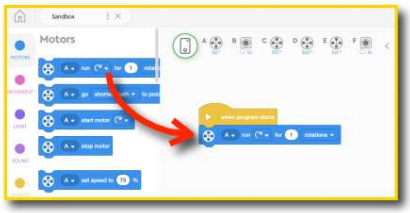

Hello and welcome to the FIRST LEGO League Challenge Programming Self Guided Training. In this hands-on workshop, you will be guided through the programming of a competition-ready robot. Before beginning this training, you should have already completed the Robot Build Self Guided Training. I would like to take a moment to thank Louis Rubbo from FIRST Nevada for sharing the materials that this training is adapted from.

# Today's Agenda

Intro to Programming

- Introduction to the SPIKE App
- Programming Basics

**Basics of Programming**




FIRST LEGO LEAGUE

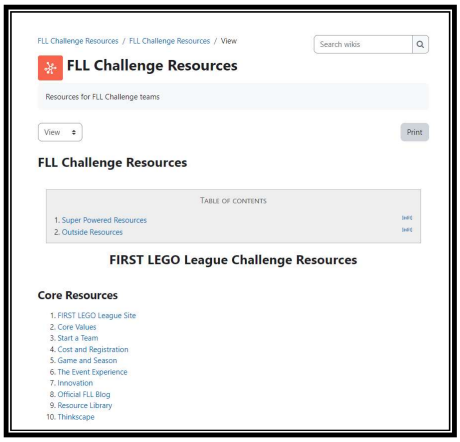
FIRST LEGO LEAGUE CHALLENGE

2

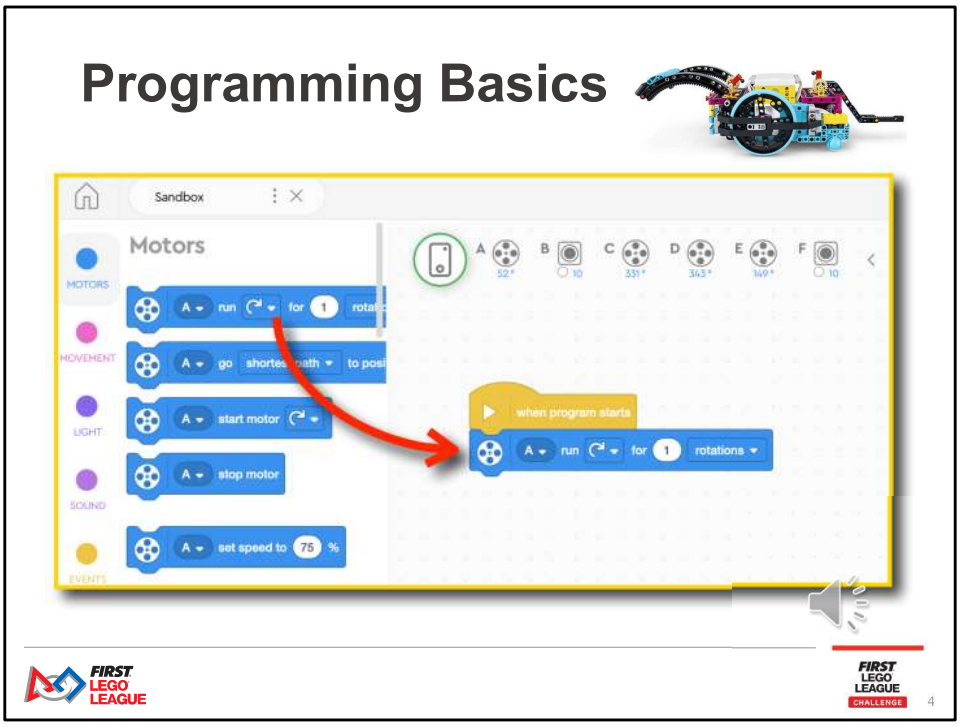
In this session, you will be introduced to programming with the SPIKE App.

# FIRST Indiana Robotics Playbook

*https://playbook.firstindianarobotics.org/*




Today's presentation, as well as other useful documents can be found in the FIN Playbook.




After completing the robot build training, you should have a robot that looks something like the one at the top of this page. Now it's time to learn how to make it move! Feel free to pause this presentation at any time as you are working along with the slides.

# Programming Basics

## *Connecting the Hub*

- Turn on the SPIKE App and let it start up completely.
- Turn on the SPIKE Prime Hub by pressing the large, white button on the top.
  - This is referred to as the enter button
  - The Hub will take a few minutes to boot up.
- Use the included white mini-USB to USB cable to connect the SPIKE Prime Hub to a computer running the SPIKE App.
  - The mini-USB connection is plugged into the top of the SPIKE Hub.
  - The USB connection is plugged into a USB port on the computer.
- When the Hub is connected to the computer using the cable, it's said to be tethered to the computer.


FIRST LEGO LEAGUE

FIRST LEGO LEAGUE CHALLENGE 5

First, you'll want to connect the Hub.

**Read info from the slide**

There is a way to connect the Hub using Bluetooth. We will cover that a little later!

# Programming Basics

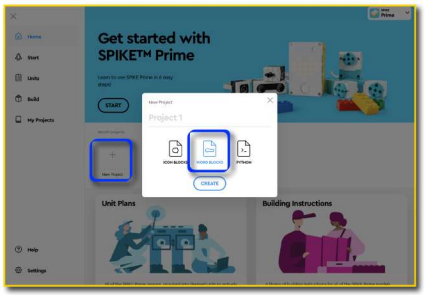
*Updates*


- If this is the first time the Hub is used, an update prompt may show up on the computer screen.
- The computer must be connected to the internet for the update to be completed.

