

LAWRENCE TECHNOLOGICAL UNIVERSITY
ROBOFEST 2022 **GAME**

OceanBots

Spike Prime/Robot Inventor
with Python Game Workshop

This file can be found under the **eAcademy > Workshops** page on the website

www.robofest.net

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2022 Workshops

Presented by

Lawrence Technological
University
Computer Science

Course Overview

- 2022 Robofest competition OceanBots
 - Autonomous robot that get points by moving Turtles and Trash objects
- Workshop Robot introduction
- Using the Workshop Robot to solve the OceanBots challenge

2022 Robofest Competition

- Video overview
- Key tasks

Task 0: Finding the edge of the table

Task 1: Following the edge of the table

Task 2: Stop line following when you reach a corner

Task 3: Stop line following when you reach a given distance

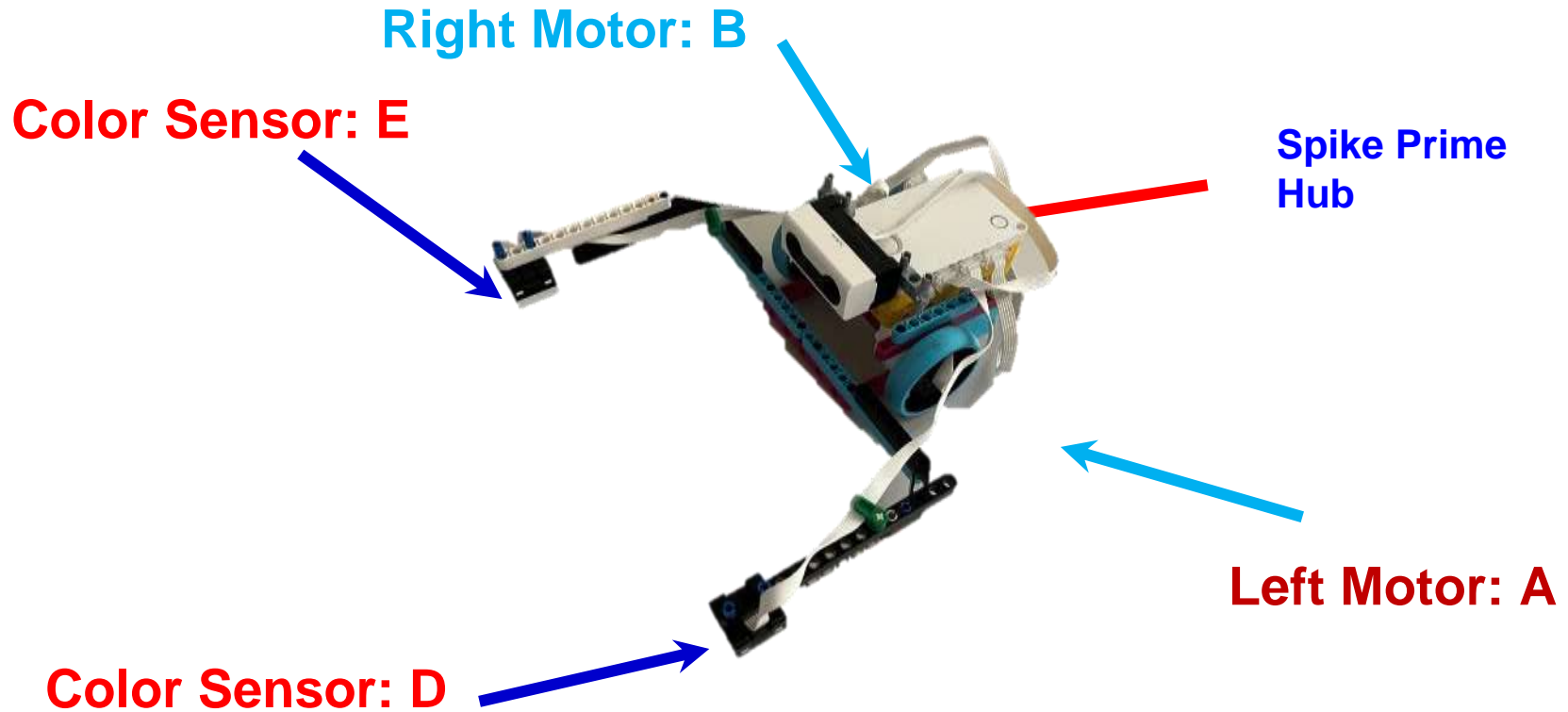
Task 4: Turning the robot

Task 5: Aligning the robot to an edge

Task 6: Building Functions

Task 7: Gyro Turns

LEGO Spike Prime robot used



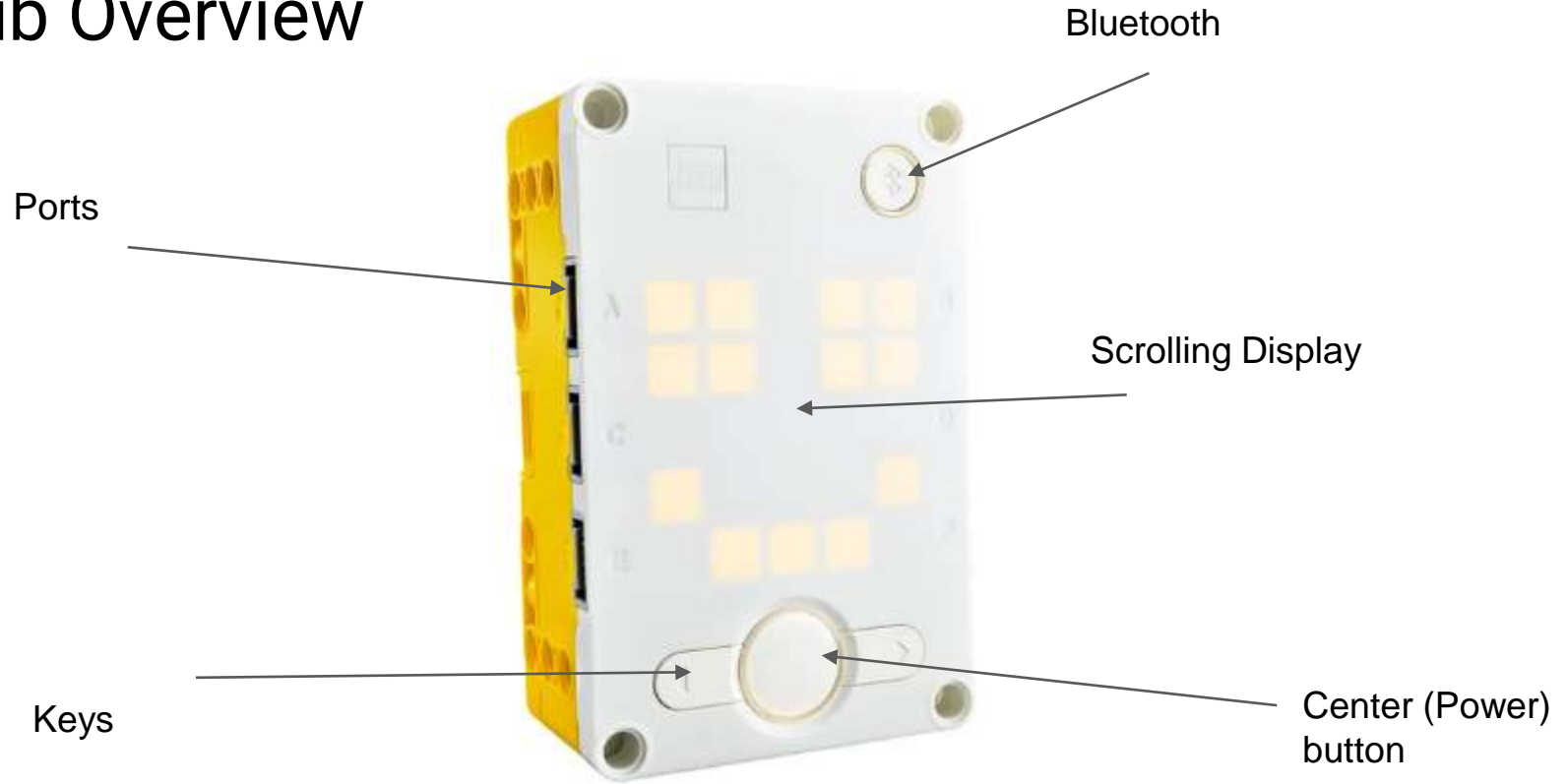
Remember the connections!

