FRC C++ Programming How-To’s

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# Projects

## Creating a new project

To try out new ideas or functionality away from the clutter of existing code, create a new project.

1. Open Eclipse.
2. *File 🡪 New 🡪 Project*…
3. *WPILib Robot C++ Development -> Robot C++ Project*.
4. Team Number = 4917 (if asked).
5. Choose a name.
6. Select *Command-Based Robot*.
7. *Finish*.

The project is now ready to use. You may have noticed that the project template includes an ExampleCommand and ExampleSubsystem. Once you have your own commands and subsystems defined, you can remove these example files.

## Moving a project to the Git repository

By default, new projects are created in your workspace directory. This may not be where you want it to live. For example, maybe you want it in your Git repo so you can share it with the team. To move an existing project, do the following.

1. In Eclipse, right-click the project you want to move and select *Delete*.
2. Make sure that *Delete project contents on disk* is **NOT** checked.
3. Click *OK*.
4. Using Windows Explorer (or similar), move your project folder to the new location.
5. In Eclipse, go to *File 🡪Import*.
6. Select *General 🡪 Existing Projects into Workspace*.
7. Click *Next*.
8. Click *Browse…* next to the *Select* *root directory* box.
9. Make sure your project is checked and click *Finish*.

# Joysticks

Other than running Auto, you can’t do much with the robot without configuring a joystick so it’s good to set up the basics early on. The joystick is handled in the OI class. OI stands for Operator Interface.

1. Open your project’s src/OI.h from the Project Explorer pane
2. Just below the includes, add a constant that links a user-friendly name to the joystick’s number (0 to 5)

e.g. const int DRIVER\_CONTROLLER\_PORT = 0;

1. In the class’s private section, add a Joystick pointer

e.g. std::unique\_ptr<Joystick> driverController;

1. Open src/OI.cpp
2. Create the joystick in the class’ constructor (OI:OI())

e.g. driverController.reset(new Joystick(DRIVER\_CONTROLLER\_PORT));

1. Save all of the files\* and build the project\*\*

\*To save all files, do a CTRL-SHIFT-S.

\*\*To build the project, right-click your project in the Project Explorer and click Build Project. Make sure that the build didn’t generate errors by clicking on Eclipse’s Console tab.

That’s it. You’re now ready to make use of the joystick(s).

# Subsystems

A “subsystem” is a group of all of the actuators and sensors that make something work. For example: the drivetrain, the box stacking mechanism, the ball shooting mechanism, the shot-alignment mechanism.

### Defining a new subsystem

1. Right-click the project folder in Eclipse’s Project Explorer.
2. Choose *New 🡪 Subsystem.*
3. For the Class Name, enter a descriptive name followed by *Sub*
   * e.g. DrivetrainSub
4. Click *Finish.*

The subsystem is now defined (we know what it looks like) but it doesn’t actually exist in a way that the robot can use.

### Adding the subsystem to the robot

1. Open src/CommandBase.h
2. Add an include for the new subsystem

e.g. #include “Subsystems/DrivetrainSub.h”

1. Create a pointer to the new subsystem by adding a line to the public section of the *CommandBase* class (above the OI entry).

e.g. static std::unique\_ptr<DrivetrainSub> drivetrainSub;

1. Open src/CommandBase.cpp
2. Near the top of the file, after the includes, initialize the new subsystem pointer

e.g. std::unique\_ptr<DrivetrainSub> CommandBase::drivetrainSub = NULL;

1. Create the subsystem by adding a line in CommandBase::init().

e.g. drivetrainSub.reset(new DrivetrainSub());

1. Open the subsystem’s cpp file

e.g. src/Subsystems/DrivetrainSub.cpp

1. Change Subsystem(“ExampleSubsystem”) to Subsystem(“*YourNewSubName*”)

e.g. DrivetrainSub::DrivetrainSub() : Subsystem("DrivetrainSub")

The robot can now use the new subsystem, but it doesn’t do anything yet.

### Setting up the subsystem’s hardware

1. Open the subsystem’s h file

e.g. src/Subsystems/DrivetrainSub.h

1. In the private section of the class, add a pointer for each piece of hardware that this subsystem uses. If you’re not sure what the subsystem will eventually use, add what you know and come back to fix it later.

e.g.

std::unique\_ptr<Talon> leftMotor1;

std::unique\_ptr<Talon> leftMotor2;

std::unique\_ptr<Talon> rightMotor1;

std::unique\_ptr<Talon> rightMotor2;

1. In the public section of the class, add a list of methods that can be used for controlling the subsystem. You can modify this list at any time.

e.g. void drive(float rSpeed, float lSpeed);

1. Open the subsystem’s cpp file again.
2. In the constructor (e.g. DrivetrainSub::DrivetrainSub()), initialize all the actuators and sensors that were defined in the h file. If the h file ever changes, don’t forget to update this section too.