IMPORTANT: Do not disconnect the Hub while it is updating. This can cause the Hub to malfunction later.

# Programming Basics

*Projects*




- The SPIKE App uses projects (programs) to organize workflow.
- In the SPIKE App, select NEW PROJECT, which is found just to the left of the middle of the screen.
- In the pop-up window, select WORD BLOCKS.
- ICON BLOCKS is used when working with SPIKE Essential (FIRST LEGO League Explore) components

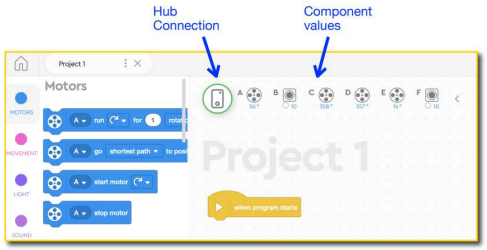
FIRST LEGO LEAGUE

FIRST LEGO LEAGUE CHALLENGE 7

Advanced teams can program in Python. For this workshop, we will use block coding in the SPIKE app.

# Programming Basics

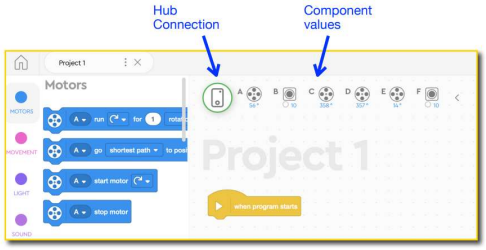
*Information in the SPIKE App*




- On the top-left is the HOME icon, which takes the user back to the main home screen.
- Across the top are tabs listing opened projects.
  - Each project is an independent program.

# Programming Basics

*Information in the SPIKE App*

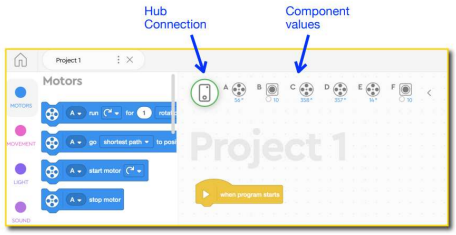



When a SPIKE PRIME Hub is connected to the computer…

- The Hub connection icon shows a green circle if the Hub is tethered to a computer;
- The Hub connection icon shows a blue circle when the Hub is connected via Bluetooth;
- To the right of the Hub connection icon is information related to the components currently plugged into the Hub.

# Programming Basics

*Information in the SPIKE App*



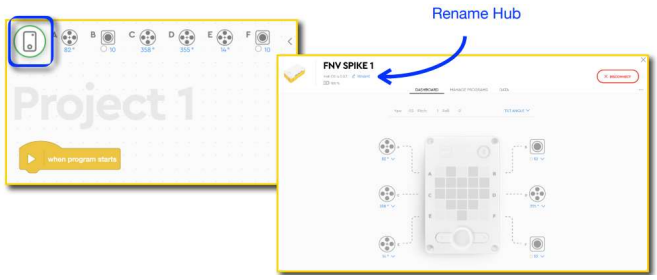

Notice that the component values are updated in real time.

Component = motor or sensor

- Try rotating a wheel on the robot and notice how the values of the A and E motors changes.
- Try placing the robot over different surfaces and notice how the values from the color sensors in ports B and F change.

# Programming Basics

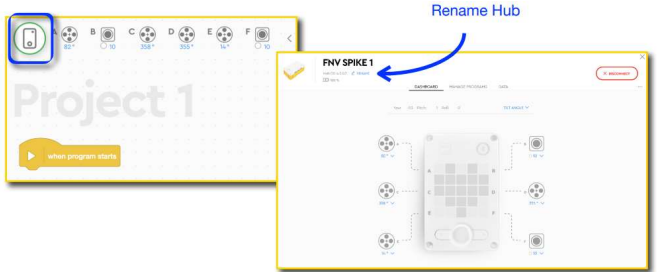
*Hub Connection Icon*




- By clicking on the Hub connection icon, a new pop-up window is opened.
- This is called the Hub Dashboard

# Programming Basics

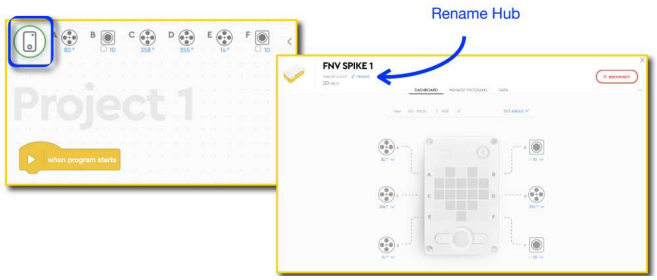
*Hub Dashboard*




- The Hub Dashboard shows detailed information about the hub, as well as the connected motors and sensors.
  - By clicking on the individual motors or sensors, the readout units can be changed.

