ROBOFEST 2021 GAME

Stack Rolls

EV3 for Game with Scratch Workshop

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

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Please take Pre Assessment:

https://docs.google.com/forms/d/e/1FAIpQLScdoEHfiirs93sToeY3eZ6Ur9pA1DX86l8hev9v4LKXFHMDBA/viewform?usp=sf_link

This file can be found under the **eAcademy** on the website **www.robofest.net** along with online training and certifications

LAWRENCE TECHNOLOGICAL UNIVERSITY
ROBOFEST

2021 Workshops

Presented by

Lawrence Technological University

Computer Science

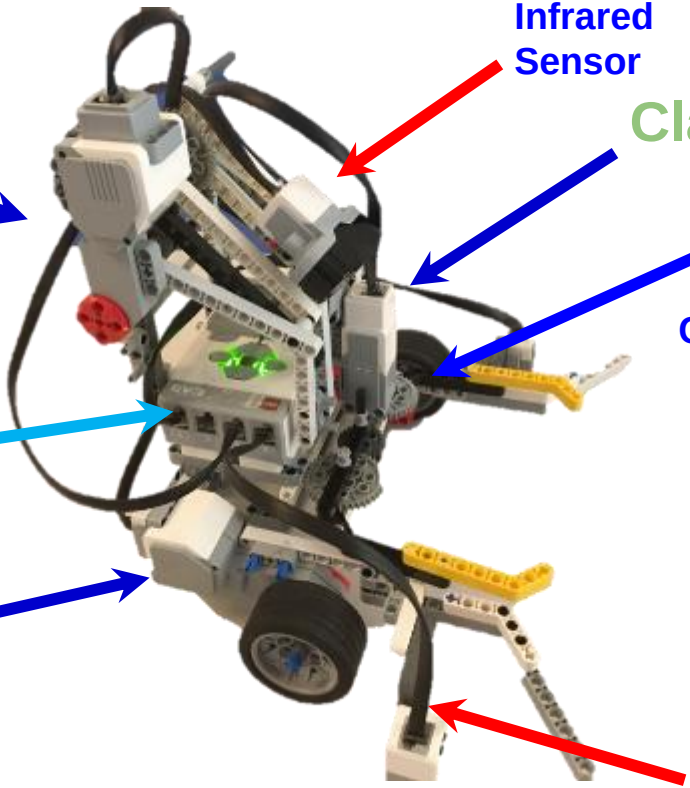
Course Overview

- 2021 Robofest competition Stack Rolls
  - Autonomous robot that get points by moving and stacking rolls
- SPbot introduction
- Using SPbot to solve the Stack Rolls challenge

2021 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: Finding a Paper Roll
    - Task 5: Turning the robot
    - Task 6: Aligning the robot to an edge
    - Task 7: Manipulating Paper Rolls
    - Task 8: Building MyBlocks

LEGO EV3 robot used



Infrared Sensor

Arm Motor: D

Claw Motor: A

Left Motor: B

Color Sensor 2

EV3 Computer

Right Motor: C

Color Sensor 1

Remember the connections!

- Left Motor connects to **B**
- Right Motor connects to **C**
  - If your motors are upside down forward will be backwards in your program
- Arm Motor connects to **D**
- Claw Motor connects to **A**
- Color sensor 1 (Right) connects to port no. **1**
- Color sensor 2 (Left) connects to port no. **2**
- Infrared sensor connects to port no. **3**

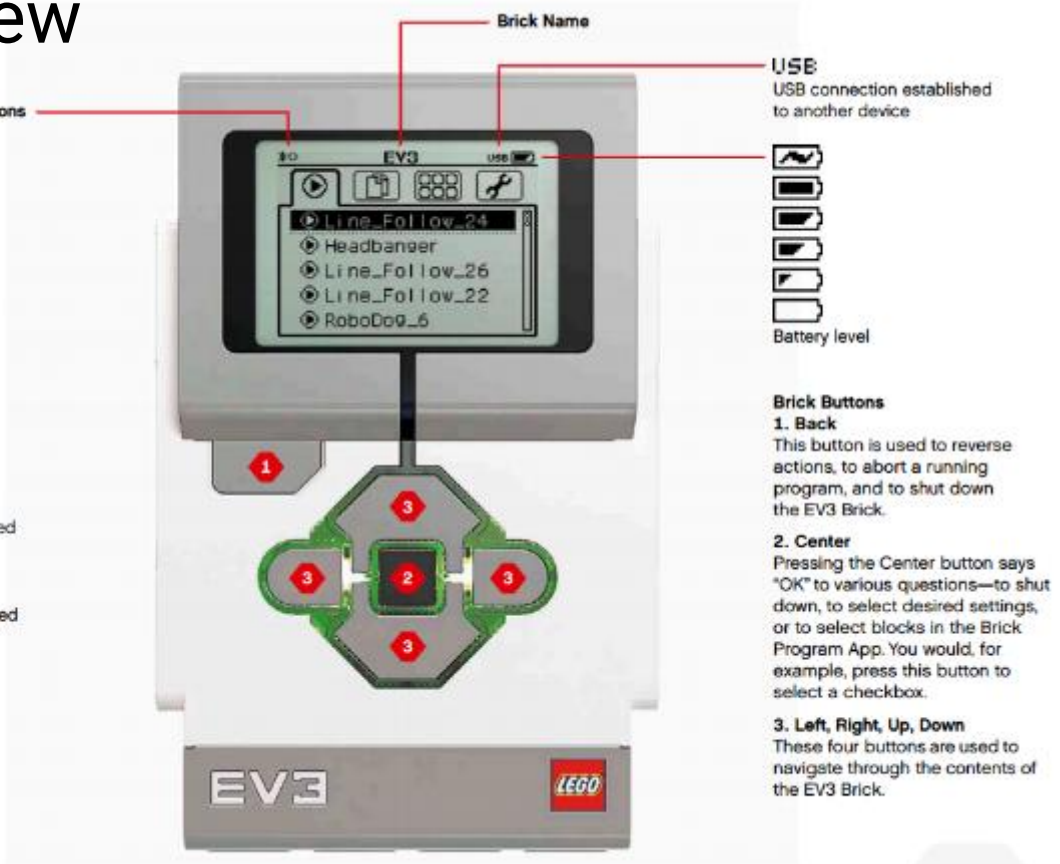
EV3 Versions Used

- Examples use EV3 Educational Version **1.2.2**
  - Download
    - https://education.lego.com/en-us/downloads/mindstorms-ev3/software

- EV3 Firmware version: **V1.10E**

- Presentation and all example programs are available at robofest.net under Tech Resources

