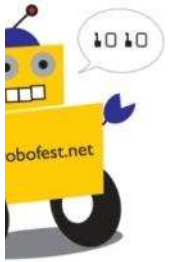

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ROBOParade

EV3 Workshop

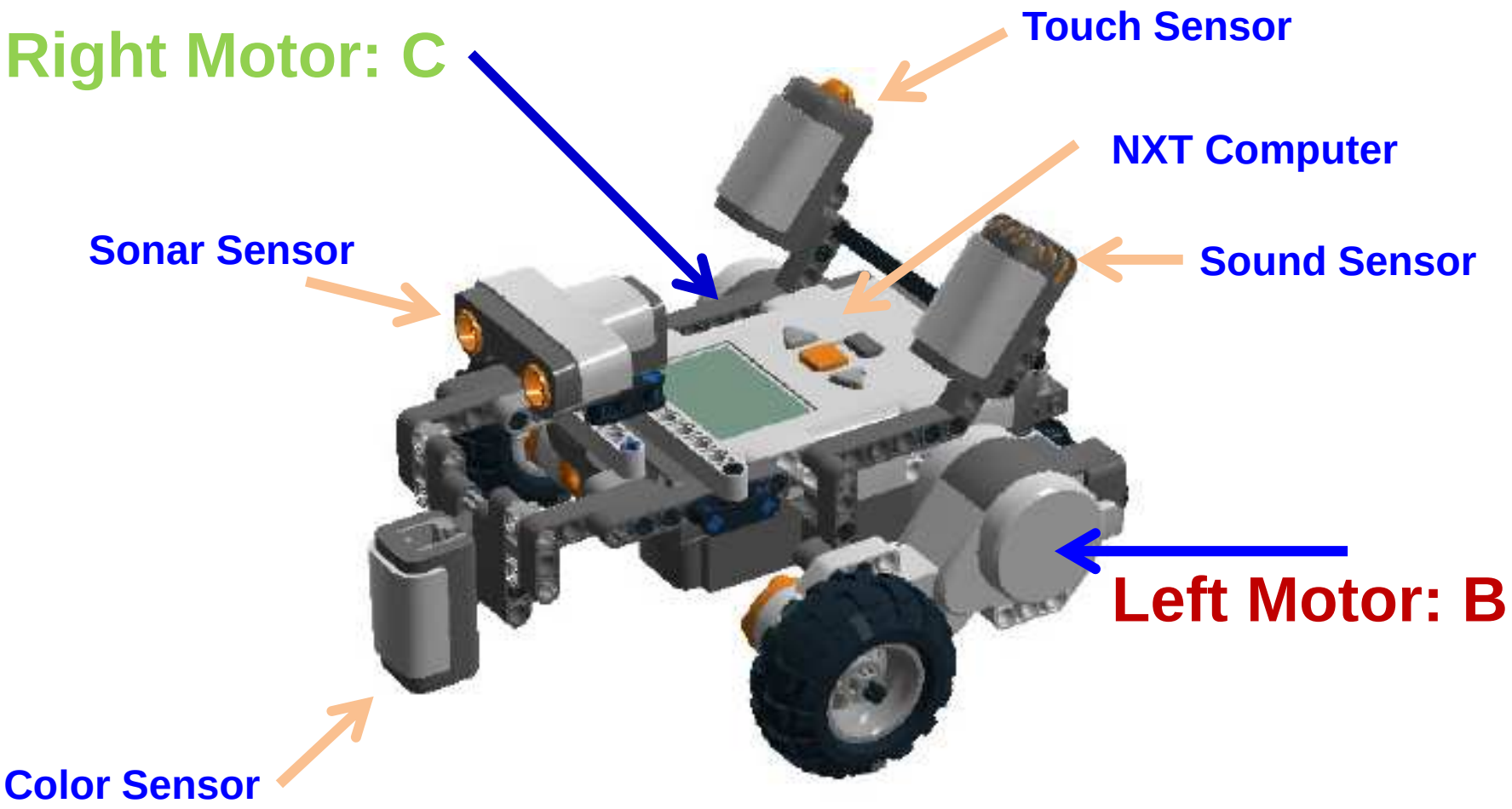
Instructor: Joe DeRose, Ph.D.
Assistant(s): Chris Parker & Eli Fry

Curriculum Developed by Joe DeRose, Ph.D.
Robefest Lead Instructor

Curriculum Based Off NXT Version Developed by CJ Chung, Ph.D.
Professor / Robofest Founder & Director

Lawrence Technological University

Lego NXT robot used – OmniBot



Remember the connections!

