

FTC Auton with Pedro Pathing

Kanthan Rajendran
Infinity Tech Mentor



FTC Canton Kickoff
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Agenda

- Auton Overview
- Localization & Odometry
- Pedro Pathing Setup & Tuning
- Auton OpMode



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Auton Overview



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What is Auton?

- The first 30 seconds of an FTC match
- Robots operate with only their preprogrammed instructions
- Drivers may not provide input to their robots



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Why is Auton Important?

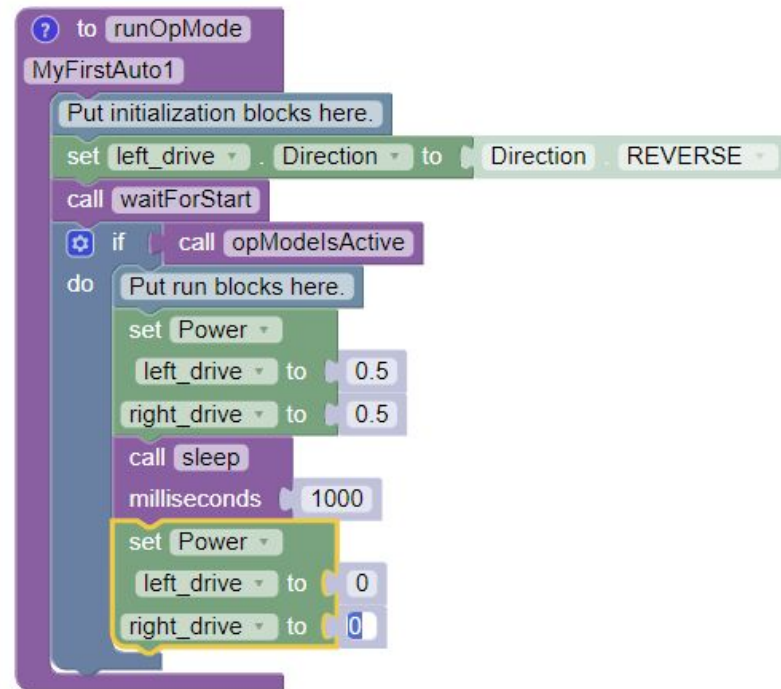
- Points scored in Auton are essentially DOUBLED!
- First Tie Breaker in Qualification Ranking
- Makes your team an attractive alliance partner



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How to Auton?

- Pre-programmed code sequence
 - Easier to implement
 - Not very accurate
- Path Follower
 - More effort but much more accurate
 - Roadrunner or **PedroPathing**



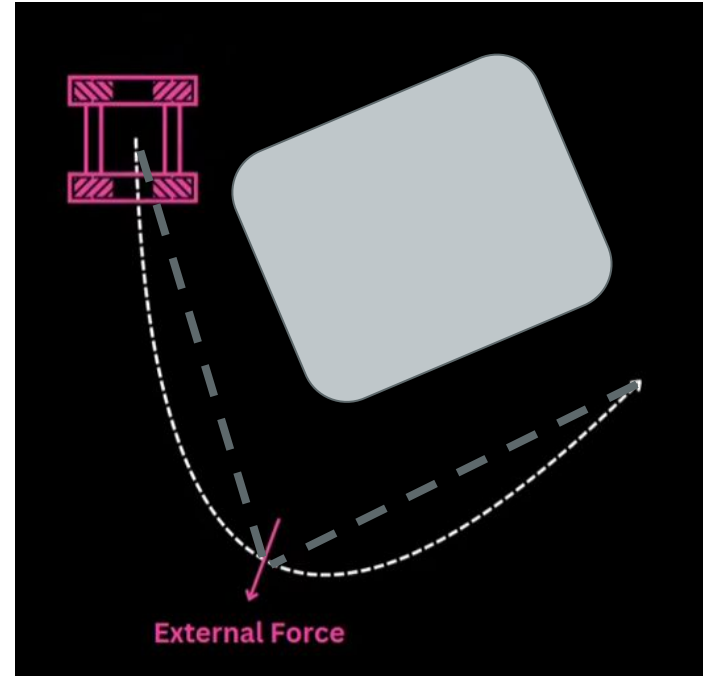
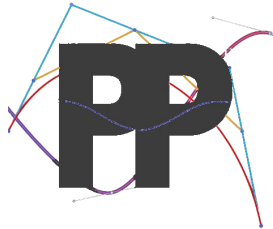
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Pedro Pathing Overview