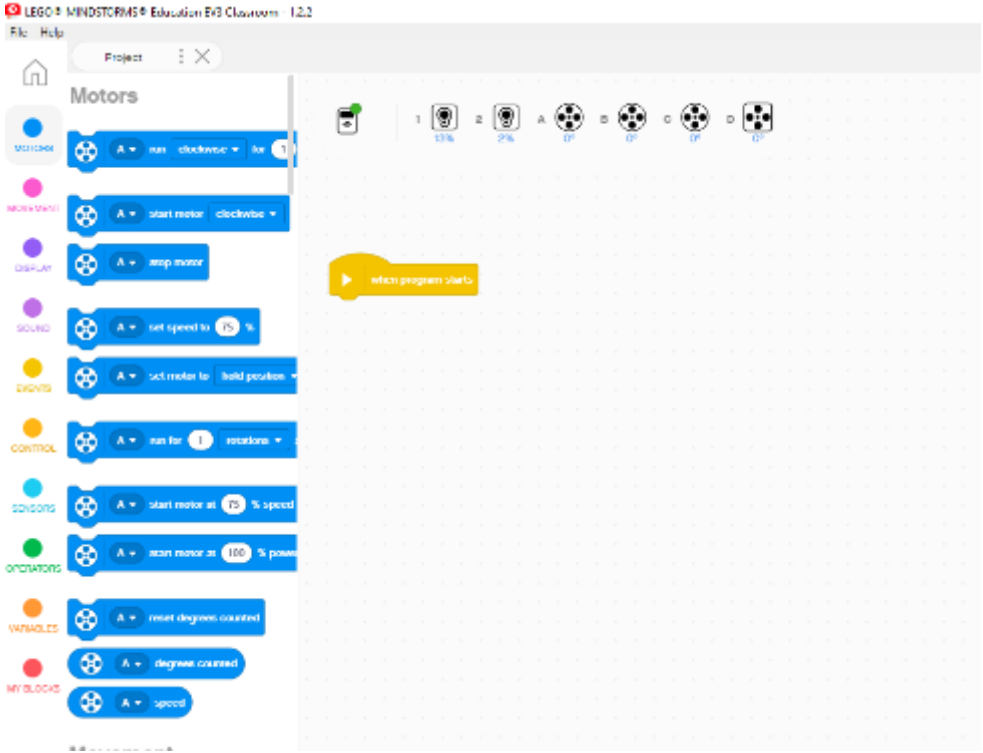
Brick Overview



Connect to Brick

- Two options
  - USB Cable
  - Bluetooth

Scratch Programming Environment

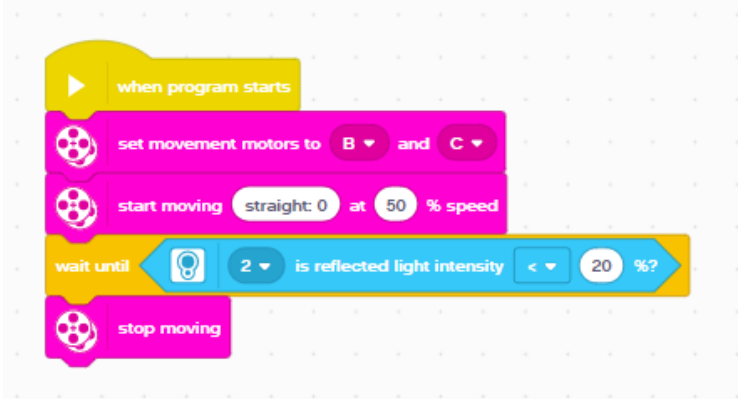


Task 0

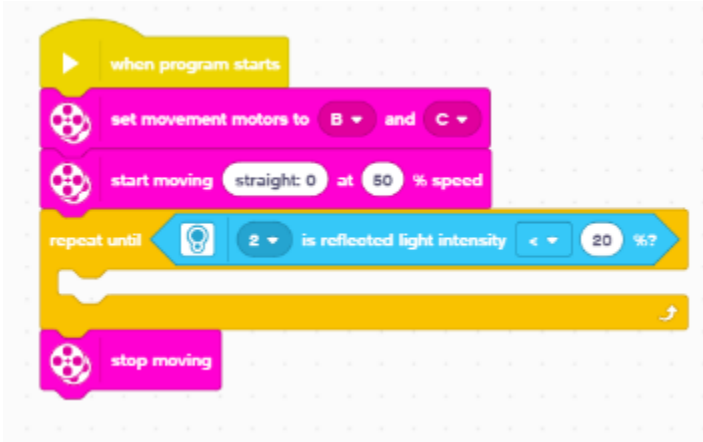
Finding the edge of the table

Task 0: Example Solutions

- Using a wait block



- Using a loop block



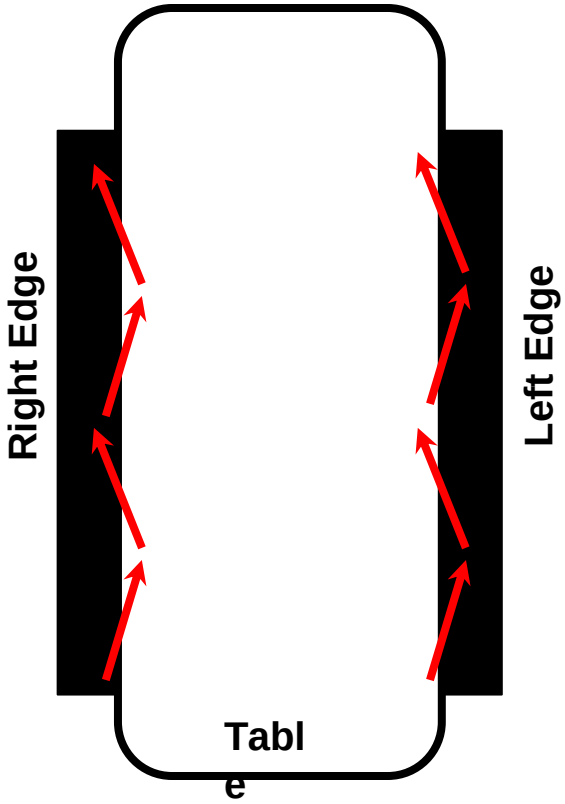
YouTube: https://youtu.be/NgXrOGvQsII

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

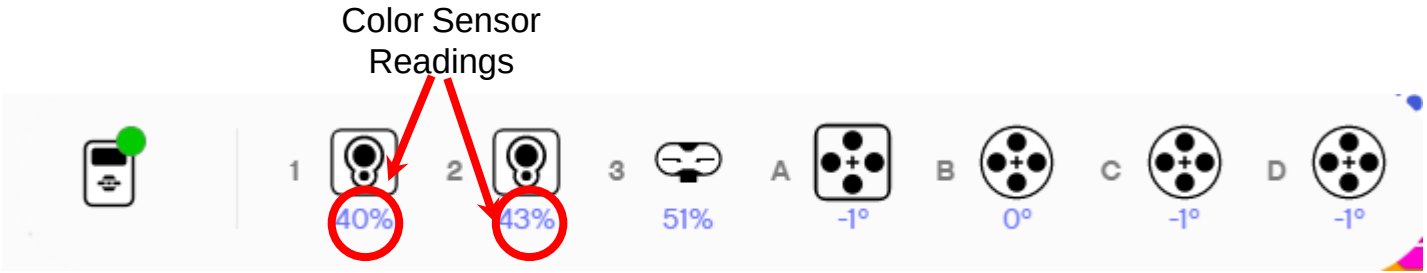
- Get color sensor values to determine when the robot is **on** or **off** the table. We will use the color sensor in Reflective Light Intensity mode.