- Left Motor connects to **B**
- Right Motor connects to **C**

- Color sensor connects to port no. **1**
- Touch sensor connects to port no. **2**
- Sound sensor connects to port no. **3**
- Sonar sensor connects to port no. **4**

EV3 Versions Used

- Examples are using EV3 Version 1.0.1
- NXT Firmware version: 1.31
- All example programs in RoboParade.ev3
- Free version from EV3 may be downloaded

http://www.lego.com/en-us/mindstorms/downloads/software/ddsoftwaredownload/download-software/

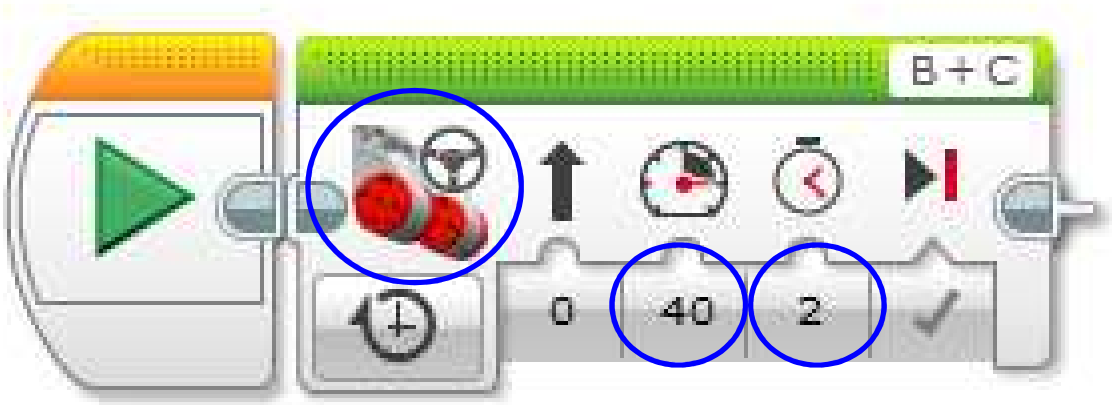
Mission 0:

Go straight for 2 seconds using different power levels

LAUNCH 

LEGO MINDSTORMS
Education EV3

Go forward for 2 seconds with power level 40 %



EV3 offers two move blocks

Move Steering Block: Controls and regulates two motors with a steering input and single power level. (+) steering = right; (-) steering = left

Move Tank Block: Controls two motors with a power level to each motor

In this course we will use the Move Steering Block.

Let's test it

- Connect the NXT to the laptop (if this is the first time, then a "Found New Hardware" message will appear)
- Click on the 'Download' button

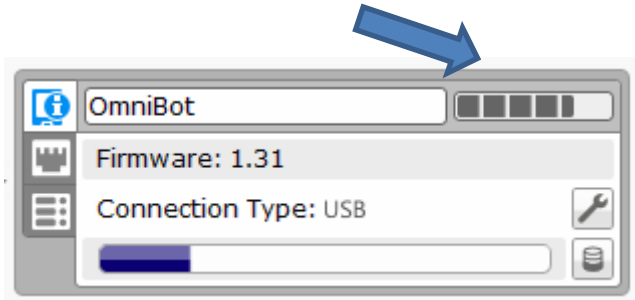
- It's recommended to always unplug the cable from the bot before running the program
- Navigate through the NXT's menu:
  - Turn On > My Files > Software Files
  - Then select your program and run it!