- Advanced Reactive Vector Follower developed by FTC Team 10158
- Uses Bézier curves to produce smoother, more efficient trajectories
- Dynamic Adjustments: Reacts to obstacles or changes in the environment in real-time
- More intuitive to tune and setup than Roadrunner

www.pedropathing.com

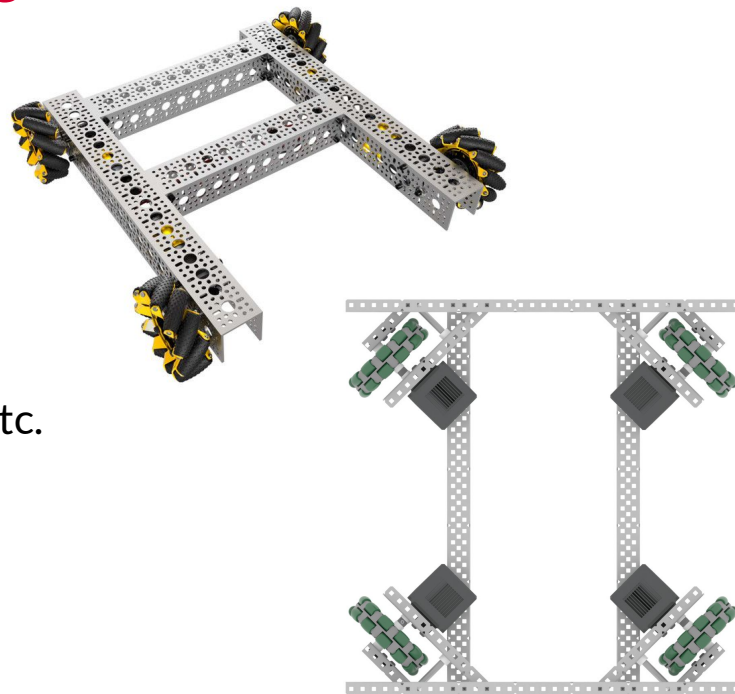


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Pedro Pathing Prerequisites

- Omni-Directional Drive
 - Mecanum, X-Drive, or Swerve
 - **No** tank drive robots
- Localization
 - Motor encoder, dead-wheel odometry, etc.
- Android Studio
 - **No** Blocks or OnBot Java



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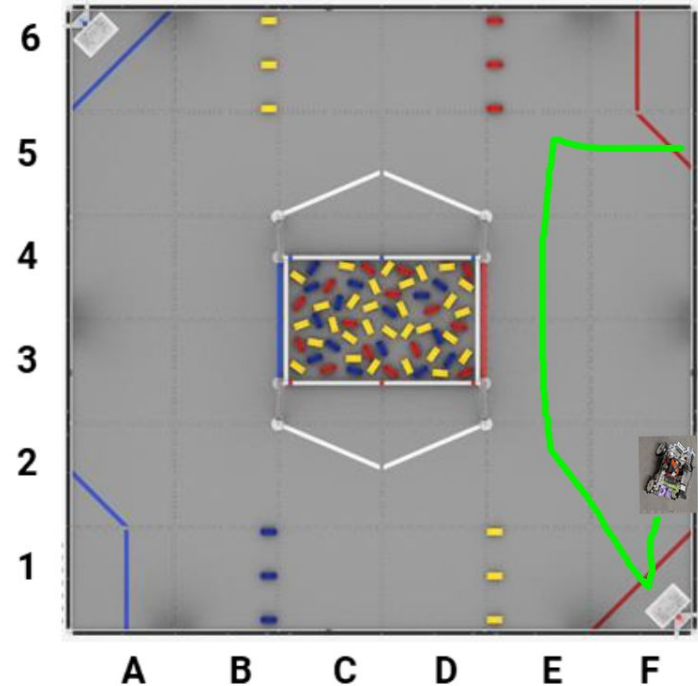
Localization & Odometry



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Localization

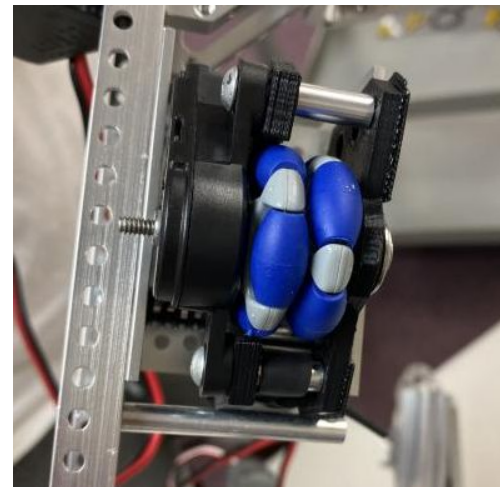
- **Localization** is the process of the robot determining its **position** and **orientation** on the game field
- Localization is essential for **autonomous** driving.



