modification is to cube the values. This preserves the sign of the value (positive stays postive, negative stays negative) and the maximum value (doesn't reduce the max speed of the robot) while providing less sensitivity at low inputs, potentially allowing for more precise control at low speeds. To make this type of modification, you can apply the modification to the axis where it's being captured.

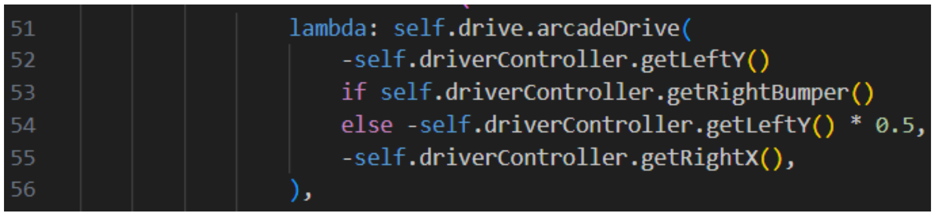
Example: changing only the rotation axis to be cubed:



```python
        self.drive.setDefaultCommand(
            # A split-stick arcade command, with forward/backward controlled by the left
            # hand, and turning controlled by the right.
            commands2.cmd.run(
                lambda: self.drive.arcadeDrive(
                    -self.driverController.getLeftY(),
                    -self.driverController.getRightX() ** 3,
                ),
                self.drive,
            )
        )
```

Another common modification is to scale the values down by default, but allow for the maximum value if a button is pressed (turbo mode). This type of modification can also be done at the point of capture, though as complexity grows, you may wish to shift from an inline command definition to a different type where you can define the command behavior more clearly.

Example: Scale the forward-back driving by 50% unless the right bumper is pressed



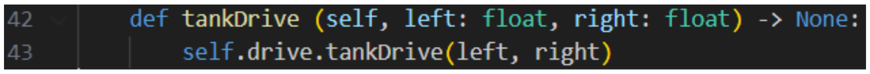
```python
                lambda: self.drive.arcadeDrive(
                    -self.driverController.getLeftY()
                    if self.driverController.getRightBumper()
                    else -self.driverController.getLeftY() * 0.5,
                    -self.driverController.getRightX(),
                ),
```

This example uses a shorthand if else construction called the ternary operator. This operator allows us to write a simple "if" statement in a very compact way, if the right bumper is pressed, we pass the full value, if not we multiply it by .5.

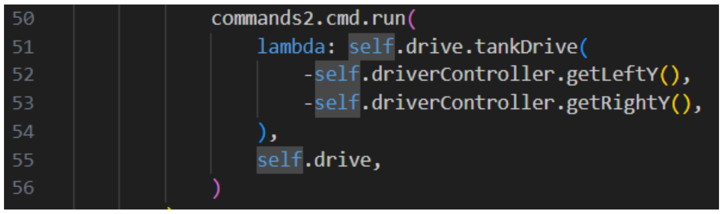
6.3 Changing Drive Type

The last likely change we will cover is changing from Arcade Drive to Tank Drive. Unlike Arcade drive which maps one axis to rotation and one to forward/back, Tank drive maps one axis (generally the Y-axis) to each side of a differential drivetrain. To make this change, you'll have to reach beyond RobotContainer as the provided drivetrain subsystems don't expose a tank drive method. In the appropriate drivetrain subsystem (PWMDrivetrain or CANDrivetrain) make a new method called tankDrive(). This method should look a lot like the arcadeDrive method. Then, modify the default command mapping in RobotContainer to use this new method with the appropriate joystick axis.

Example:



```python
    def tankDrive (self, left: float, right: float) -> None:
        self.drive.tankDrive(left, right)
```



```
            commands2.cmd.run(
                lambda: self.drive.tankDrive(
                    -self.driverController.getLeftY(),
                    -self.driverController.getRightY(),
                ),
                self.drive,
            )
```

6.4 Developing Autonomous Routines

The provided code contains a very basic autonomous mode that drives backwards at ½ power for 1 second. Additional autonomous modes can be developed, either by adding additional methods in the Autos file (see the Hatchbot Inlined example project for an example of this style with more complex autonomous) or by creating separate files for each autonomous routine (see the Hatchbot Traditional for an example of this approach).

It's common (but definitely not required!) to have multiple autonomous routines that you may wish to run based on different starting locations or strategies. If you pursue this, the most common way to choose between them for each match is to select between them using a SendableChooser on the dashboard.