- Color Sensor 1
  - On table = _____ (60)
  - Off table = _____ (20)

Color Sensor 2

On table = _____ (60)

Off table = _____ (10)

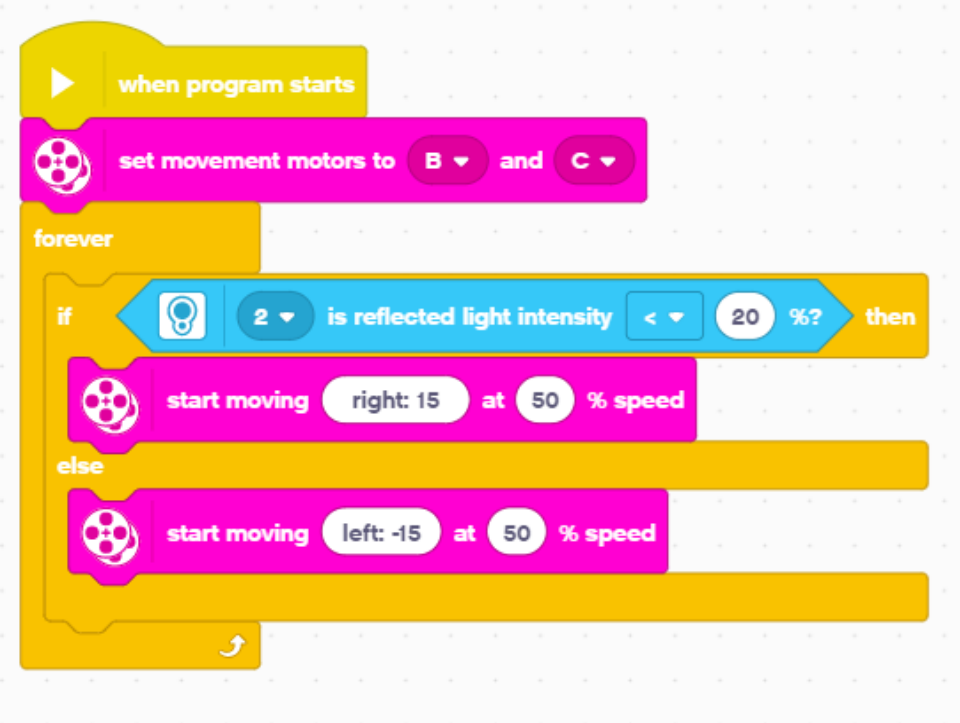


Following The Edge Of The Table

- For light sensor #2 settings example
  - On table = 40
  - Off table = 0
  - Median threshold = (40+0)/2 = 20

- Two cases
  - Light sensor reading > 20. On table.
  - Light sensor reading < 20. Off table.