Let's measure the distance traveled

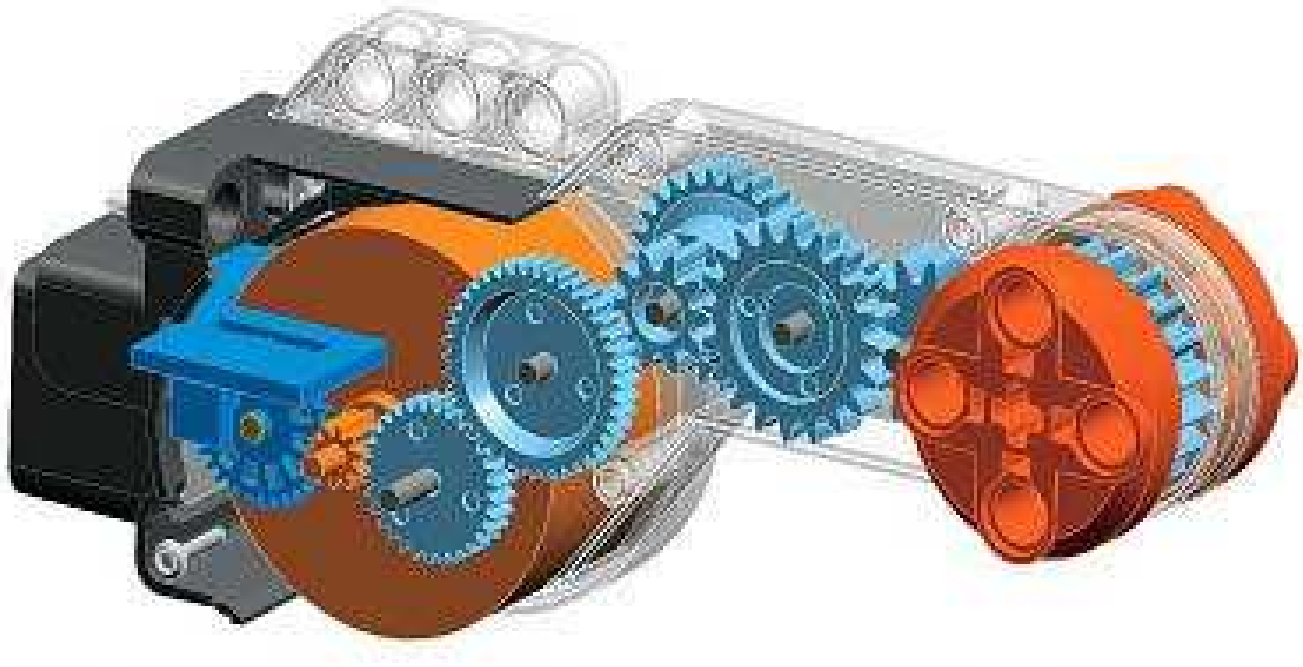
- How many centimeters when 40% power used?

- How many centimeters when 70% power used?

How to find out the current battery voltage level?

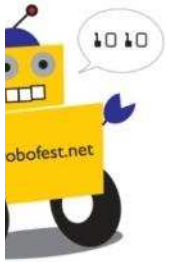


NXT motors: geared motor with built-in rotation sensor



Rotation sensor gives “degrees” turned. (It can also give “rotations,” but the pop-up incorrectly displays “degrees.”)

For example, if the value is 360, the motor turned one rotation.



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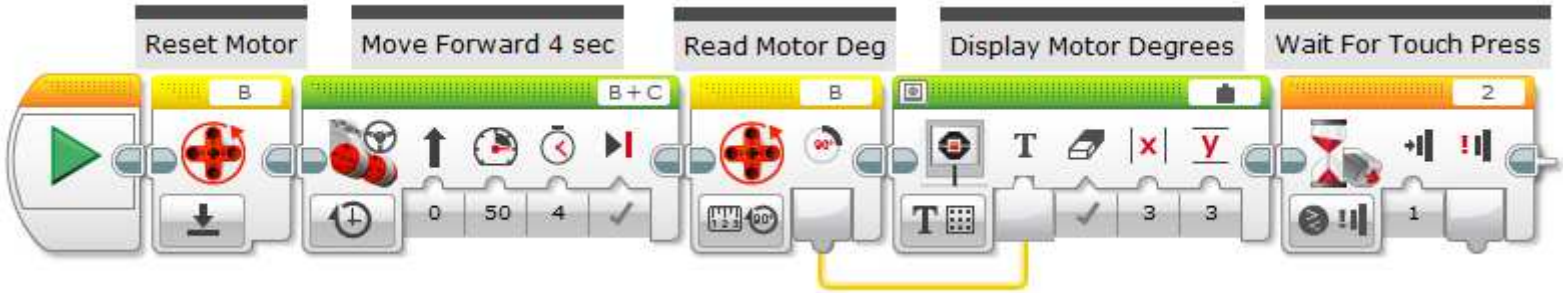
Mission 1:

Display the “degrees” when the bot goes forward for 4 seconds

Display the “degrees” turned for going forward for 4 seconds

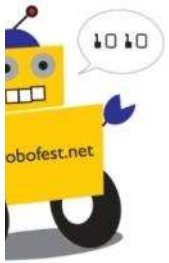


Program: DisplayDegrees

Review

- Number of rotations = degrees / 360
- Circumference of a circle = diameter * 3.14
- Travel distance = number of rotations * circumference of the wheel

- Speed = distance / time



How to calculate the average speed of robot for that 4 seconds ?