- Left Motor connects to **A**
- Right Motor connects to **B**
- RH Color sensor connects to **E**
- LH Color sensor connects to **D**

Software Versions Used

- Examples used Version **2.0.4**
 - Download
 - <https://education.lego.com/en-us/downloads/spike-prime/software>
- Presentation and all example programs are available at robofest.net under Tech Resources

Hub Overview



Start a New Program

- Create new program using icon or “File>new project”
- Select “Python” option



NEW PROJECT

Create new Programming Canvas

New Project

OB_Workshop|



Connect to Hub

- Two options
 - USB Cable
 - Bluetooth
- Follow instructions in software



```
LEGO Education SPIKE - 1.3.3
File View Window Help
Project 1 PyAlign
Connect
1 from spike import PrimeHub, LightMatr
2 from spike.control import wait_for_se
3 from math import *
4
5 hub = PrimeHub()
6
7 hub.light_matrix.show_image('HAPPY')
8
```

Connect Hub

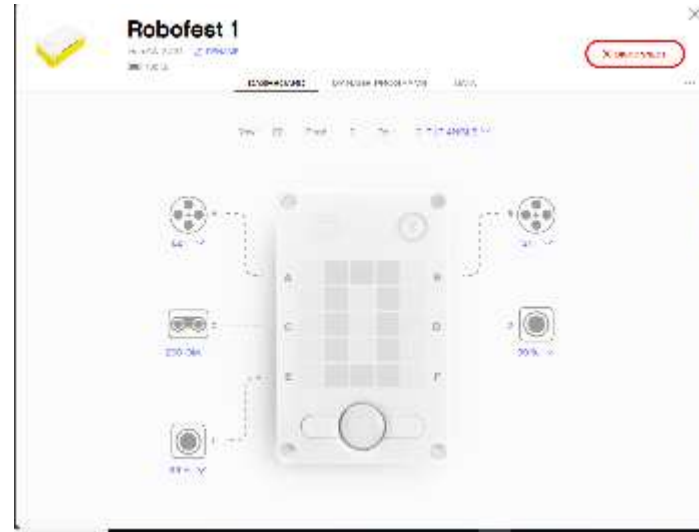
1. Turn on the Hub.
2. Activate Bluetooth.
3. Connect.



Choose your hub



Hub Settings



Configure Motors And Sensors



The screenshot shows a Python IDE window titled "LEGO Education SPIKE - 1.3.3". The menu bar includes "File", "View", "Window", and "Help". The address bar shows "PyFindEdge". The toolbar contains icons for a home button, a green lightbulb, and sensors A, B, D, E, and F with their respective values: 200°, 200°, 10, 10, and 200um. The code in the editor is as follows:

```
1 from spike import PrimeHub, LightMatrix, Button, Statuslight, ForceSensor, MotionSensor, Speaker, ColorSensor, App, DistanceSensor, Motor, MotorPair
2 from spike.control import wait_for_seconds, wait_until, Timer
3 from math import *
4
5 hub = PrimeHub()
6
7 drive_motors = MotorPair('A', 'B')
8 distance_sensor = DistanceSensor('F')
9 color_L = ColorSensor('D')
10 color_R = ColorSensor('E')
11
12
```

Task 0

Finding the edge of the table

Task 0: Example Solution

```
wait_for_seconds(1)
drive_motors.start(0,30)
wait_until(color_L.get_reflected_light()<50)
drive_motors.stop()
```