# Programming Basics

*Hub Dashboard*

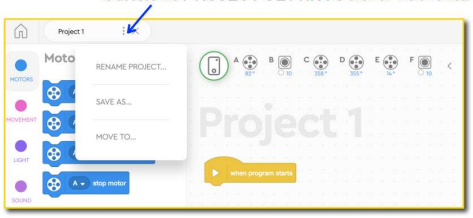



- The same window allows users to rename the brick.
  - The rename option is shown as a hyperlink located toward the top-left part of the screen.
- Give the SPIKE Prime Hub a unique name.
  - This will help later when making a Bluetooth connection

# Programming Basics

## *Naming Projects*

To access the PROJECT SETTINGS click on the 3 vertical dots



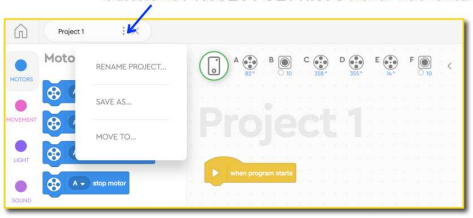

Rename *Project 1* to *Sandbox*

- Clicking on the three vertical dots next to the project name opens up a settings window for the project.
- The PROJECT SETTINGS pop-up window allows for renaming the project, saving under a different file name and moving to a new folder on the computer.

# Programming Basics

## *Naming Projects*

To access the PROJECT SETTINGS click on the 3 vertical dots

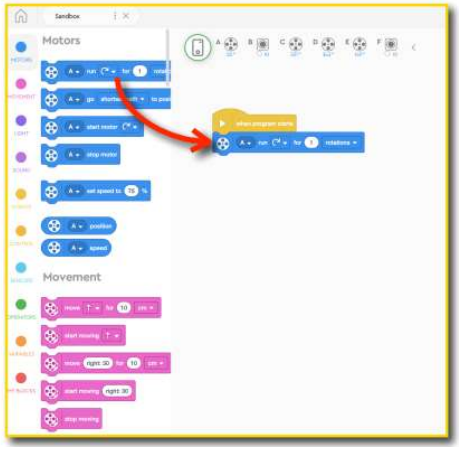



Rename *Project 1* to *Sandbox*

- For the purpose of this session, rename the project *Sandbox.*
  - With a real sandbox, a simple representation (castle) is built without a lot of details.
  - Similarly, a sandbox code is one that is a simple version of a more complex concept.
  - The purpose of a sandbox code is to quickly test out an idea.

# Programming Basics

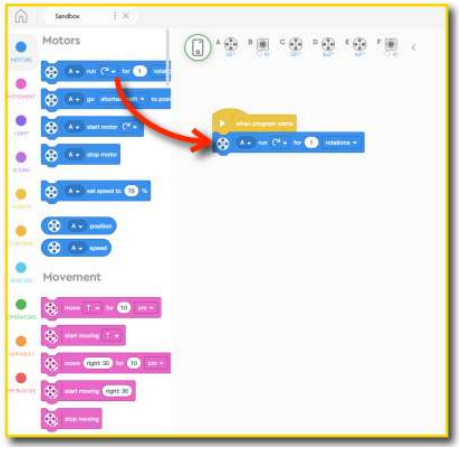
*Word Blocks/Scratch*




- Word Blocks programming in the SPIKE App uses a version of Scratch.
  - Scratch is the de facto standard that students use to learn coding.
  - Technically speaking, SPIKE Word Blocks is an extension of Scratch 3.0.
  - It is not possible to use programs created in the SPIKE App with Scratch 3.0 or vice versa.

# Programming Basics

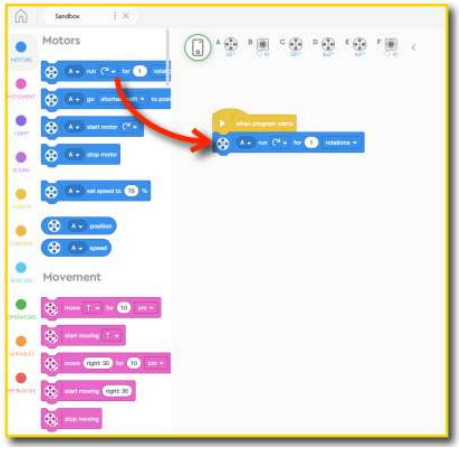
*Word Blocks/Scratch*




Word Blocks programs are written by clicking on a block on the left side of the screen (in the palettes area), dragging it to the canvas, and connecting it to the existing stack of blocks.

# Programming Basics

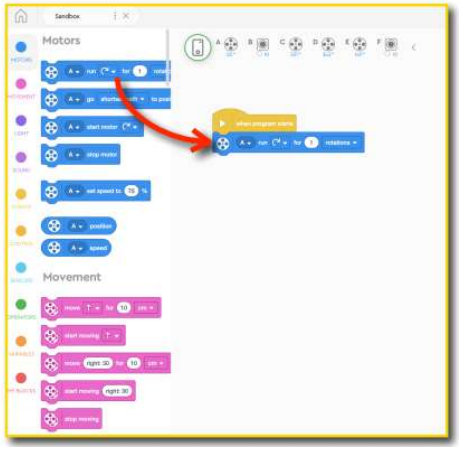
*Word Blocks/Scratch*




- By default a WHEN PROGRAM STARTS block is already on the canvas when a new project is started.
- The drag-and-drop programming style makes it easy for all skill levels.

# Programming Basics

*Word Blocks/Scratch*

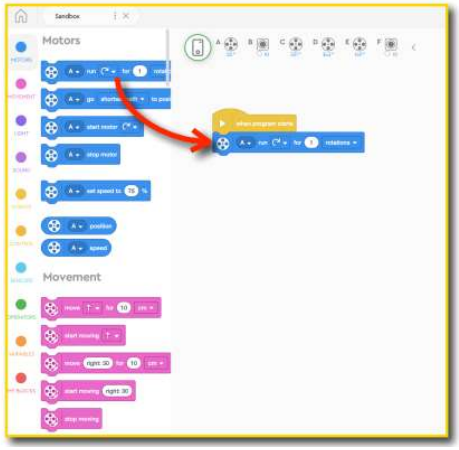



The palettes found on the left side of the screen are separated into color coded categories.