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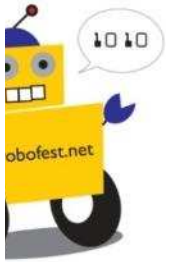
1) If “degrees” were 1,300, then how many times the wheel was rotated?
2) If the circumference of the wheel is 17cm, what is the travel distance for 4 sec?
3) Then what is the averaged speed of the robot for the 4 seconds?

- Note: RoboParade has min and max speed limits. **7** ~ **17** cm/sec



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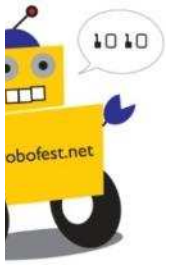
Mission 2:

Display the “speed” when the bot goes forward for 4 seconds



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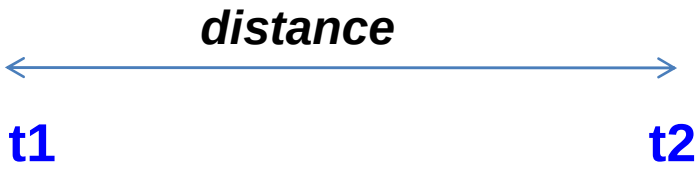


HOW DO YOU CALCULATE SPEED?

v = distance / time (cm/second)

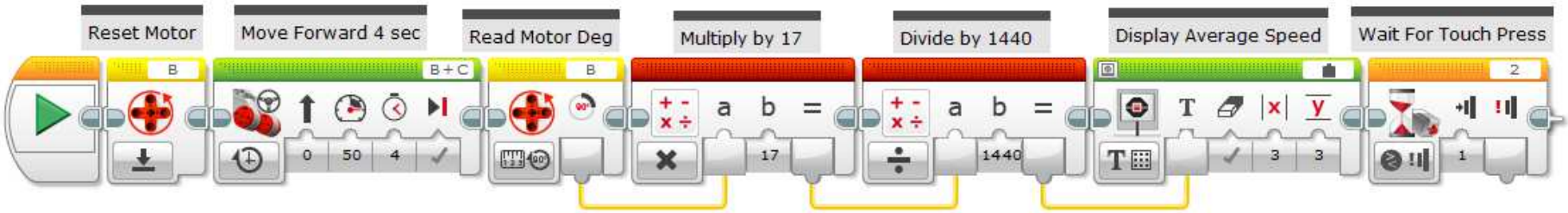
Example when the degrees = 1300

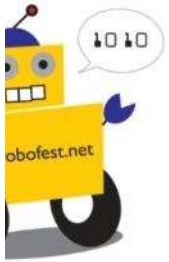
$$\text{Speed} = \frac{\text{distance}}{\text{time}}$$

$$= \frac{\frac{1300}{360} \times 17}{4}$$

$$= \frac{1300 \times 17}{360 \times 4} = 15.3 \text{ cm/sec}$$

Program: DisplaySpeed





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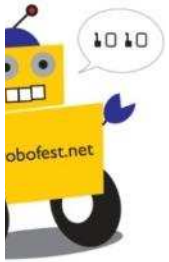
Exercise

- We can make the program shorter
- Instead of multiplying by 17 and then dividing by 360*4=1440, we can just multiply by 17/1440=0.0118
- This uses one math block instead of two