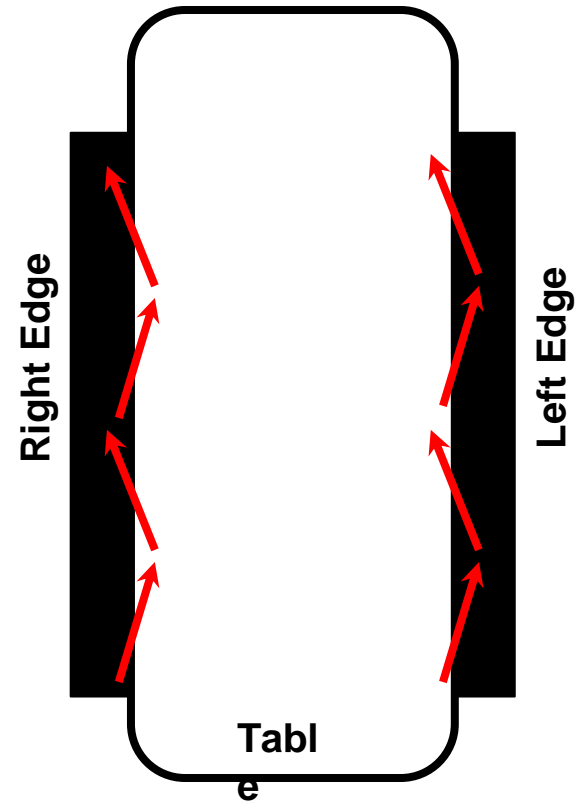
<https://youtu.be/goFLg-SG1lo>

Task 1

Following the edge of the table

Following The Edge Of The Table

- Use the zig-zag method to follow the edge of the table
- Edge following is also referred to as line following
- The zig-zag method requires the use of a sensor determine when the robot is on or off the table



Following The Edge Of The Table

- Get color sensor values to determine when the robot is **on** or **off** the table. We will use the color sensor in Reflective Light Intensity mode.

- Color Sensor 1

- On table = _____ (99)

- Off table = _____ (5)

- Color Sensor 2

- On table = _____ (99)

- Off table = _____ (5)



Following The Edge Of The Table

- For light sensor #2 settings example
 - On table = 40
 - Off table = 0
 - Median threshold = $(99+5)/2 = 52$
- Two cases
 - Light sensor reading > 52 . On table.
 - Light sensor reading < 52 . Off table.

Simple Line Following Algorithm

```
while True:  
    if color_R.get_reflected_light() < 50:  
        drive_motors.start(-15, 30)  
    else:  
        drive_motors.start(15, 30)
```

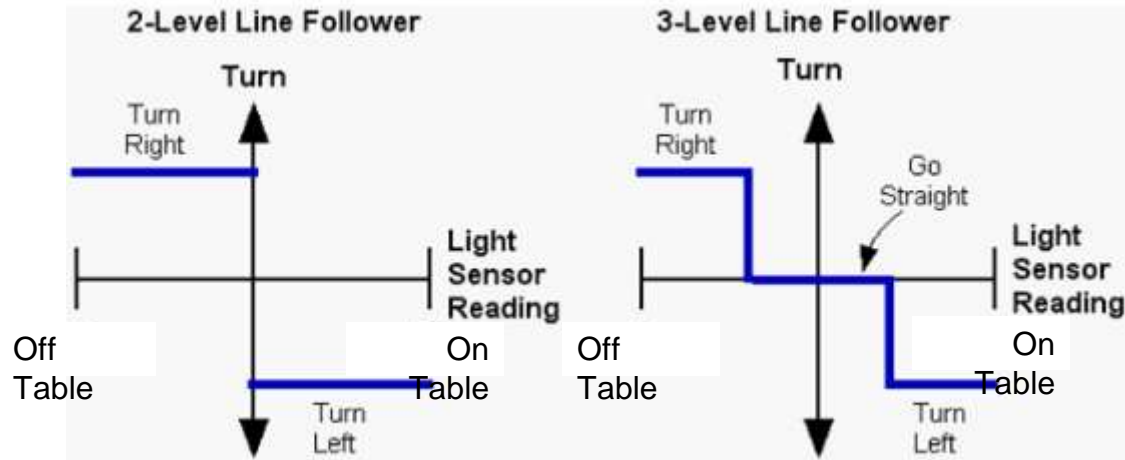
Follow using RIGHT
side of robot

19

<https://youtu.be/RGB8nKO5How>

How to improve our line following algorithm

- The zig-zag method can cause a bumpy response
- To improve the response, you can use a 3-level line follower (concept shown below)