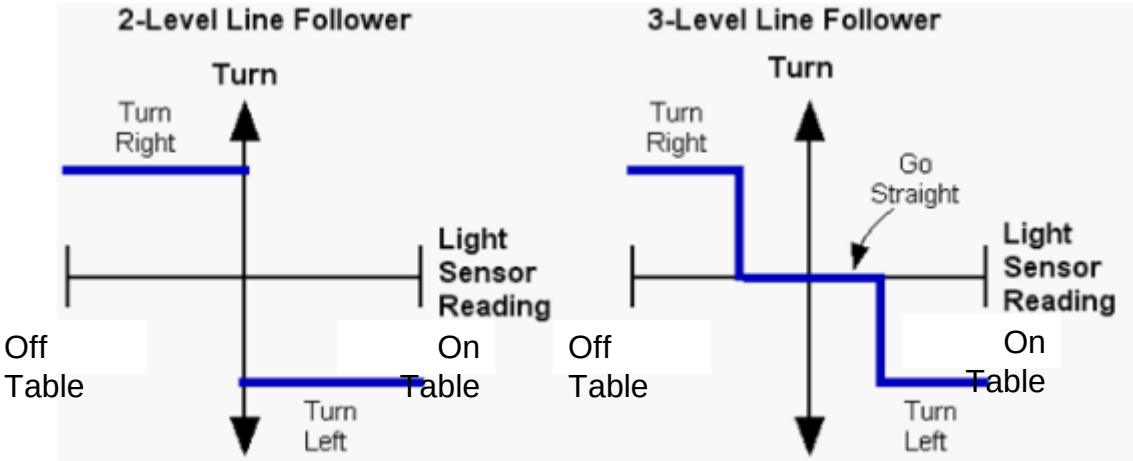
Simple Line Following Algorithm



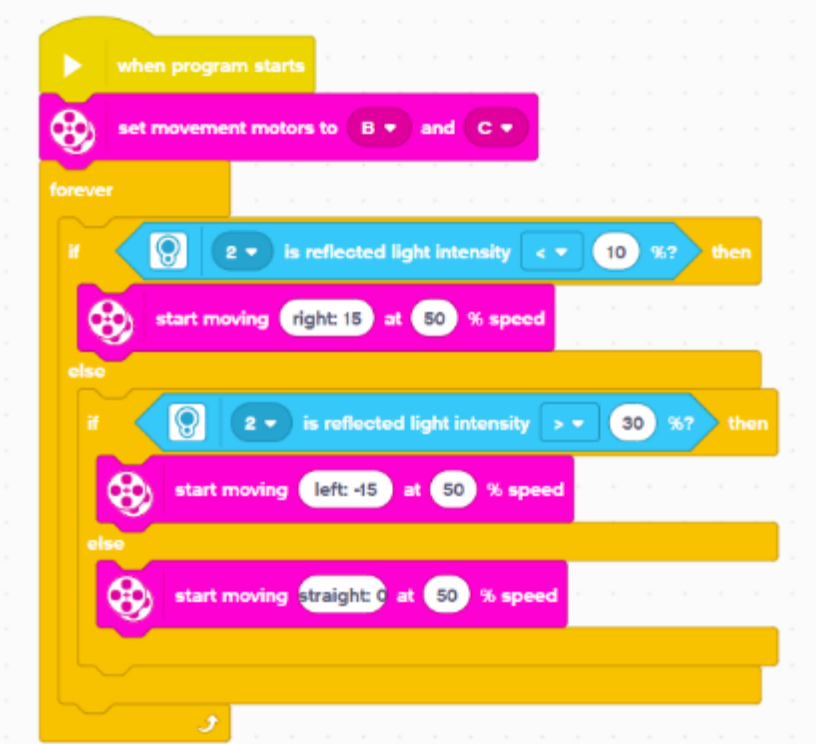
YouTube: https://youtu.be/EfBdoJESIro

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

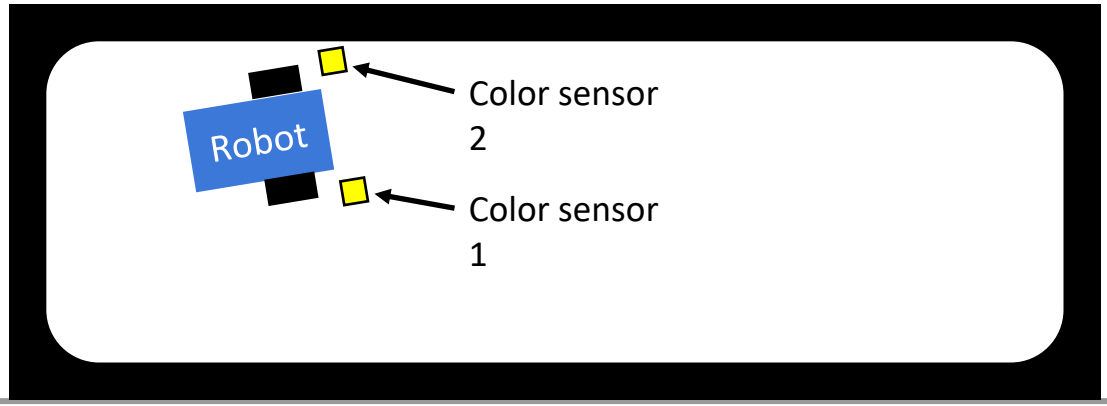


Task 2

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

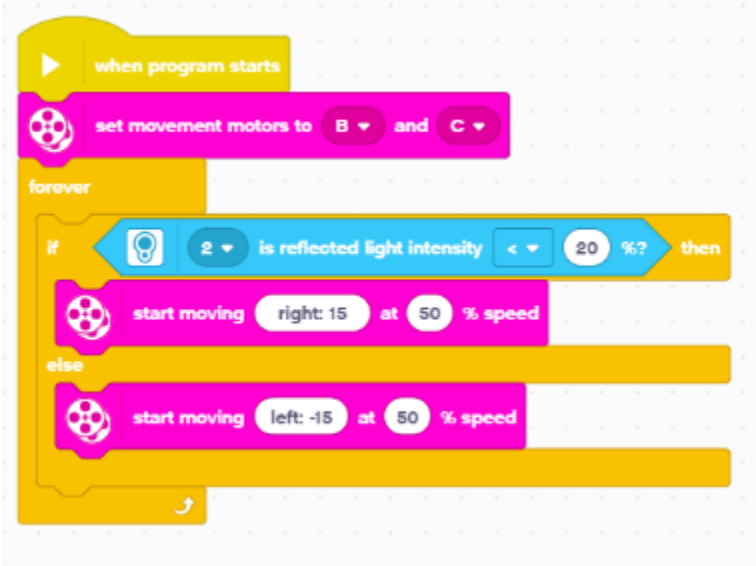


Line following to the corner

- 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**.

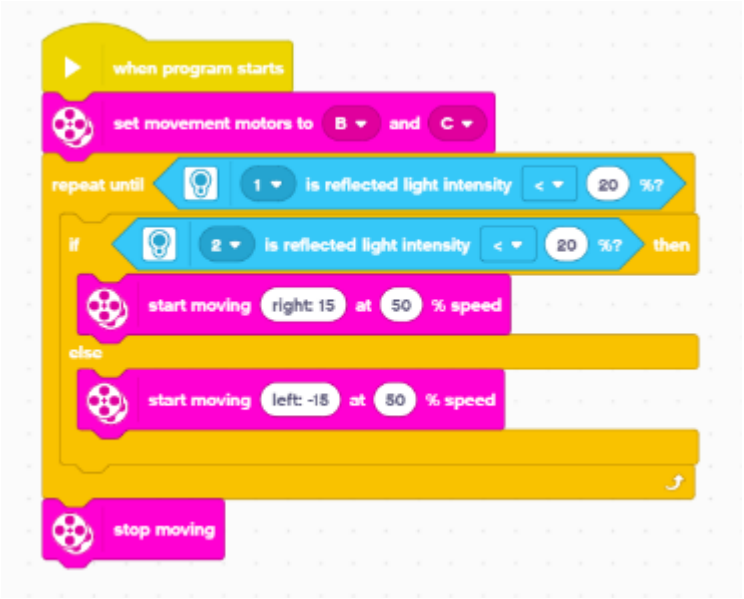
Line following to the corner

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



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



YouTube: https://youtu.be/oh8a5bk0PkY

Task 3

Line following a given distance

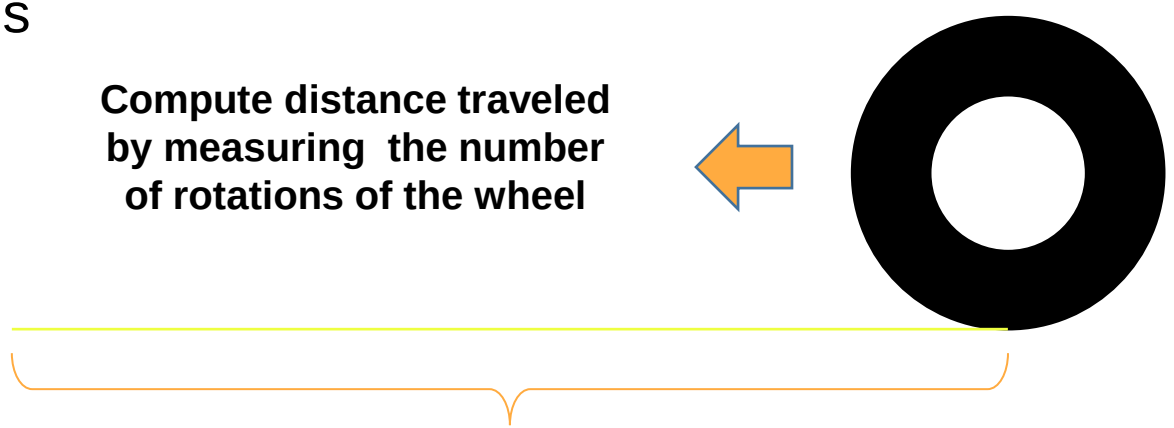
Line following a given distance

- Approach
  - Modify LineFollow program to stop when the robot travels a given distance
- Tools needed
  - Line following
  - Measure distance traveled

Measuring Distances

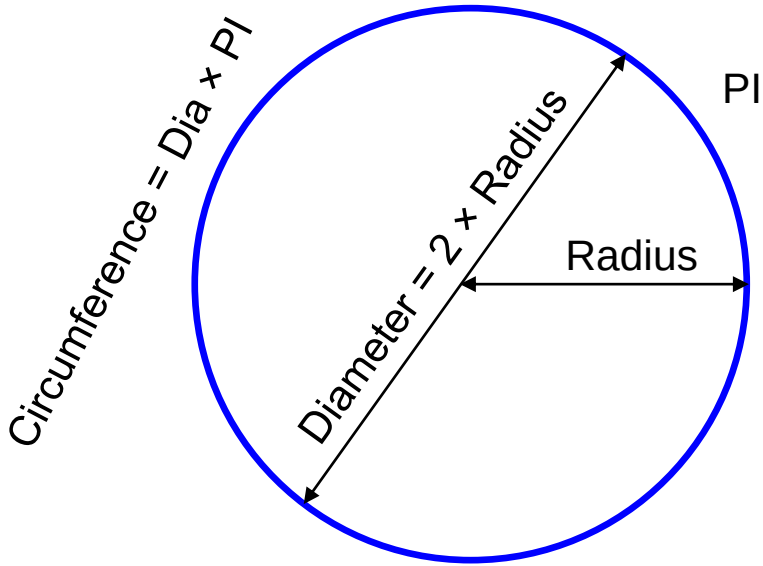
- How do we measure distance traveled?
- Let's determine how far the robot travels moving forward for 2 seconds

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



Measuring Distances

- Use the wheel geometry



How can we use this information?