- This makes it easy to quickly find a specific type of block
- By clicking on one of the circles, you can jump directly to a particular category of blocks.

# Programming Basics

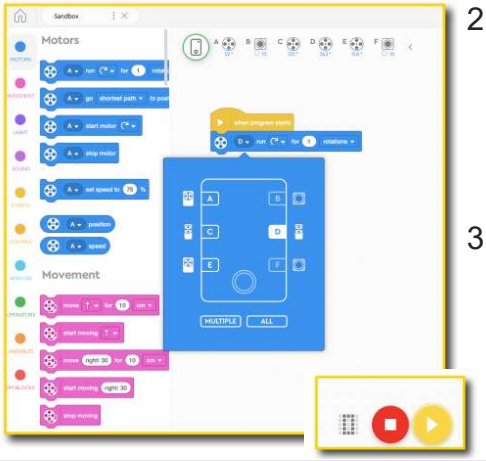
*Word Blocks/Scratch*




1. From the blue MOTORS palette, click and drag the RUN MOTOR FOR DURATION block to the canvas and place it so that it snaps into place beneath the WHEN PROGRAM STARTS block.

# Programming Basics

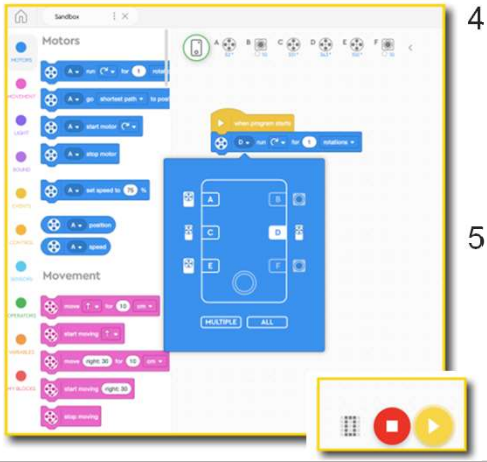
*Word Blocks/Scratch*




2. Change which motor runs by clicking on the “A” and then clicking on motor “D” in the blue pop-up box.
3. To run the program, click the yellow PLAY button on the bottom right. The program will automatically begin.

# Programming Basics

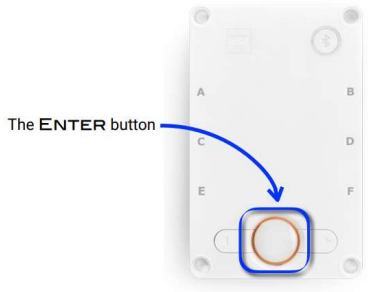
*Word Blocks/Scratch*




4. The Medium motors on the front of the robot (the side with the light up color sensors) should rotate the gray gear.
5. Projects are automatically saved with each change to the program and each download to the Hub.

# Programming Basics

*The Hub*




Press the ENTER button once to bring up the program selection menu

Press ENTER again to select the 0 program

Once downloaded, programs can be started directly on the Hub.

# Programming Basics

## *Running Programs from the Hub*

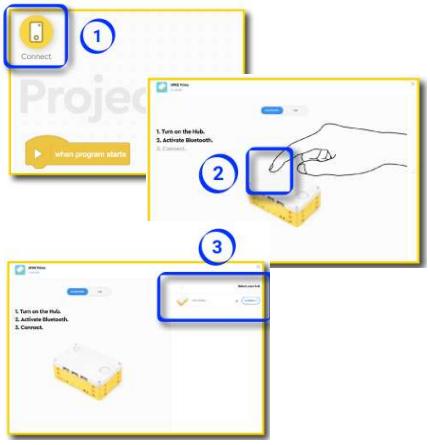
When the Play button is pressed, it triggers a sequence of steps.

1. The Word Blocks environment uses human friendly blocks that needs translated into a simplified machine language code.
   a) The first step is that the SPIKE App makes this translation. This is called compiling the code.
   b) The machine language code is not very human friendly, but it's more streamlined because it doesn't include the aesthetics of the Word Blocks.
2. The machine language code is sent through the connecting cable, from the computer to the Hub.
3. The machine language code is executed.

- Because the machine language code is transferred to the Hub during this process, it's possible to repeatedly run the code directly from the Hub.
  - This is accomplished by pressing the large, white Enter button once to start the program selection menu, and once again to select the program.
  - Unless otherwise changed, the default code is placed in the code 0 slot.
  - Although not evident with this slide, the SPIKE Hub has an embedded LED display that easily shows which program number has been selected.
  - After pressing the Enter button once, a large number 0 is displayed on the top side of the Hub.
  - The second press of the Enter tells the Hub to execute program 0.
- If the project files on the computer are erased, it's not possible to retrieve them from the Hub.
  - This means it's important to take care of the original Word Blocks codes on the computer.
  - The transfer of the machine language code to the Hub is a one-way street

# Programming Basics

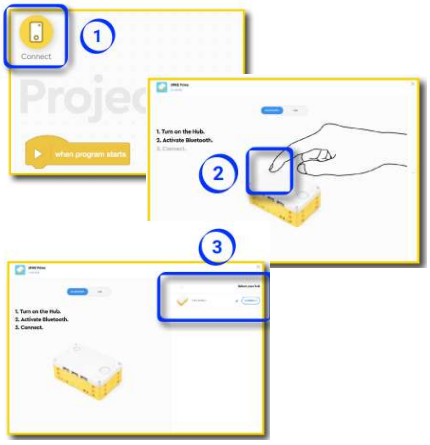
*Connecting the Hub via Bluetooth*




1. Untether the Hub from the computer.
2. Verify the Hub is on
3. Make sure the computer's Bluetooth is turned on.
4. Click the Hub connection icon
   a. Verify that the Bluetooth option is highlighted in Blue.
5. Press the smaller Bluetooth circle on the top of the Hub.
6. Press the CONNECT button next to the Hub's name from the list on the right.