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Localization Options

- **Drive Motor Encoder** ← **Least accurate**
- **Dead-Wheel Odometry** ← **Standard option**
 - Two-Wheel + IMU
 - Three-Wheel
 - Three-Wheel + IMU
 - Pinpoint
- **OTOS** ← **New tech**
 - Optical Tracking Odometry Sensor



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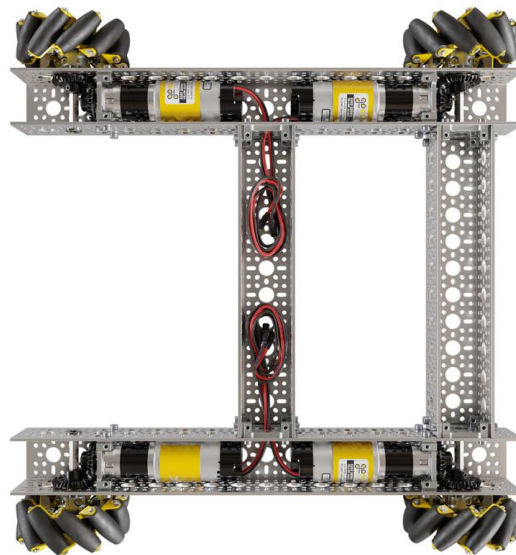
Drive Motor Encoder

Localization can technically be achieved using the encoders on the drive motors

But...

- Mecanum wheels suffer from slippage, which leads to drift
- built-in encoders are not as precise
 - 1 motor rotation = 538 ticks

Odometry pods are better



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Deadwheel Odometry Pods



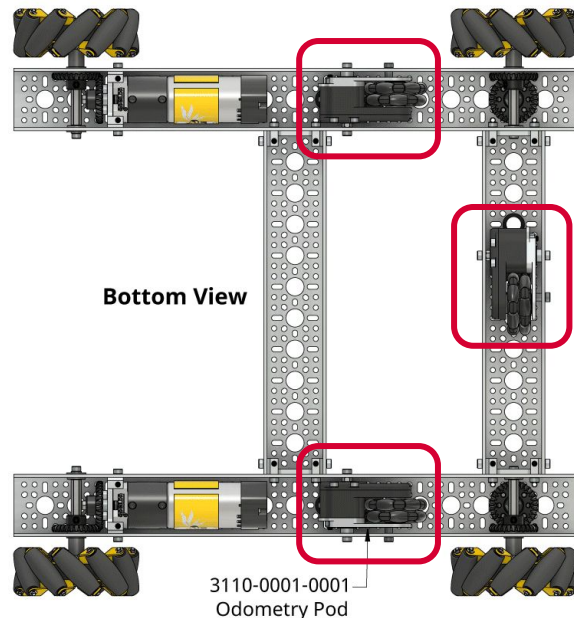
Swingarm Odometry Pod



4-Bar Odometry Pod

Both fit within GoBilda U-channels!

\$75 each (Minimum 2 needed)



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Pinpoint Odometry



Pinpoint Odometry Coprocessor

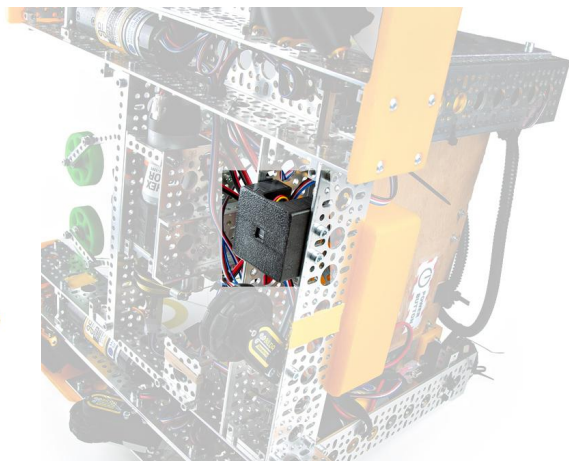
- Localization calcs performed by Pinpoint
- Requires 2 odometry pods
- Built in IMU
- \$60 (+ \$150 for 2 odometry pods)