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)

YouTube: https://youtu.be/r0psO1aK0ME

Measuring Distances

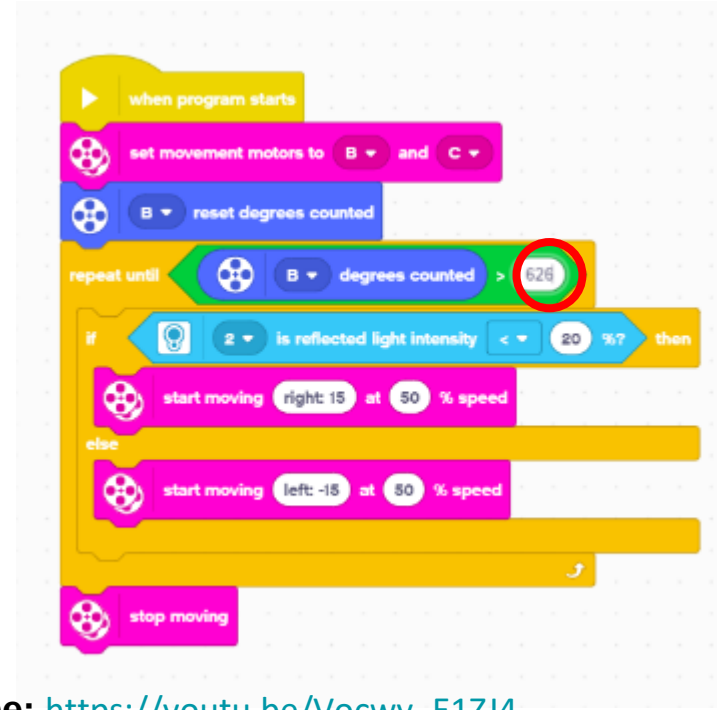
- Example
  - Let's program the robot to line follow for 30 cm
    - Distance = 30 cm
  - Number of rotations
    - Distance = (Wheel Diameter) x (PI) x (# Rotations)
    - Distance = (Wheel Diameter) x (PI) x (# degrees/360)
    - Solve for (# degrees)

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

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

Line following a given distance

- Line follow a desired distance



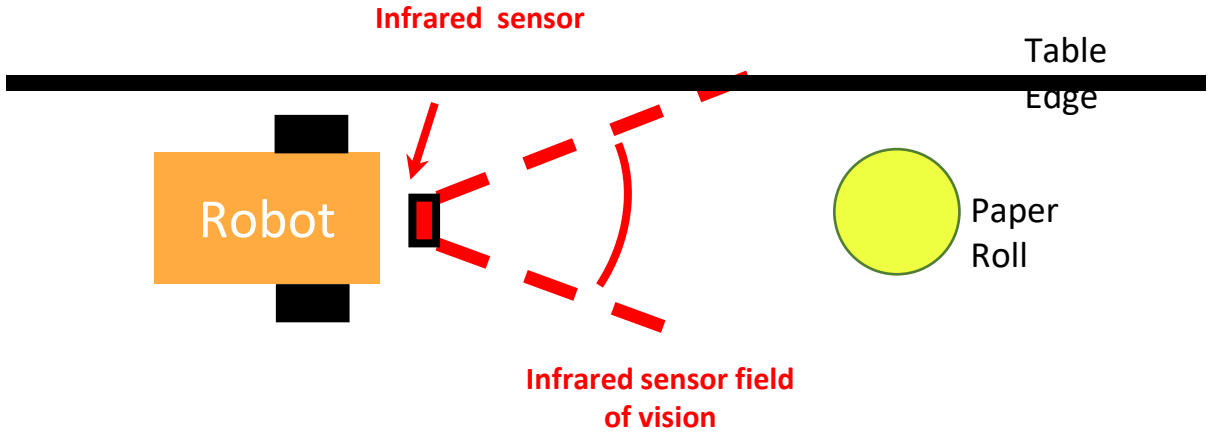
YouTube: https://youtu.be/Vocwy_E1ZJ4

Task 4

Finding a Roll

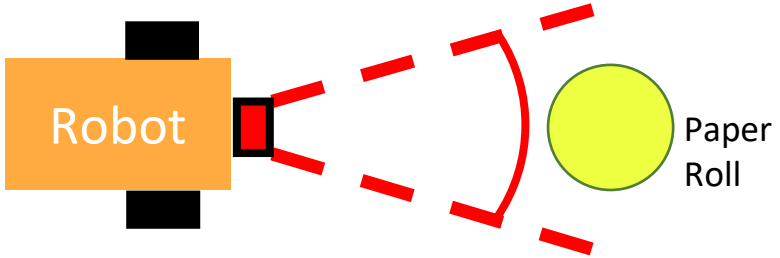
Finding a Rolls

- We can use the infrared sensor to determine if an object is near the robot
- Here we will assume that we are following the edge of the table and wish to stop the robot once a paper roll close to the robot



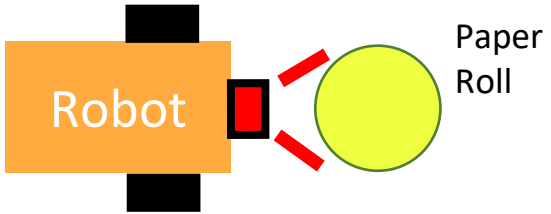
Finding a Paper Roll

- Here we will use our line following program to follow the edge of the table and stop the robot when the Paper Roll is close to the infrared sensor



Infrared sensor will read high values when the Paper Roll is far away

Starting Position

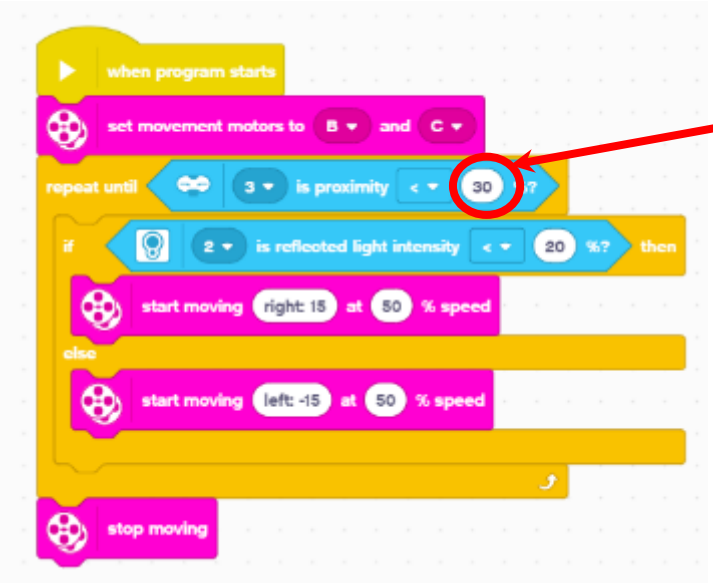


Infrared sensor will read low values when the Paper Roll is close to the robot

Final Position

Finding a Paper Roll

- Now, we travel along the edge of the table and stop if we find aPaper Roll



We chose a low threshold. We can determine the appropriate value by testing the sensor readings with aPaper Roll near the front of the robot.