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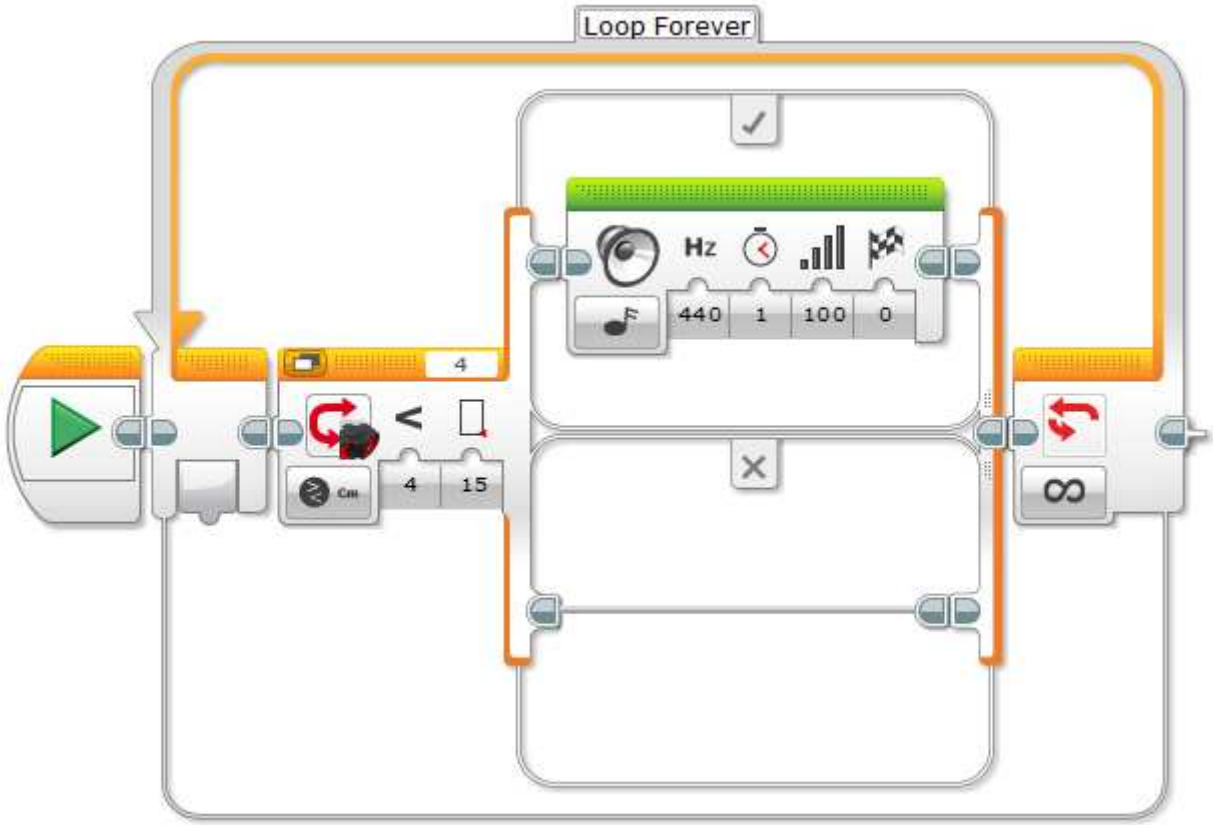
NXT-G Basics

SONAR (ULTRASONIC) SENSOR
ENDLESS LOOP
DECISION MAKING
SOUND SENSOR

Ultrasonic Sensor

- Uses the same scientific principle as bats
- Can measure in centimeters or inches
- Large objects with *hard* surfaces return the best readings

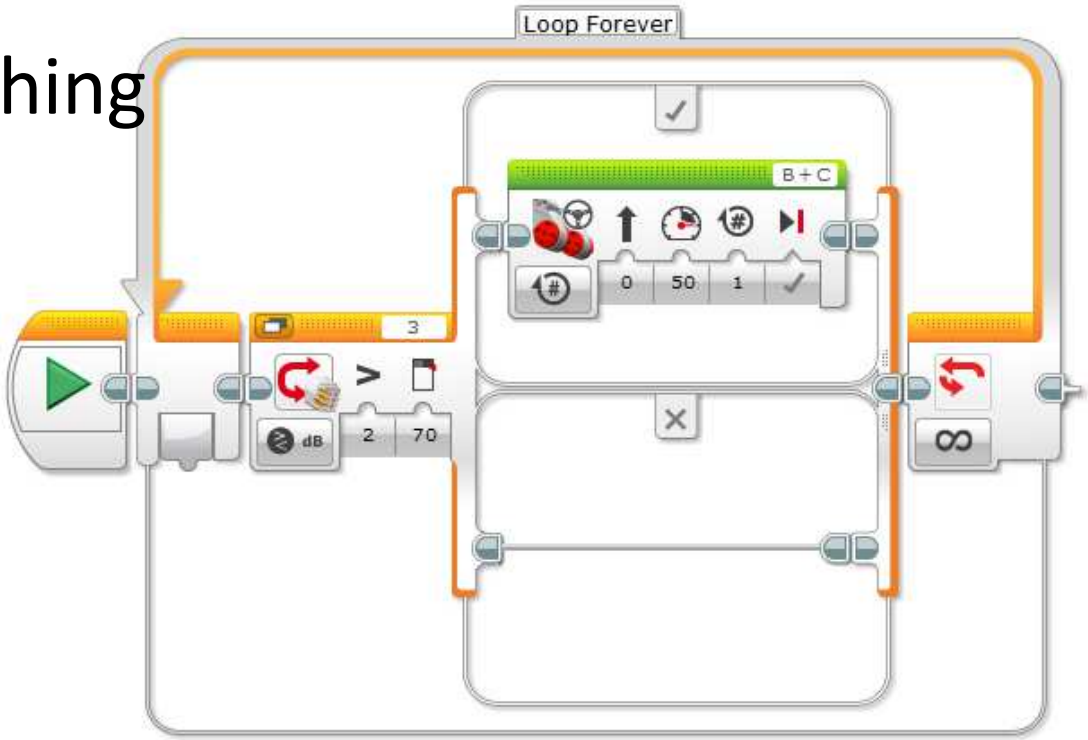
Can you tell what the following program, usTst2, is doing?