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OTOS



- Lasers to track robot position (like computer mouse)
- Compact, light, and simple
- Requires exact 10 mm distance from FTC field tiles
- \$85

Optical Tracking Odometry Sensor

New tech - effectiveness and accuracy unclear



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Pedro Pathing Setup & Tuning



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PedroPathing Setup Step by Step

- Installation
- Constants
- Robot Setup
- Localization
- Auto Tuners
- PID Tuners
- Testing

This example is for a
Three Wheel Localizer
but similar steps are
described for other
localizers in PP website



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PedroPathing Setup - Installation

Setup FTC SDK with PedroPathing libraries in Android Studio.

Option 1

Download Quickstart and open in Android Studio

<https://github.com/Pedro-Pathing/Quickstart>

Option 2

In Android Studio, go to Main Menu -> File -> New -> Project from Version Control.

For the URL, enter <https://github.com/Pedro-Pathing/Quickstart>.



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PedroPathing Setup - Constants

Constants file in the pedroPathing package.

1. **Follower constants** - values from the automatic, PID, and centripetal tuners
2. **Drivetrain constants** - constants specific to your drivetrain type.
3. **Localizer constants** - constants specific to your localizer.
4. **Path constraints** - determine under what conditions a path may end.

Follow steps on pedropathing.com and add lines to Constants file for various settings



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PedroPathing Setup - Drivetrain Setup

- Set Mecanum drive motor names and directions

```
public static MecanumConstants driveConstants = new MecanumConstants()  
    .leftFrontMotorName("motorFrontLeft")  
    .leftRearMotorName("motorRearLeft")  
    .rightFrontMotorName("motorFrontRight")  
    .rightRearMotorName("motorRearRight")  
    .leftFrontMotorDirection(DcMotorSimple.Direction.REVERSE)  
    .leftRearMotorDirection(DcMotorSimple.Direction.REVERSE)  
    .rightFrontMotorDirection(DcMotorSimple.Direction.FORWARD)  
    .rightRearMotorDirection(DcMotorSimple.Direction.FORWARD)
```



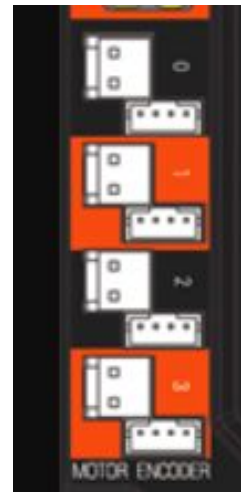
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PedroPathing Setup - Localization

- Set motor ports that encoders are connected to
- Run `LocalizationTest`:
 - x-coordinate should increase when robot is pushed forward
 - y-coordinate should increase when robot is pushed left

```
public static ThreeWheelConstants localizerConstants
= new ThreeWheelConstants()
    .leftEncoder_HardwareMapName("motorFrontLeft")
    .rightEncoder_HardwareMapName("motorRearRight")
    .strafeEncoder_HardwareMapName("motorFrontRight")
    .leftEncoderDirection(Encoder.FORWARD)
    .rightEncoderDirection(Encoder.REVERSE)
    .strafeEncoderDirection(Encoder.FORWARD);
```



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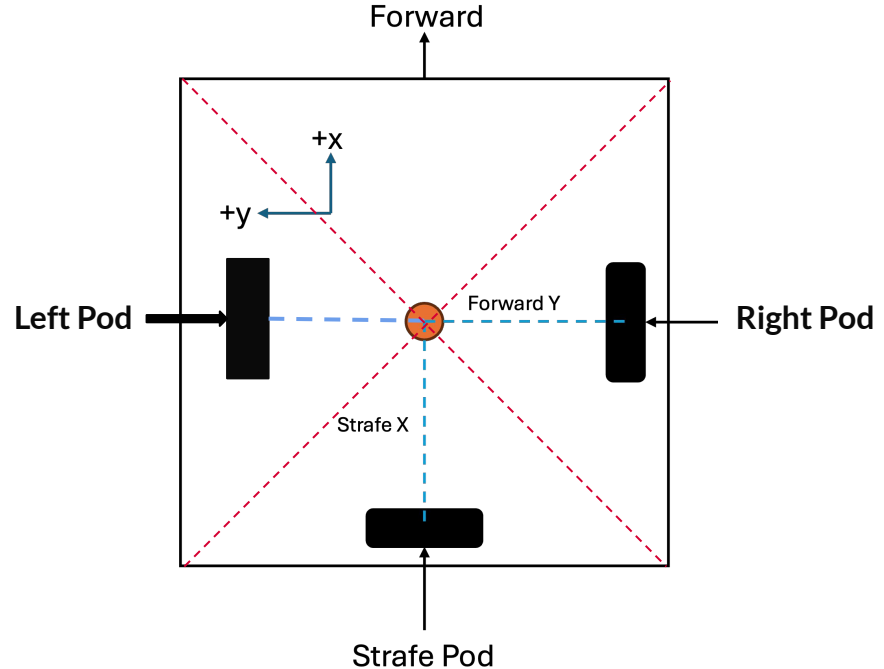
PedroPathing Setup - Localization