# Programming Basics

*Connecting the Hub via Bluetooth*




Although the Hub was renamed in an earlier step, that name doesn't always show up in the list.

- If this is the case, after establishing the Bluetooth connection, use the Bluetooth menu on the computer to rename the Hub to match the name given in the SPIKE App.

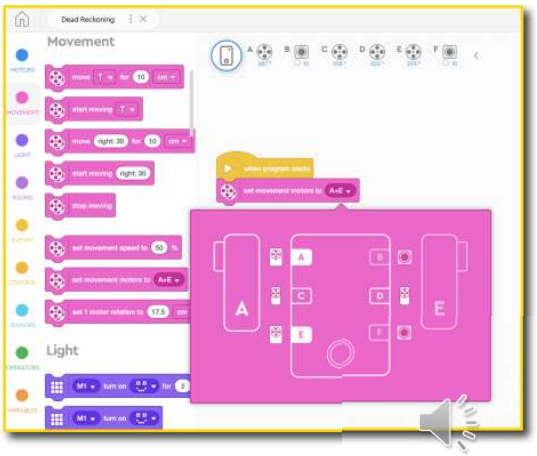
Once a Successful Bluetooth connection is established between the computer and the Hub

- The Bluetooth button on top of the Hub will have a light up blue ring and
- The Hub connection on the SPIKE App will also have a blue ring around it.

# Programming Basics

*Defining Drive Motors*

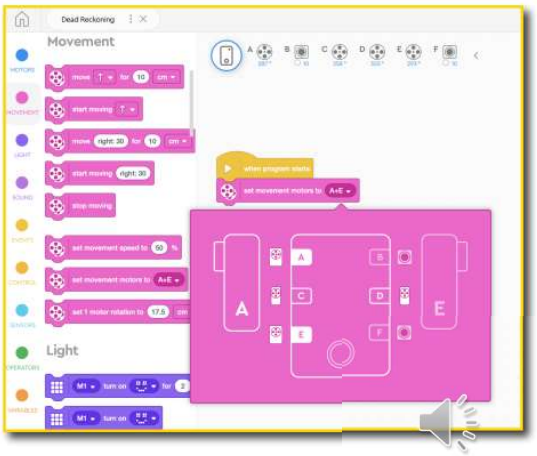
Before the robot can move, it needs to be taught which ports on the Hub are connected to the drive motors.



# Programming Basics

*Defining Drive Motors*

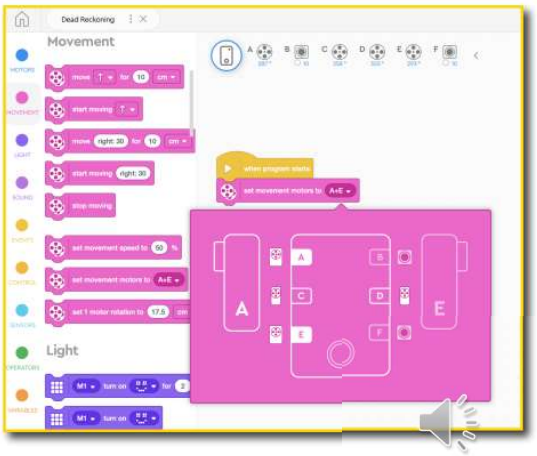
If the Advanced Driving Base assembly instructions were carefully followed, the drive motors should be connected to the A & E ports.



# Programming Basics

*Defining Drive Motors*

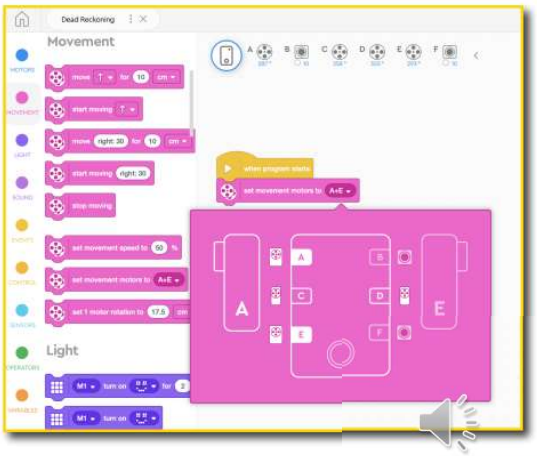
To teach the port assignment to the Hub, the SET MOVEMENT MOTORS block is used.



# Programming Basics

*Defining Drive Motors*

By default, the A&E motors are identified as the drive motors, which is consistent with the Advanced Driving Base instructions.