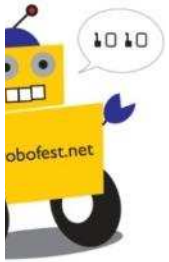


Mission 3: Clap -> Move

(Program: clapMove1)

- Use a Sound Sensor connected to port no. 3
- If sound level is greater than 70, go for 1 rotation
- Otherwise, do nothing





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Mission 4:

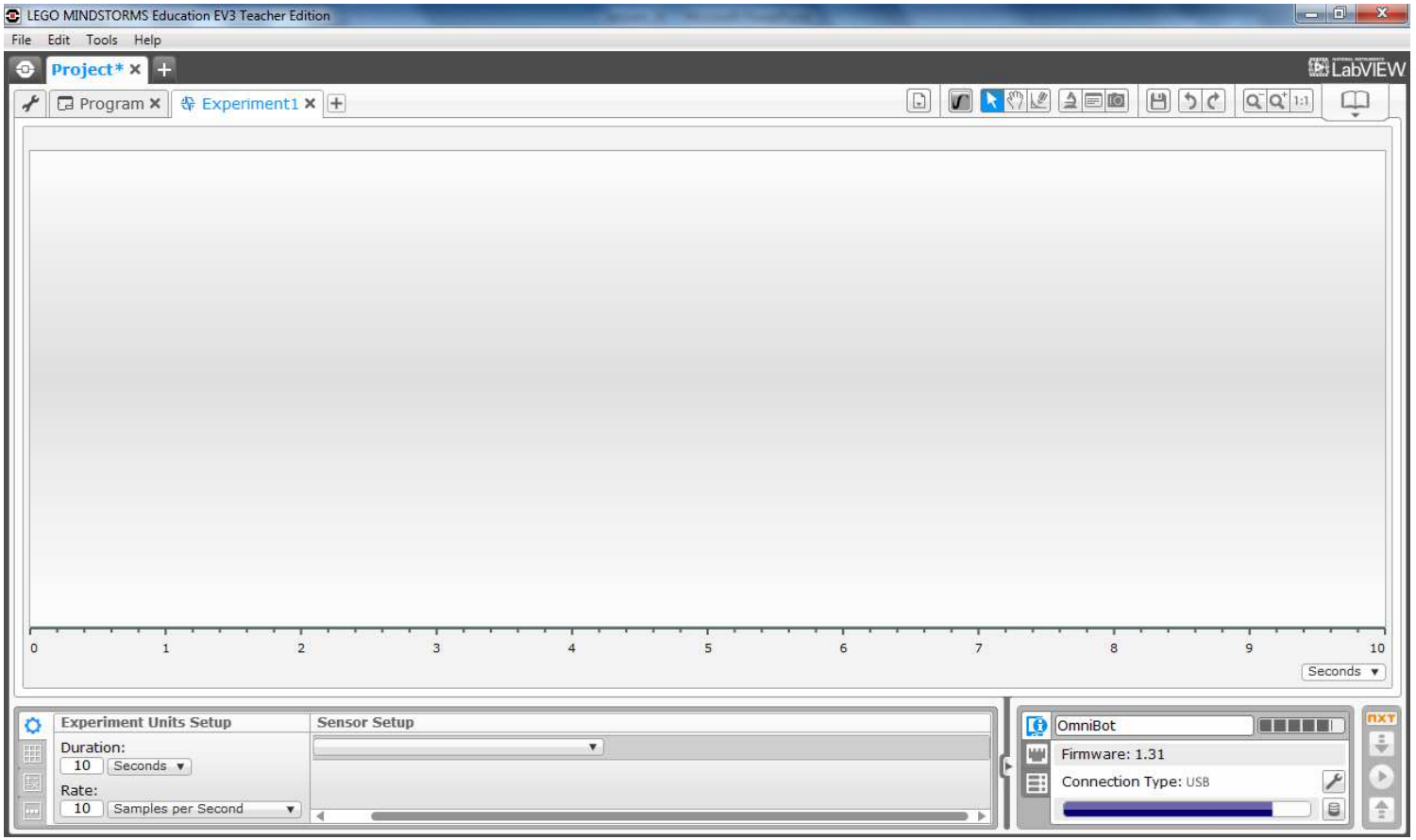
Line following using a Color Sensor

NXT Color Sensor

- Percent Mode:
  - 5% = lowest dark