How to improve our line following algorithm

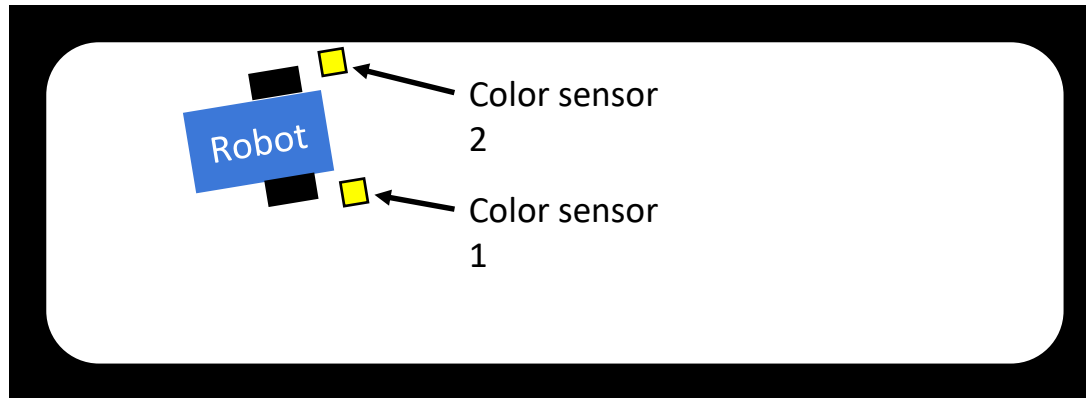
```
while True:
    if color_R.get_reflected_light()<20:
        drive_motors.start(-15,30)
    else:
        if color_R.get_reflected_light()>70:
            drive_motors.start(15,30)
        else:
            drive_motors.start(0,30)
```

Task 2

Line following to the corner of the table

Line following to the corner

- One method of line following to the corner is to follow the edge of the table with one color sensor and detect the end of the table with a other color sensor
 - Sensor 1 used to locate the end of the table
 - Sensor 2 used to follow the edge of the table



Line following to the corner

- Couple comments regarding moving around the table
 - It is possible to travel around the edge of the table with only one color sensor, but it is more difficult and potentially less reliable than using two colors sensors
 - Black tape is used to denote zones. We can use the black tape to line follow to the end of a **zone**.

Line following to the corner

- Recall our line following program
 - Let's modify the program to stop when the robot reaches the end of the table

```
while True:  
    if color_R.get_reflected_light()<50:  
        drive_motors.start(-15,30)  
    else:  
        drive_motors.start(15,30)
```

Using this program, the robot will line follow continuously. How can we make the robot stop when it reaches a corner?

Line following to the corner

```
wait_for_seconds(1)
while color_L.get_reflected_light()>50:
    if color_R.get_reflected_light()<50:
        drive_motors.start(-15,30)
    else:
        drive_motors.start(15,30)
drive_motors.stop()
```

Task 3

Line following a given distance

Line following a given distance

- Approach

- Modify LineFollowStop to stop when the robot travels a given distance

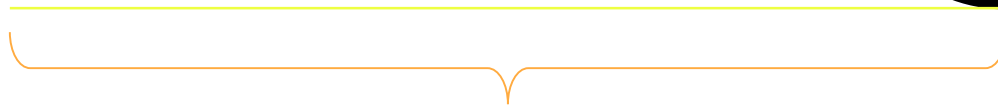
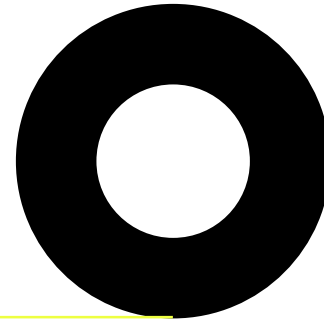
- Tools needed