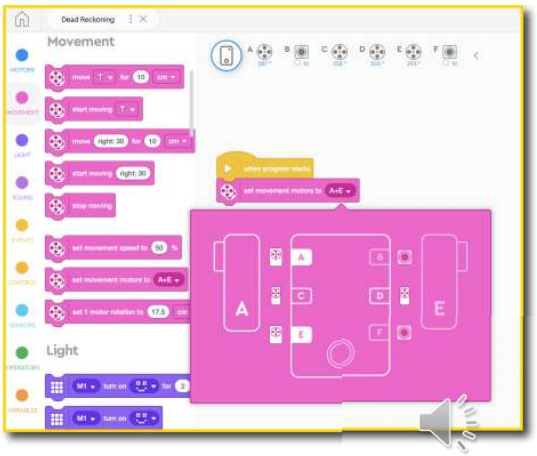


# Programming Basics

*Defining Drive Motors*

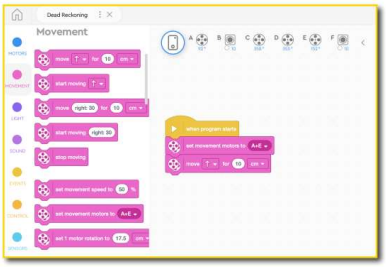
It's important to get the port assignments correct, including the order. If the ports are reversed, then the robot will drive backwards.

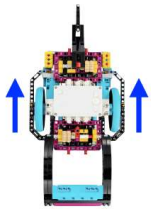
When blocks have 2 inputs for wheels, the first one is for the left wheel and the second is for the right when viewing the robot from above.



# Programming Basics

*Moving the Robot*

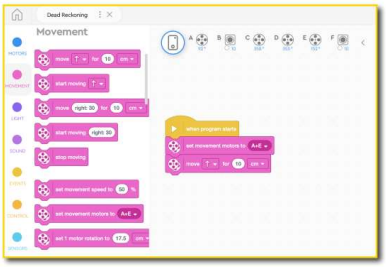


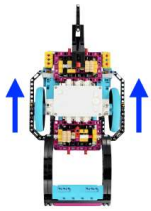



- The pink MOVEMENT blocks are used to tell the robot how to move.
- The MOVEMENT blocks take care of coordinating the two drive motors to work together to move the robot.
- You can tell the drive motors to move independently if needed.

# Programming Basics

*Moving the Robot*

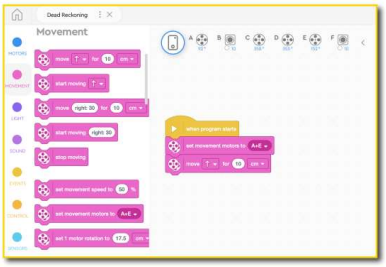


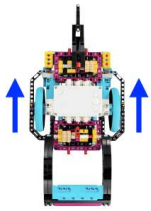



- Use the MOVE FOR DURATION block, without changing any of options in this block.
- The robot should move 10 cm forward, in the direction of the two color sensors.

# Programming Basics

*Moving the Robot*



- Carefully consider what must be accomplished in moving the robot forward.
  - Both large motors connected to the robot, in ports A & E, must be told to rotate at the same rate.
  - Since the motors are mounted in mirrored positions from one another one motor must rotate clockwise while the other rotates counter-clockwise.
  - The MOVE FOR DURATION block takes care of all this coordination.

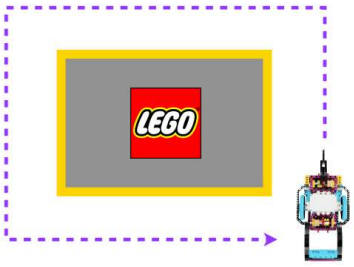
# Programming Basics

*Learning Through Play*

There is not enough time to cover all programming commands and techniques. Try things out to explore the possibilities!

# Programming Basics

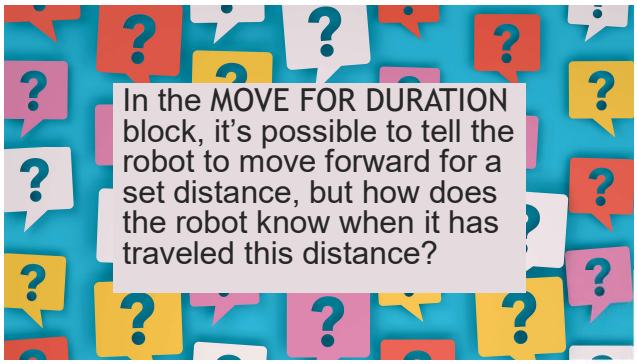
*Learning Through Play*



Program the robot to complete a rectangular path around the SPIKE Prime box. This will take some exploration of the programming blocks, specifically, how to turn the robot.

# Programming Basics

*Setting Travel Distances*



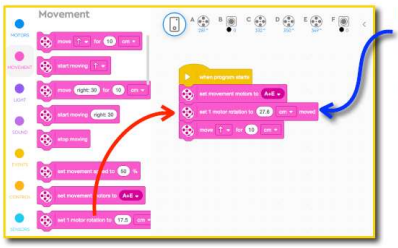
# Programming Basics

## *Setting Travel Distances*

- The SPIKE App assumes a certain diameter for the wheels attached to the drive motors.
  - With this assumption, one complete rotation of a drive motor is equivalent to moving the robot forward a set distance.
    - The circumference of the wheel is equal to the distance the robot travels in one complete rotation.
    - The circumference is found by taking the wheel diameter and multiplying it by 3.14. ($\pi$)
  - By default, it is assumed that the smaller wheels (diameter 5.6cm) are attached to the drive motors.
    - With these smaller wheels, each rotation moves the robot forward by a distance of 3.14 x 5.6 cm = 17.5cm.
  - The Advance Driving Base robot uses the larger wheels, which have a diameter of 8.8cm.
    - With these larger wheels, each rotation moves the robot forward by a distance of 3.14 x 8.8 cm = 27.6 cm.