  - 100% = very bright
- Reflected Light Mode: shines a red light
- The light can be turned off – detecting ambient light (surrounding light)
- We will use EV3 Experiments to test our color sensor

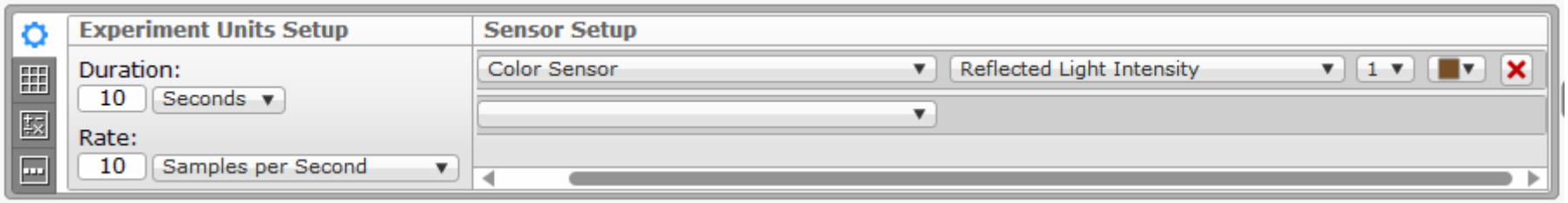
NXT Color Sensor

- Create a New Experiment

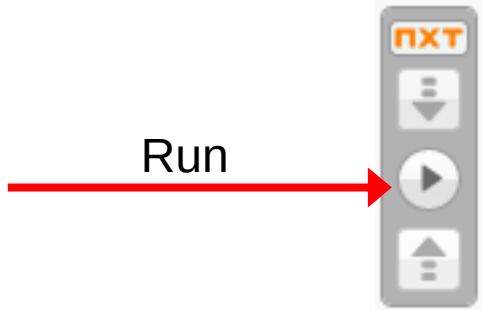


NXT Color Sensor

- Set up the experiment to plot the color sensor reading using “Reflective Light Intensity”