YouTube: https://youtu.be/vy89KXPUfcQ

Task 5

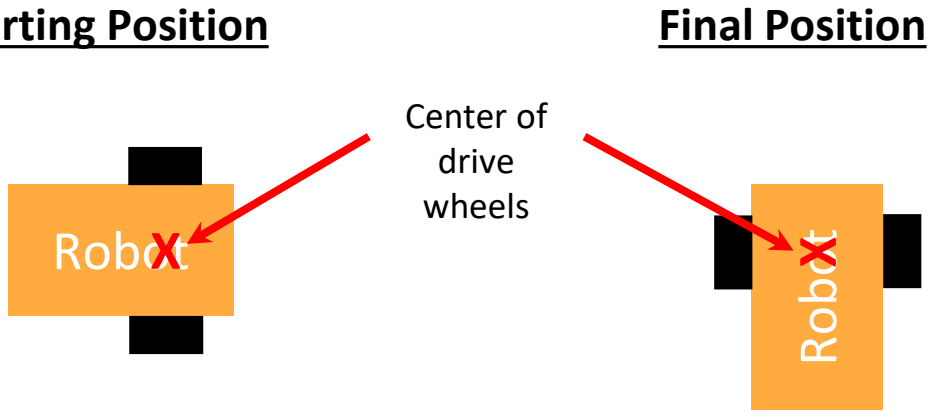
Turning the robot

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

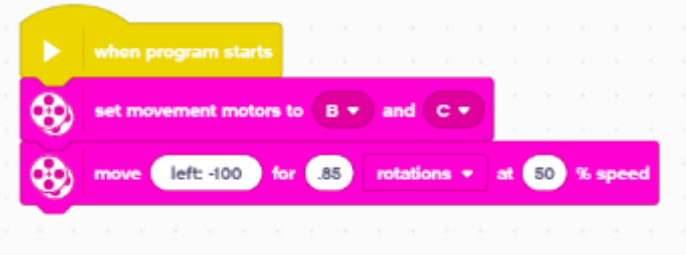
90 Degree Spin

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



90 Degree Spin

- To spin 90 degrees CCW, we use the Move block as shown here
- 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

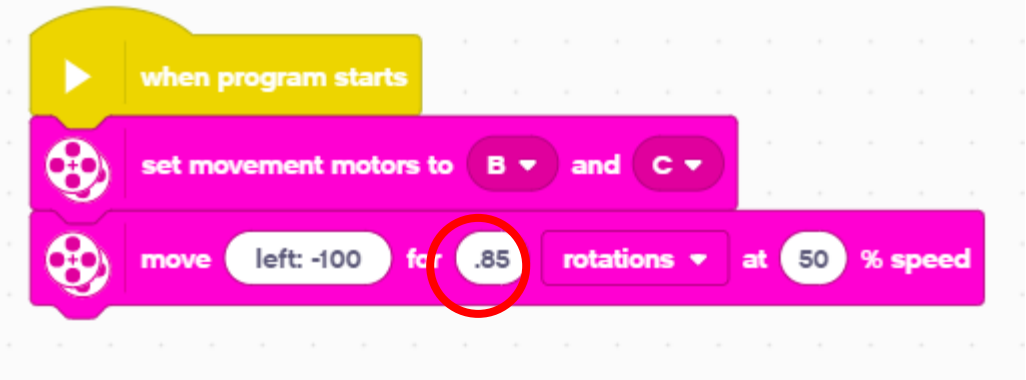
90 Degree Spin

- 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 one block to spin the robot



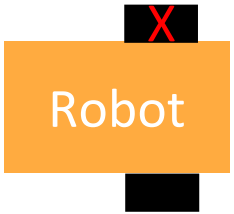
- For our sample robot, it takes 0.85 rotations to spin the robot 90 degrees

YouTube: https://youtu.be/Wdej_zMUEag

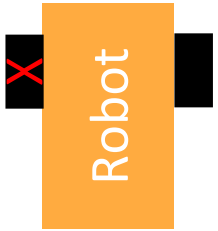
90 Degree Swing

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

Starting Position

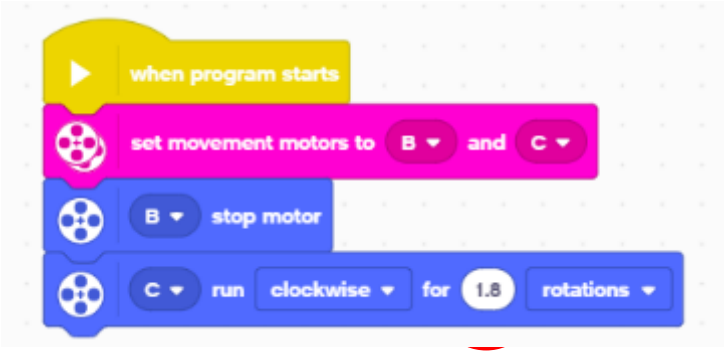


Final Position



90 Degree Swing

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



- For our sample robot, it takes 1.8 rotations to swing the robot 90 degrees

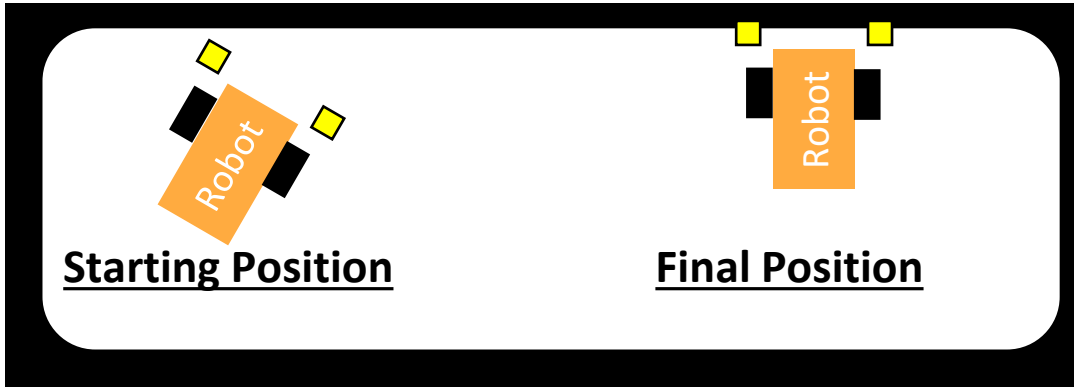
YouTube: https://youtu.be/PBcYS8ugfRM

Task 6

Aligning the robot to an edge

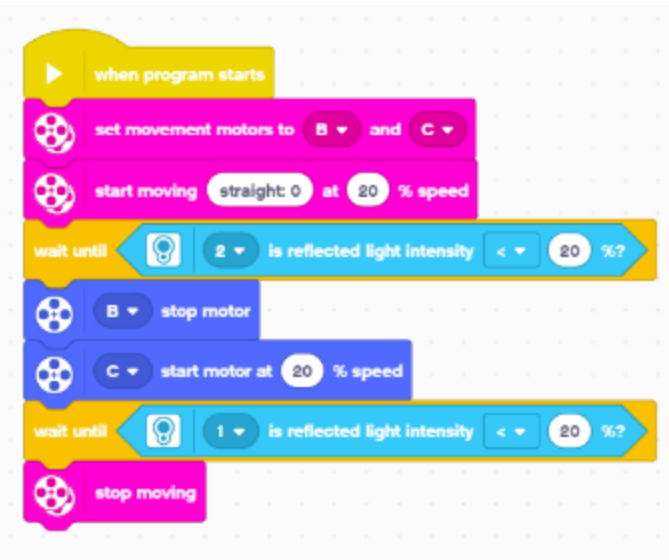
Aligning the robot to an edge

- 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?