# Programming Basics

*Setting Travel Distances*




Enter a value that is 3.14 times the wheel diameter (27.6 for the large SPIKE wheels)

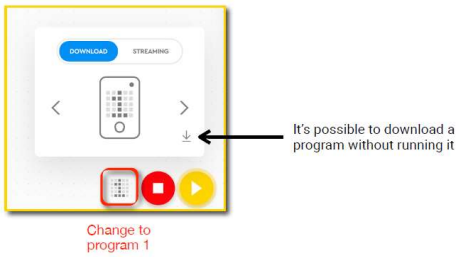
The wheel diameter is printed on most wheels or found at http://wheels.sariel.pl


To accurately use the MOVE FOR DURATION block, the SET 1 MOTOR ROTATION TO DISTANCE MOVED block must first be executed with the appropriate distance set.

(17.5 cm for small wheels, 27.6 for the larger wheels we are using today)

# Programming Basics

## *Assigning Program Slots*




By clicking on the program number on the bottom right area of the canvas, you can assign a a program to one of 20 program slots.

- The arrows on either side of the Hub icon are used to select a slot.
- The Hub can hold 20 programs, numbered 0-19.

- In addition to assigning a program number, the same window allows for a program to be downloaded without immediately executing it.
- Different versions of the same code can be assigned to different program slots.

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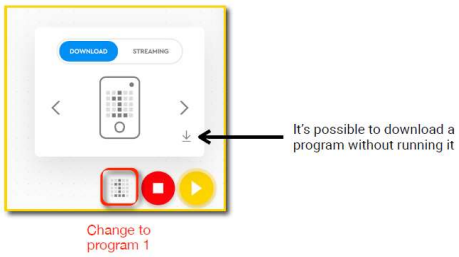
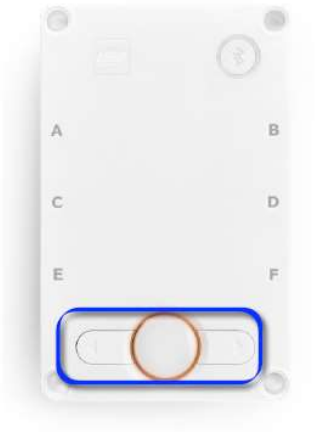



There are two modes in which programs are sent to the Hub from the SPIKE App.

- The DOWNLOAD mode compiles and transfers the current version of the program to the Hub by assigning the program to a program slot and the program is automatically saved each time the PLAY button is pressed.
- In STREAMING mode, the program streams to the Hub when the PLAY button is pressed, without storing the program. This allows the freedom to tinker with the program until the coding is just right.

# Programming Basics

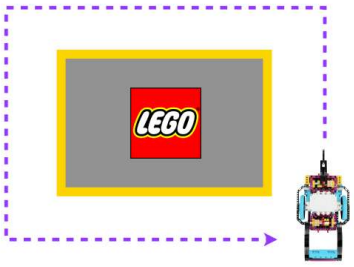
*Starting Programs from the Hub*




- Once downloaded, programs can be started directly on the Hub, using the arrows to select the program number.
- The SPIKE Hub has an LED display that shows which program number has been selected.
  - After pressing the ENTER button once, a large number 0 Is displayed on the top of the Hub.
  - Using the arrows next to the ENTER button, you can change which program will be executed.
  - Once the desired program is selected, a second press of the ENTER button tells the Hub to execute the numbered program.

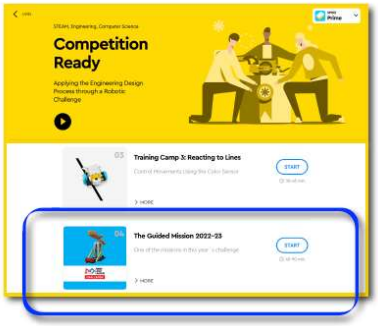
# Programming Basics

*Learning Through Play*



Now, try to rewrite the code that has the robot circle around the LEGO storage bin. This time use actual distances.

## Solve a mission




The guided mission is part of the Competition Ready UNIT in the Spike App, resources are available online.

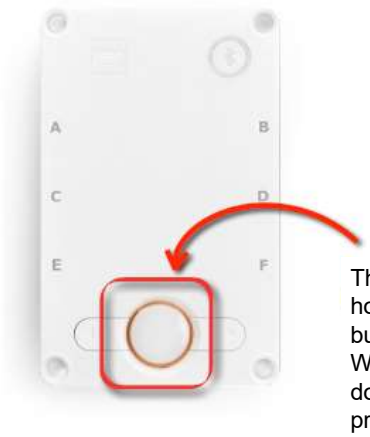
- Teacher's Guide: https://education.lego.com/en-us/lessons/prime-competition-ready/spike-prime-smart-grid-guided-mission#lesson-plan
- Student's Guide: https://education.lego.com/en-us/lessons/prime-competition-ready/spike-prime-smart-grid-guided-mission/student-worksheet
- Code: https://www.firstinspires.org/resource-library/fll/challenge/challenge-and-resources