e.g.

leftMotor1.reset(new Talon(LEFT\_MOTOR1\_PORT));

leftMotor2.reset(new Talon(LEFT\_MOTOR2\_PORT));

rightMotor1.reset(new Talon(RIGHT\_MOTOR1\_PORT));

rightMotor2.reset(new Talon(RIGHT\_MOTOR2\_PORT));

Note: This example assumes you’ve already defined the motor ports in src/RobotMap.h

1. Add the code for every method that was defined in the h file. Add, remove or modify them whenever the h file changes.

e.g.

void DrivetrainSub::drive(float rSpeed, float lSpeed)

{

leftmotor1->Set(lSpeed);

leftmotor2->Set(lSpeed);

rightmotor1->Set(rSpeed);

rightmotor2->Set(rSpeed);

}

1. Save all the files and build the project.

Your subsystem is now ready to be used.

# Commands

Commands are a list of one or more actions (really just calls to methods) that accomplish something over time. For example:

**Suck-in a ball**

1. Set the intake motor to rotate inwardly.
2. Keep checking the limit switch to determine if it has detected the ball.
3. Once it has detected the ball, stop the motor.

Commands are usually triggered by the joysticks.

## Creating a new command

1. Right-click the project folder in Eclipse’s Project Explorer.
2. Choose *New 🡪 Command.*
3. For the Class Name, enter a descriptive name followed by *Cmd*
   * e.g. BallIntakeCmd
4. Click *Finish.*

The command is now runnable … but doesn’t do anything yet.

## Configuring the command

Commands are made up of 6 methods and each of these methods lets you configure a different part of how the command works. When creating a new command you should think about what, if anything should go into each of these methods. Open src/Commands/*Name*Cmd.cpp and fill in the code as follows.

1. **The Constructor (i.e. the method that has the same name as the command)**

Here is where you list all of the subsystems that this command requires. If you will be calling a method from a subsystem anywhere in this command, then you should add a *Requires* entry for it. This is important because the robot has the ability to run multiple commands in parallel but doesn’t want to run two commands that use the same subsystem at the same time. For example, you don’t want to try going forward at the same time that you reverse.

e.g If this command will use the intake subsystem to move the robot, add Requires(intakeSub).

Note: If you get a casting error when using *Requires* with a unique\_ptr, use this format: Requires((Subsystem \*)(intakeSub.get()));

1. **Initialize()**

When a command is executed, the first thing it does is run this code. This is a good place to do any prep work for your command. For example, if you need to unlock your wheels before you can move, you would call the wheel-unlock method here.

For simple commands that don’t do something repeatedly and that don’t need to wait until something else happens to finish, you may only need to put code in this method. For example, if the command opens your robot’s hand with a pneumatic actuator, you would just call something like armSub->openHand() and your command is complete.

1. **Execute()**

This method is called continuously (several times a second). Here is where you put code that handles continuously handles input changes.

For example, if you are driving using a joystick, you want the motor speed to change based on how far the joystick is moved forwards or backwards. To do this, you’d add something like drivetrainSub->setSpeed(oi->getStickValue()) . That way, every time *Execute()* is called, the motor speed would get updated with the latest value from the joystick.

1. **IsFinished()**

This method determines when the command is finished. It’s called after every Execute() to determine if the command should keep running of not.

When it comes to this method, there are three types of commands.

1. Do something in Initialize() and that’s it. These commands simply return true; (*I’m done*). Continuing with the open-hand example, once you’ve told the robot to open the hand, you are done. You don’t have to check if to see if it’s opened far enough or if a limit switch has been hit.
2. Keep doing something until something else kills the command. These commands return false; (*I’m never quitting on my own*). An example of this is driving using a joystick. This command should always respond to changes in the joystick so it needs to execute all the time. If the joystick is centered, it will set the motor speed to zero and as soon as it is not zero it will set the speed accordingly.
3. Do something and then wait until something else happens. These commands will run code that checks to see if what you are waiting for has happened yet or not. If it hasn’t happened yet, it returns false. When it does happen, it returns true and the command ends.

For example, let’s say you wanted to suck a crate into your robot and that you know that the crate is safely inside when it hits a limit switch. In *Initialize()*, set the intake motor to turn inwards. In *Execute()*, you don’t need to do anything because nothing is changing during the command. In *IsFinished()* you add something like

return intakeSub->isLimitSwitchHit(). This means that the command will end once the limit switch is hit.

1. **End()**

The method handles any cleanup that needs to be done before the command really quits. It is kind of the opposite of *Initialize()*. It only happens once after *IsFinished()* returns true.

With the crate example above you may have noticed that we never actually turned the intake motor off after we determined that we had hit the limit switch. That’s because you would do that here.