- Measure offset of odometry pods from robot's **center of rotation** in inches

```
.leftPodY(1)
```

```
.rightPodY(-1)
```

```
.strafePodX(-2.5)
```



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PedroPathing Setup - Localization

- Run Forward Tuner
- Run Lateral Tuner
- Run Turn Tuner

Determine how **encoder ticks** convert to real-world robot movement

```
.forwardTicksToInches(.001989436789)
```

```
.strafeTicksToInches(.001989436789)
```

```
.turnTicksToInches(.001989436789)
```



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PedroPathing Setup - Velocity Tuners

- Run ForwardVelocityTuner and LateralVelocityTuner

```
.xVelocity(78.2619)  
.yVelocity(61.4945);
```

Determine **robot velocity**
at full motor power



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PedroPathing Setup - Follower Tuners

- Weigh the robot in kilograms (for centripetal force compensation)
- Run ForwardZeroPowerAccelerationTuner and LateralZeroPowerAccelerationTuner

```
public static FollowerConstants followerConstants = new  
FollowerConstants()  
    .mass(16.2)  
    .forwardZeroPowerAcceleration(-25.9346)  
    .lateralZeroPowerAcceleration(-67.3425)
```

Determine robot
deceleration



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PedroPathing Setup - Follower Tuners

- Run Translational Tuner
- Run Heading Tuner
- Run Drive Tuner

Determine **PID coefficients** for smother robot movements

```
.translationalPIDFCoefficients(new PIDFCoefficients(0.1, 0, 0.01, 0))  
.headingPIDFCoefficients(new PIDFCoefficients(0.1, 0, 0.01, 0))  
.drivePIDFCoefficients(new FilteredPIDFCoefficients(0.1,0.0,0.01,0.6,0.0));
```



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PedroPathing Setup - Build Follower

```
public static PathConstraints pathConstraints  
= new PathConstraints(0.99, 100, 1, 1);
```

Determine when a path is
considered complete

```
public static Follower createFollower(HardwareMap hardwareMap) {  
    return new FollowerBuilder(followerConstants, hardwareMap)  
        .mecanumDrivetrain(driveConstants)  
        .threeWheelLocalizer(localizerConstants)  
        .pathConstraints(pathConstraints)  
        .build();  
}
```

Build the follower



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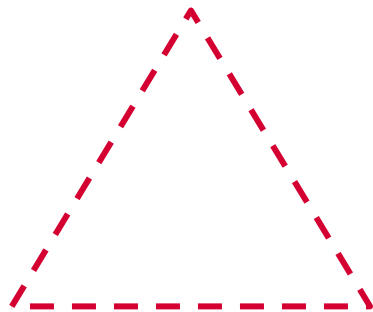
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PedroPathing Setup - Tests

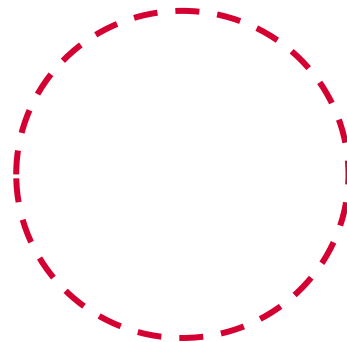
- OpModes to move robots in different patterns to check whether robot has been tuned properly



Line



Triangle



Circle

Note: If you modify the robot and mechanisms, add weight, etc., you will need to tune again