- Line following
- Measure distance traveled

Measuring Distances

- How do we measure distance traveled?
- Let's determine how far the robot travels moving forward for 2 seconds

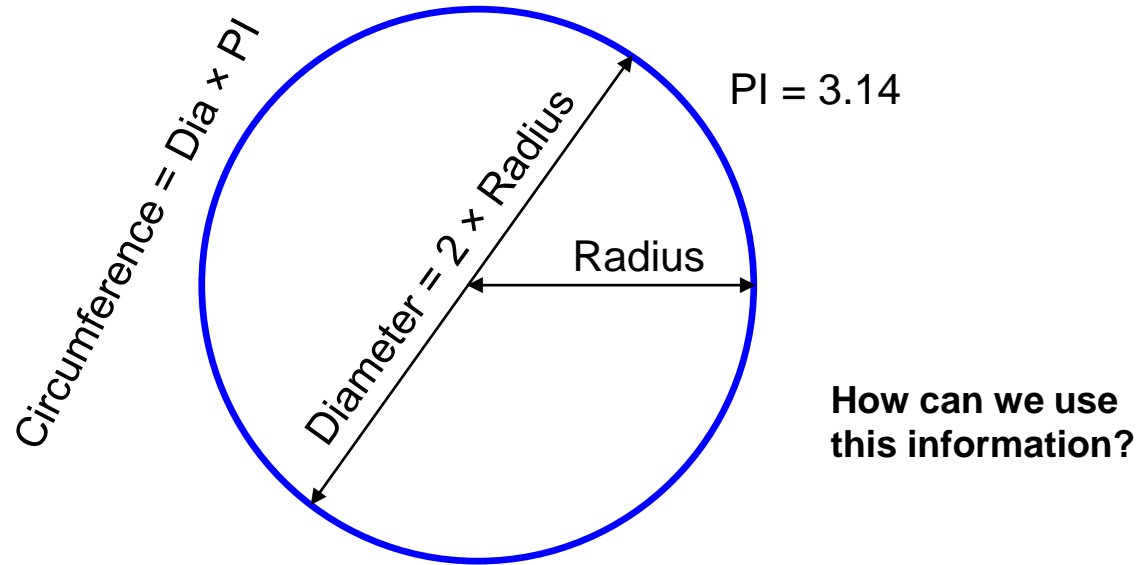
**Compute distance traveled
by measuring the number
of rotations of the wheel**



Distance

Measuring Distances

- Use the wheel geometry



Measuring Distances

- For each rotation of the wheel, the robot travels (Wheel Diameter) x (PI)
 - Distance = (Wheel Diameter) x (PI) x (# Rotations)
 - Distance = (5.5 cm) x (PI) x (# Rotations)
 - Distance = (17.28 cm) x (# degrees/360)
- Note: Right side motor (B) moves in positive direction, Left side motor (C) side moves in negative direction

```
position_start = right_motor.get_degrees_counted()
drive_motors.start(0,30)
wait_for_seconds(2)
drive_motors.stop()
dist = (right_motor.get_degrees_counted()-position_start)
while True:
    hub.light_matrix.write(dist)
    wait_for_seconds(.2)
```

<https://youtu.be/lsRGvC7vaMI>

Measuring Distances

● Example

- Let's program the robot to line follow for 30 cm
 - Distance = 30 cm
- Number of rotations
 - Distance = (Wheel Diameter) x (PI) x (# Rotations)
 - Distance = (Wheel Diameter) x (PI) x (# degrees/360)
 - Solve for (# degrees)

$$(\# \text{ degrees}) = \frac{\text{Distance} \times 360}{(\text{Wheel Diameter}) \times (\text{PI})}$$

$$(\# \text{ degrees}) = \frac{30 \text{ cm} \times 360}{(5.5 \text{ cm}) \times (\text{PI})} = 626 \text{ degrees}$$