1. **Interrupted()**

This method is like a special case of *End()*. If another command that starts running requires one or more subsystem that the current command requires, this command will end immediately after this method is executed.

Often, all you do here is call *End()*. That would be the case with the crate-intake example above. If another command wants to use the intake subsystem, just stop the motor and let them take over.

On the other hand, if leaving a crate half-in the robot would be really bad, you could add code to expel or release the crate before the command quits.

Now that the command’s behavior is defined, it’s ready to be used.

## Running the command

A command is usually run in response to something happening on a joystick. It can also be started by calling its Start() method (used for Autonomous mode) or by setting it as the default command for a particular subsystem.

### Tying a command to a joystick button

Buttons can trigger commands in multiple ways. Here’s a list of the methods that you can use:

* WhenPressed: The command is scheduled once when the button is pressed
* WhenReleased: The command is scheduled when the button is released
* WhileHeld: The command is scheduled repeatedly while the button is pressed
* ToggleWhenPressed: Like WhileHeld but you tap the button once to “hold” it and a second time to “release” it.
* CancelWhenPressed: Cancels a command that is currently executing

The steps to connect a command to a button are listed below. Note that this assumes that you’ve already created and configured a Joystick. For the examples, let’s call it *operatorController*.

1. Open OI.h
2. Below the includes, add a constant that links a user-friendly name to a joystick button number

e.g. const int BALL\_INTAKE\_BTN = 2;

1. In the private section of the class, add a JoystickButton pointer

e.g. std:unique\_ptr<JoystickButton> ballIntakeBtn;

1. Open OI.cpp
2. At the top, add an include for the command

e.g. #include “Commands/BallIntakeCmd.h”

1. Go to the constructor (OI::OI()) and create the joystick button

e.g. ballIntakeBtn.reset(

new JoystickButton(operatorController, BALL\_INTAKE\_BTN));

Note: If you get cast errors with this call, use this format instead

e.g. ballIntakeBtn.reset(

new JoystickButton((Joystick \*)(operatorController.get()), BALL\_INTAKE\_BTN));

1. Also, link the button to the command

e.g. ballIntakeBtn->WhenPressed(new BallIntakeCmd);

The button is now linked to the command. Anytime that button is pressed, that command will execute.

### Starting a command in Autonomous

The template already includes code that does this. Just un-comment the lines that are there to use your own command(s).

### Setting a command as the subsystem default command

You can assign each subsystem a command that it can execute when it’s not in use by any other command. For a drivetrain, this would be the drive-using-joystick command. When no other commands need the drivetrain, it simply does what the joystick(s) tell it to do.

1. Open the subsystem’s cpp file
2. In InitDefaultCommand(), set the default command (a template is in the comments)

e.g. SetDefaultCommand(new DriveCmd());

Future Topics

Command Groups

# Cheat Sheet

## New Subsystem

* Create a new Subsystem
* Class name is *Name*Sub (where *Name* is a descriptive name)
* In CommandBase.h
  + Add #include “Subsystem/*Name*Sub” near top
  + Add static std::unique\_ptr<*Name*Sub> *name*Sub; to CommandBase’s public section
* In CommandBase.cpp
  + Add std::unique\_ptr<*Name*Sub> CommandBase::*name*Sub = NULL; after includes
  + Add *name*Sub.reset(new *Name*Sub()); in CommandBase::init()
* In Subsystems/*Name*Sub.h’s
  + In the private section, add pointers for each of the subsystem’s actuators and sensors
    - std::unique\_ptr<*I/O-Class-Type*> *descriptiveName*;
  + In the public section, add methods for controlling the subsystem
* In Subsystems/*Name*Sub.cpp
  + Change Subsystem(“ExampleSubsystem”) to Subsystem(“*Name*Sub”)
  + In the constructor, initialize all of the actuators and sensors defined in the h file
    - *descriptiveName*.reset(new *I/O-Class-Type*(*parameters*));
  + Add the code for every method that was defined in the h file

## New Command

* Create a new Command.
* Class name is *Name*Cmd (where *Name* is a descriptive name)
* In Commands/*Name*Cmd.cpp
  + Add code to the constructor, Initialize(), Execute(), IsFinished(), End() and Interrupted() as appropriate
* In OI.h
  + Add a constant for the button number below the includes
    - const int *NAME*\_BTN = 2
  + In the class’ private section, add a pointer for the button
    - std:unique\_ptr<JoystickButton> *name*Btn;
* In OI.cpp
  + Add an include for the command
    - #include “Commands/*Name*Cmd.h”
  + In the constructor, create the button
    - *name*Btn.reset(new JoystickButton(*controller*, *NAME*\_BTN));
  + Also link the button to the command
    - *name*Btn->WhenPressed(new *Name*Cmd);