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Pedro Pathing

Auton OpMode



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Auton OpMode Setup

- Define **Poses**
- Build **Paths**
- Switch Case Construct
- Execute

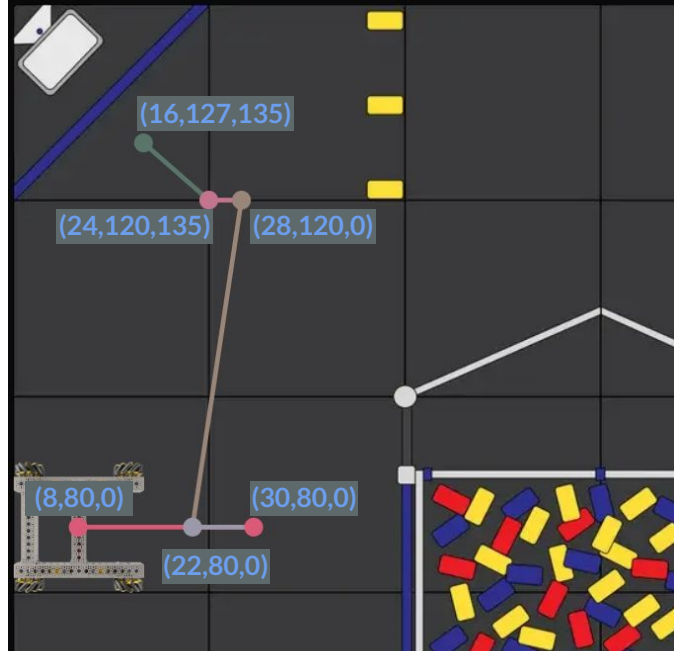
Tip: Start with an **example opmode**
from PedroPathing



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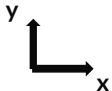
Poses



Pose specifies the robot position and heading

Pose(x, y, Θ)

```
private Pose startPos = new Pose(8, 80,
Math.toRadians(0));
private Pose chamberApproachPose = new Pose(30,
80, Math.toRadians(0));
private Pose chamberReversePose = new Pose(22,
80, Math.toRadians(0));
private Pose spikeYellowRightPose = new
Pose(28, 120, Math.toRadians(0));
private Pose basketRedPose = new Pose(24, 120,
Math.toRadians(135));
private Pose basketRedScorePose = new Pose(16,
127, Math.toRadians(135));
```



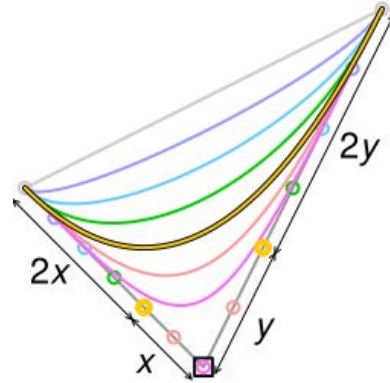
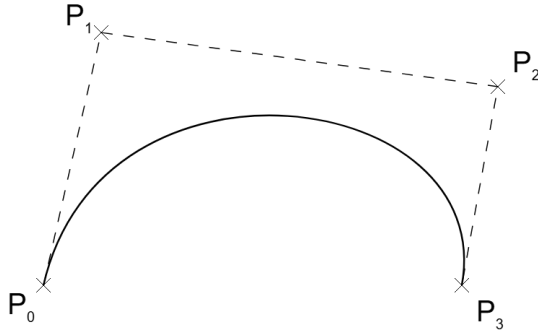
Note: All headings are in radians



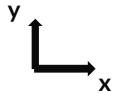
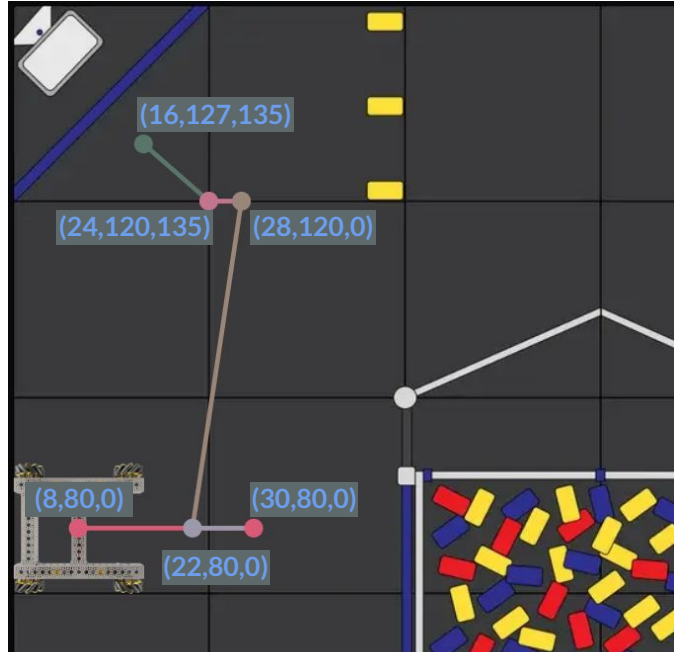
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Bezier Curves