Line following a given distance

- Line follow a desired distance

```
position_start = right_motor.get_degrees_counted()
while right_motor.get_degrees_counted()-position_start < 300:
    if color_R.get_reflected_light()<50:
        drive_motors.start(-15,30)
    else:
        drive_motors.start(15,30)
drive_motors.stop()
```

<https://youtu.be/ooJ1LFSHgDk>

Task 4

Turning the robot

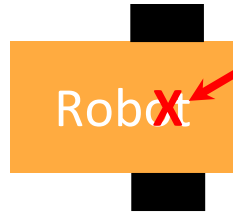
Turning The Robot

- For our example here, we wish to turn the robot 90 degrees
- There are several methods for turning a tripod robot. We will focus on two methods
 - “Spin” turn
 - “Swing” turn

90 Degree Spin

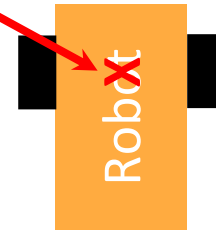
- Let's have the robot spin 90 degrees CCW
- The robot will rotate about center of the drive wheels

Starting Position



Center of
drive
wheels

Final Position



90 Degree Spin

- To spin 90 degrees CCW
- Set the steering to -100. This causes:
 - Right wheel to rotate forward
 - Left wheel to rotate reward
 - Equal and opposite rotations
- Now, we need to determine the correct number of rotations

90 Degree Spin

- You can determine the proper number of rotations mathematically; however, the result typically needs some adjustment due to lash in the motors
- For today's class, we will use trial and error to find the number of rotations that cause the robot to turn 90 degrees

90 Degree Spin

- We can use the following code to spin the robot

```
drive_motors.set_default_speed(20)
drive_motors.move(.55, 'rotations', steering=100)
```

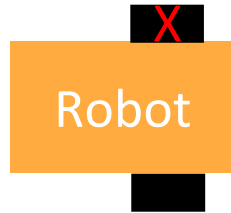
- For our sample robot, it takes 0.55 rotations to spin the robot 90 degrees

<https://youtu.be/k5cqhPShFc>

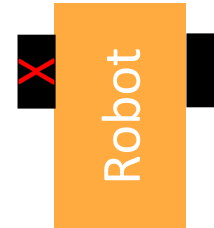
90 Degree Swing

- Let's have the robot swing 90 degrees CCW
- The robot will rotate about a locked wheel (denoted by red X)

Starting Position



Final Position



90 Degree Swing

- To swing, we lock the left motor and power the right motor to turn the robot

```
| leftMotor = Motor('A')  
| rightMotor = Motor('B')  
| leftMotor.set_default_speed(25)  
| rightMotor.stop  
| leftMotor.run_for_rotations(-1)
```

- For our sample robot, it takes 1.0 rotations to swing the robot 90 degrees

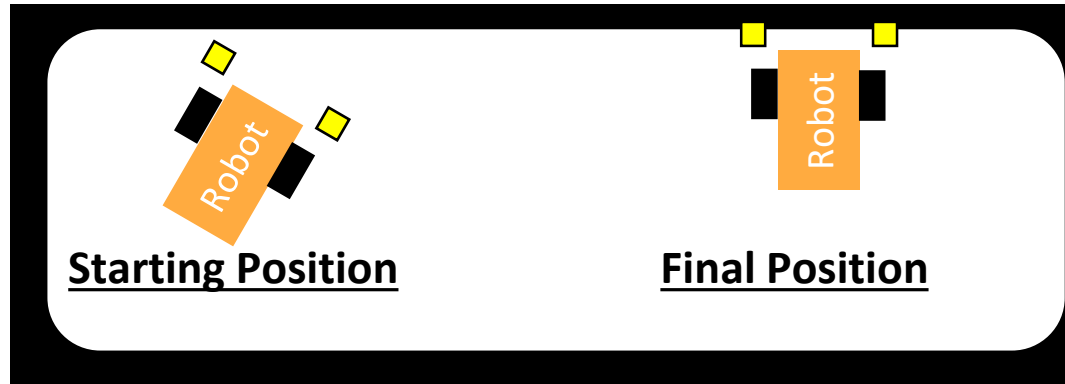
<https://youtu.be/OICKeLEf9Us>

Task 5

Aligning the robot to an edge

Aligning the robot to an edge

- In some situations we desire align with robot to an edge of the table as shown below
- Assuming the starting position below, how can we program the robot to reach the final position that is aligned with the edge of the table?