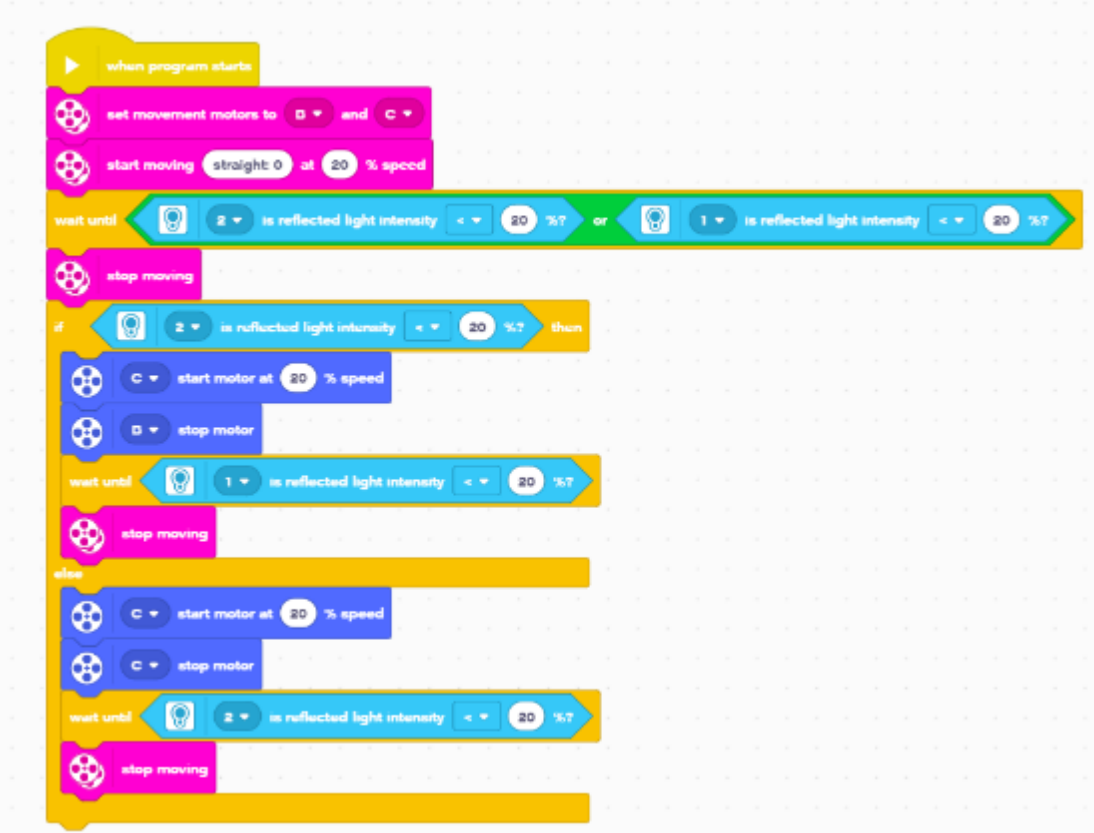
Aligning the robot to an edge

- Travel until color sensor #2 reaches the edge, swing robot until it is aligned with the edge



YouTube: https://youtu.be/TjrYUN0y6Dc

Align if either side detects edge first



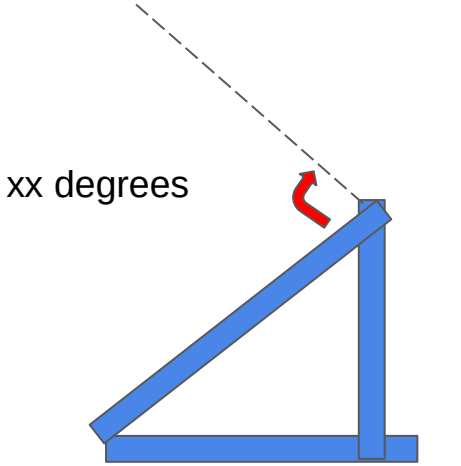
Task 7

Manipulating Paper Rolls
Moving the Arm and Claw

How to Control the Arm and Claw

- Time
- Rotation(encoder degrees)

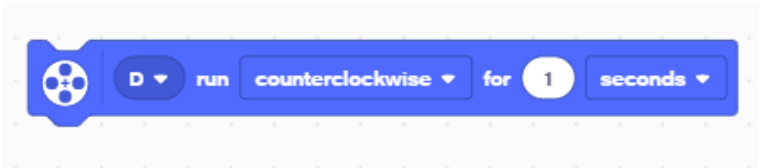
Note: To use rotation, you need to determine what direction to run the motor to raise the arm. For this workshop, the arm is run counter clockwise (negative direction)



Arm all the way down
0 degrees

Moving the Arm- Using time

- Advantages
  - Simple
  - Easy to program
  - Will not get stuck
- Disadvantages
  - Can be imprecise
  - Repeatability
- How to do it
  - Set a motor block to “seconds”
  - Select the motor port
  - Select the direction
  - Select the duration



Raise Arm

Lower Arm

Moving the Arm- Using encoder

- Advantages
  - More precise
  - More repeatable
- Disadvantages
  - More difficult to program
  - Can get stuck
- How to do it
  - Establish a “zero” point
  - Determine direction of motor
  - Set limits

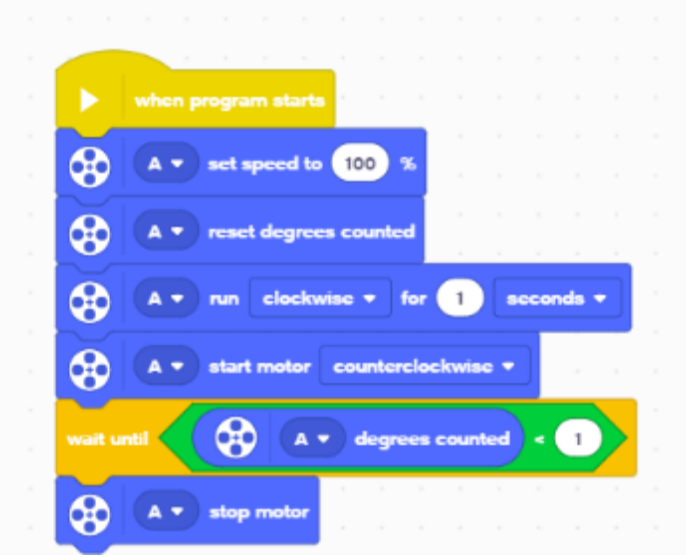
Raise arm,

Wait 1 sec

Lower arm back to 0

Moving the Claw

- May need to overdrive motor to get enough grip
- Use encoder to open back to zero position