FIRST LEGO LEAGUE

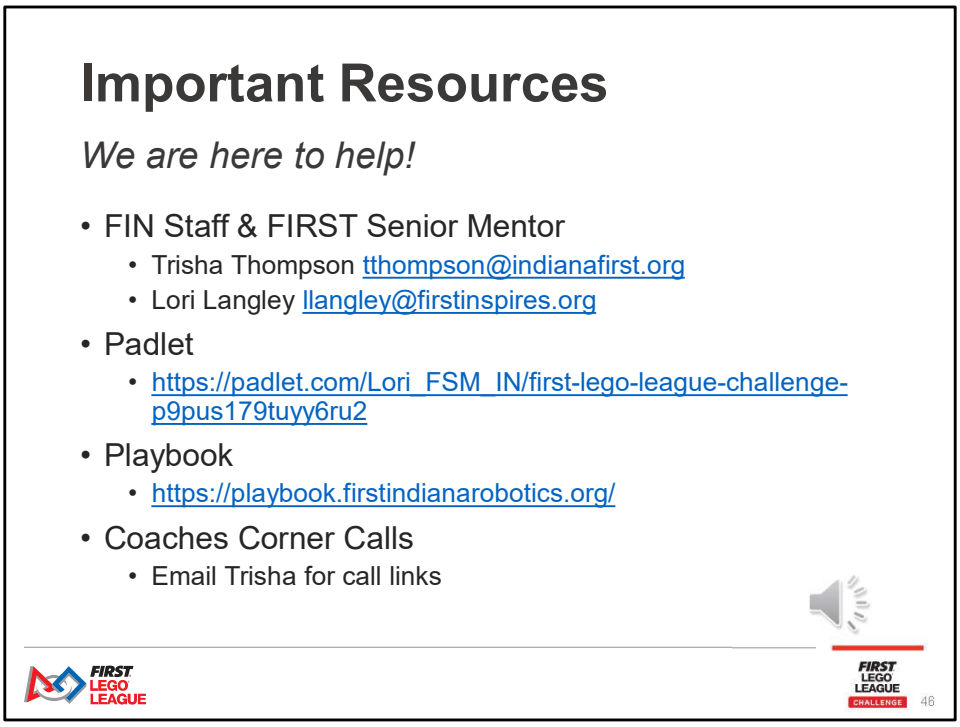
FIRST LEGO LEAGUE CHALLENGE 44

Each year, FIRST provides a guided mission to help teams learn to program and ensure completion of one mission.
The Spike app needs to be updated each season to get the latest version of the guided mission. If you'd like, you can find that mission in the SPIKE app and work through it. There is also a solution to another mission available in our training module Self-Guided Training – Mission Planning.

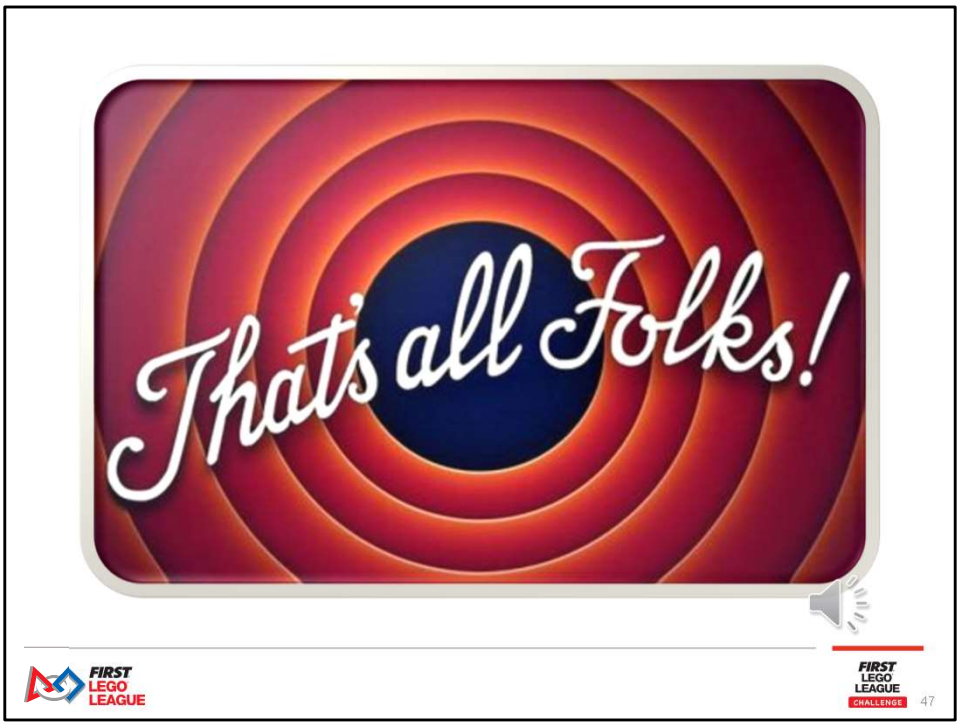
# Turning off the Hub




The Hub is turned off by holding down the ENTER button for 5 seconds. While the button is held down, the Hub will produce a ticking sound.




Remember, you are not in this alone, we are here to help! Feel free to contact me, Trisha Thompson, or FIRST Senior Mentor Lori Langley, any time for help. Lori has also put together a padlet full of useful information. All FIN trainings and season documents are available on the FIN playbook. Finally, I encourage all coaches to attend our Coaches Corner Calls. Please email me if you need the zoom link.




I hope you enjoyed our Programming Self Guided Training Session. There are two additional self-guided training sessions available, Mission Planning and Next Level Programming. You can find these online in the FIN Playbook.