Aligning the robot to an edge

- Travel until RIGHT color sensor reaches the edge, swing robot until it is aligned with the edge

```
wait_for_seconds(1)
drive_motors.start(0, 30)
while color_R.get_reflected_light() > 50:
    pass
drive_motors.stop()
drive_motors.start_tank_at_power(20, 0)
while (color_L.get_reflected_light() > 50):
    pass
drive_motors.stop()
```

Align if either side detects edge first

```
wait_for_seconds(1)
drive_motors.start(0,30)
while color_R.get_reflected_light()>50 and color_L.get_reflected_light()>50:
    pass
drive_motors.stop()

if color_R.get_reflected_light()<50:
    drive_motors.start(50,20)
    while(color_L.get_reflected_light()>50):
        pass
    drive_motors.stop()
else:
    drive_motors.start(-50,20)
    while(color_R.get_reflected_light()>50):
        pass
    drive_motors.stop()
```

<https://youtu.be/998DFfMUXw0>

Task 6

Creating Functions

Functions

- Solving the Robofest Game challenge will typically require a fairly large program (around 100 lines is not unreasonable)
- Very large programs can be difficult to understand, navigate and use
- To alleviate this issue, the software has the ability to create custom code that can replace sections of your program

Create Function to Find Edge of Table

```
def FindEdge():  
    wait_for_seconds(1)  
    drive_motors.start(0,30)  
    wait_until(color_L.get_reflected_light()<50)  
    drive_motors.stop()
```

FindEdge()

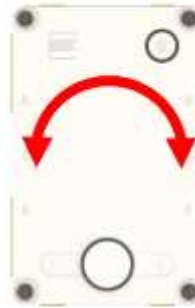
Task 7

Gyro Turns

More Precise Turns with a Gyro

- Spike Prime has a built in Gyro sensor
- Gyro sensor can be used for turns

Yaw is turning the Hub to right or left



Pitch is turning the Hub up and down



Roll is turning the Hub to side-to-side



Turning with Gyro

Right Turn

```
hub.motion_sensor.reset_yaw_angle()
wait_for_seconds(1)
drive_motors.set_default_speed(20)
drive_motors.start(100,20)
while hub.motion_sensor.get_yaw_angle()<90:
    pass
drive_motors.stop()
```

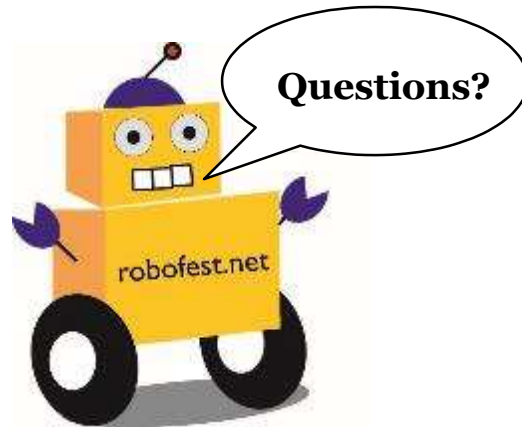
Left Turn

```
hub.motion_sensor.reset_yaw_angle()
wait_for_seconds(1)
drive_motors.set_default_speed(20)
drive_motors.start(-100,20)
while hub.motion_sensor.get_yaw_angle()>-90:
    pass
drive_motors.stop()
```

Putting It All Together

- In this course we learned about
 - Finding the edge of the table
 - Following the edge of the table
 - Stop line following
 - When you reach a corner
 - When you reach a given distance
 - Turning the robot
 - Aligning the robot to an edge
 - Building Functions
 - Gyro turns

Little Robots, Big Missions



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