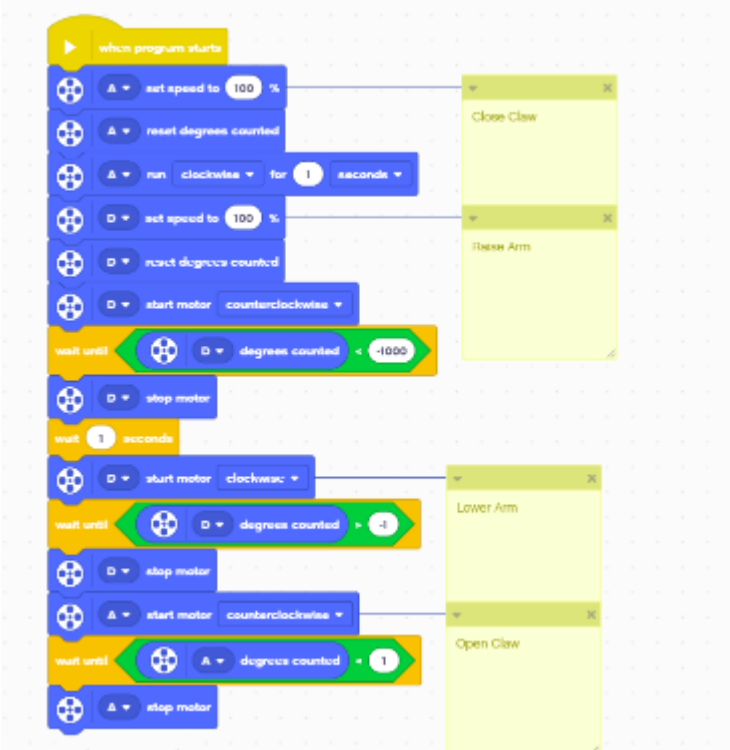


Set Power and zero position at beginning of program

Use time to close

Use rotation to open

Combine Arm and Claw Movement



YouTube: https://youtu.be/C3rSA4EsmDM

Task 8

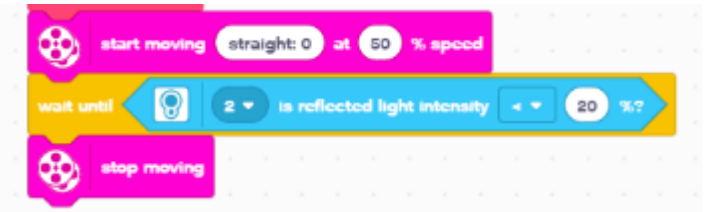
Building MyBlocks

My Blocks

- Solving the Robofest Game challenge will typically require a fairly large EV3 program (around 100 blocks is not unreasonable)
- Very large programs can be difficult to understand, navigate and use
- To alleviate this issue, the EV3 software has a My Block Builder to create custom blocks that can replace sections of your program

My Blocks

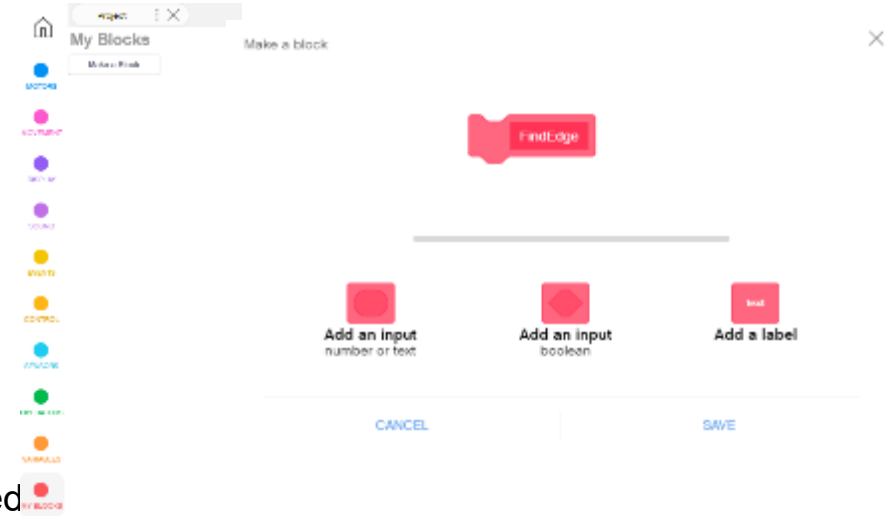
- For example, let’s assume you have a section of code that completes the following:
  - Move forward until the edge of the table is found with color sensor 1, then stop
- The code may look like this



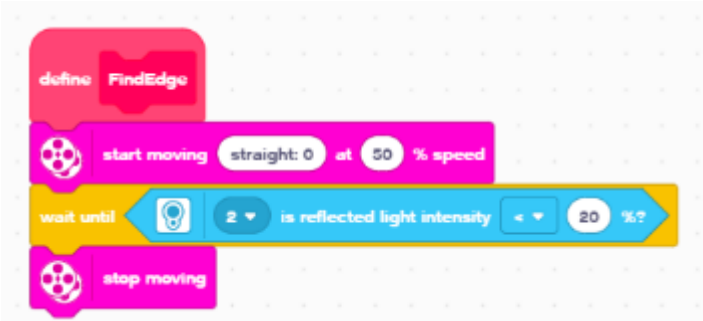
- My blocks will allow us to convert this to a single block

My Blocks

- Creating a My Block
  1. Click on “MyBlocks”
  2. Click on “Make a Block”
  3. Create a name “FindEdge” for the block
  4. Click “save
  5. Add blocks to be run when My Block is used



This creates a My Block called FindEdge that will be located in the My Blocks Pallet



Putting It All Together

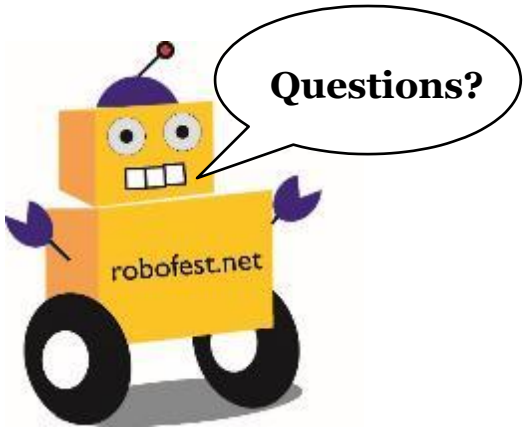
- In this course we learned about
  - Finding the edge of the table
  - Following the edge of the table
  - Stop line following
    - When you reach a corner
    - When you reach a given distance
  - Finding a Paper Roll
  - Turning the robot
  - Aligning the robot to an edge
  - Manipulating Paper Rolls
  - Building MyBlocks

Test for Knowledge

Post Assessment Link:
https://docs.google.com/forms/d/e/1FAIpQLSe1jcaCRqfyroYfyv1F-2HAe2Y8BsBNdlWwHfPv59IKaoGOcQ/viewform?usp=sf_link

LAWRENCE TECHNOLOGICAL UNIVERSITY ROBOFEST

Little Robots, Big Missions



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