- A smooth, continuous curve defined by a set of discrete "control points"
- First and last control points are always the endpoints of the curve
- Intermediate control points define the curvature; generally do not lie on the curve



Pathchains



Pathchains are defined routes for the robot to follow

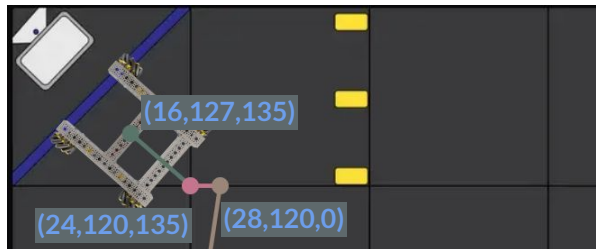
- Bezier Line

```
driveToChamber = follower.pathBuilder()  
    .addPath(new BezierLine(new Point(startPose),  
new Point(chamberApproachPose)))  
    .setConstantHeadingInterpolation(0)  
    .setPathEndTimeoutConstraint(0)  
    .build();
```



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Pathchains



Pathchains are defined routes for the robot to follow

- Bezier Curve + Bezier Line

```
driveToBasket1 = follower.pathBuilder()
    .addPath(new BezierCurve(new Point(spikeYellowRightPose), new Point(basketRedPose)))
    .setLinearHeadingInterpolation(spikeYellowRightPose.getHeading(),
basketRedPose.getHeading())
    .addPath(new BezierLine(new Point(basketRedPose), new Point(basketRedScorePose)))
    .setConstantHeadingInterpolation(basketRedPose.getHeading())
    .setPathEndTimeoutConstraint(0)
    .build();
```

Note: You can chain as many `addPath` and heading methods as you want



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Switch Case Construct

```
public void autonomousPathUpdate() {  
    switch (pathState) {  
        case 1: // raise elevator and set arm position  
            targetPos = HIGH_CHAMBER_AUTON_POS;  
            servoArm.setPosition(ARM_SERVO_DN_POS);  
            setPathState(2);  
            break;  
        case 2: // drive to chamber  
            follower.followPath(driveToChamber);  
            setPathState(3);  
            break;  
        case 3: // timer for robot to reach chamber  
            if (pathTimer.getElapsedTime() > 1400) {  
                setPathState(4);  
            }  
            break;  
    }  
}
```

Tip: Add one or two switch cases at a time; test before adding more



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Switch Case Construct

```
case 4: // clips specimen
    targetPos = HIGH_CHAMBER_AUTON_CLIP_POS;
    if (pathTimer.getElapsedTime() > 600) {
        setPathState(5);
    }
    break;
case 5: //lets go of the specimen
    servoClaw.setPosition(CLAW_SERVO_AUTON_OPEN_POS);
    if (pathTimer.getElapsedTime() > 500) {
        setPathState(6);
    }
    break;
case 6: //drive away from chamber
    if (!follower.isBusy()) {
        follower.followPath(driveAwayFromChamber);
        setPathState(7);
    }
    break;
```

Tip: Play around with timer setting



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Switch Case Construct

```
case 7: // lower the slide and set arm and claw
    if (pathTimer.getElapsedTime() > 800) {
        targetPos = LINEAR_SLIDE_LOW_POS;
        servoArm.setPosition(ARM_SERVO_UP_POS);
        servoClaw.setPosition(CLAW_SERVO_OPEN_POS);
        setPathState(8);
    }
    break;
case 8: // drive to yellow right specimen
    if (!follower.isBusy()) {
        follower.followPath(driveToYellowRight);
        setPathState(9);
    }
    break;
```



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Resources

- Pedro Pathing website
 - pedropathing.com
- Game Manual 0
 - gm0.org
 - Great resource for FTC teams



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