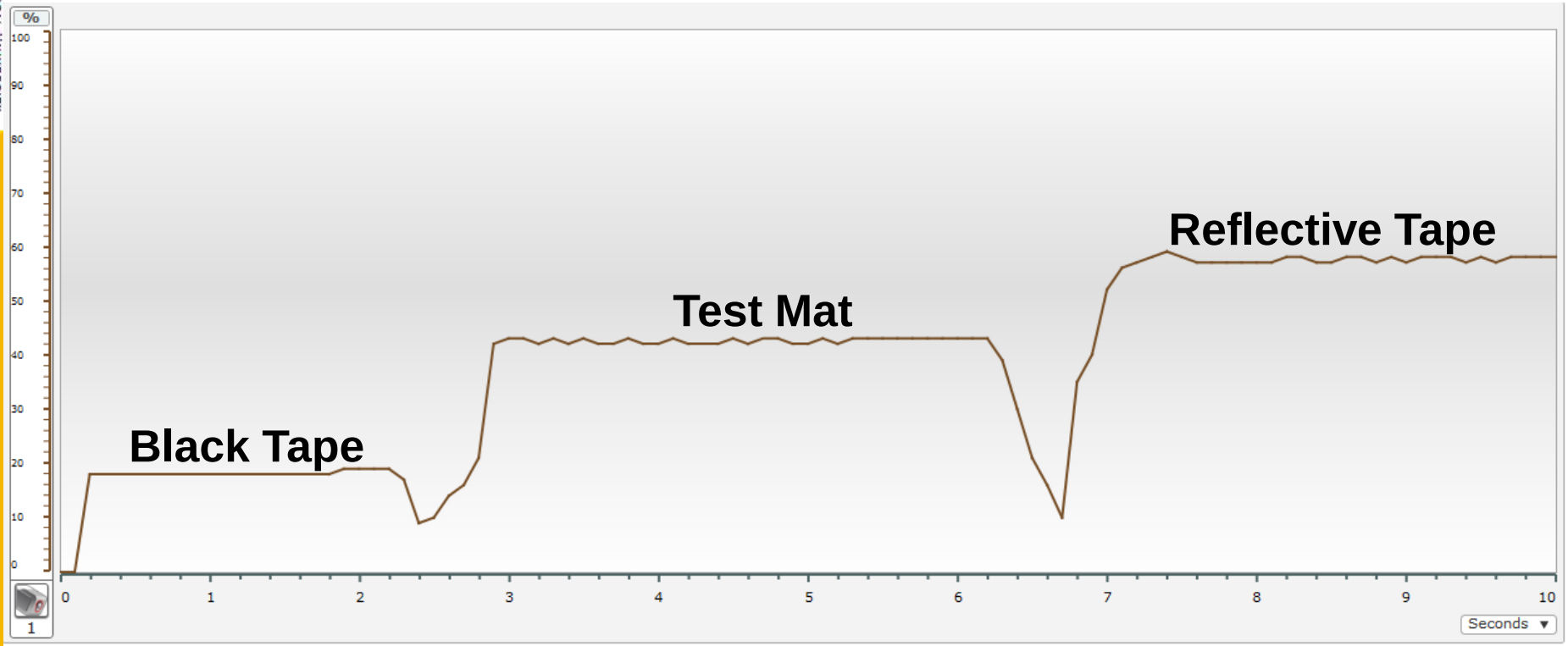


- Run the experiment with the light sensor over various objects



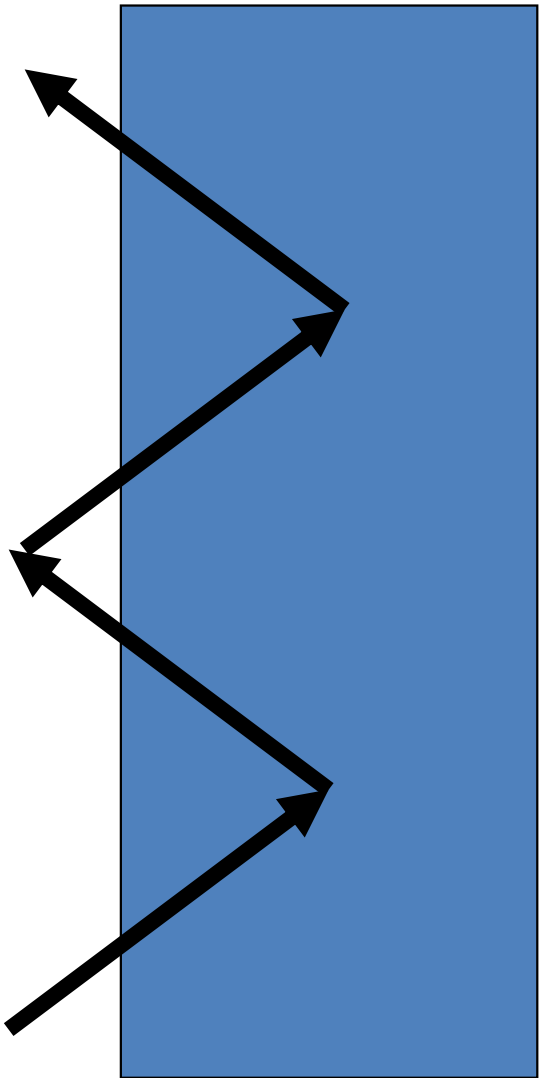
NXT Color Sensor

- Sample results

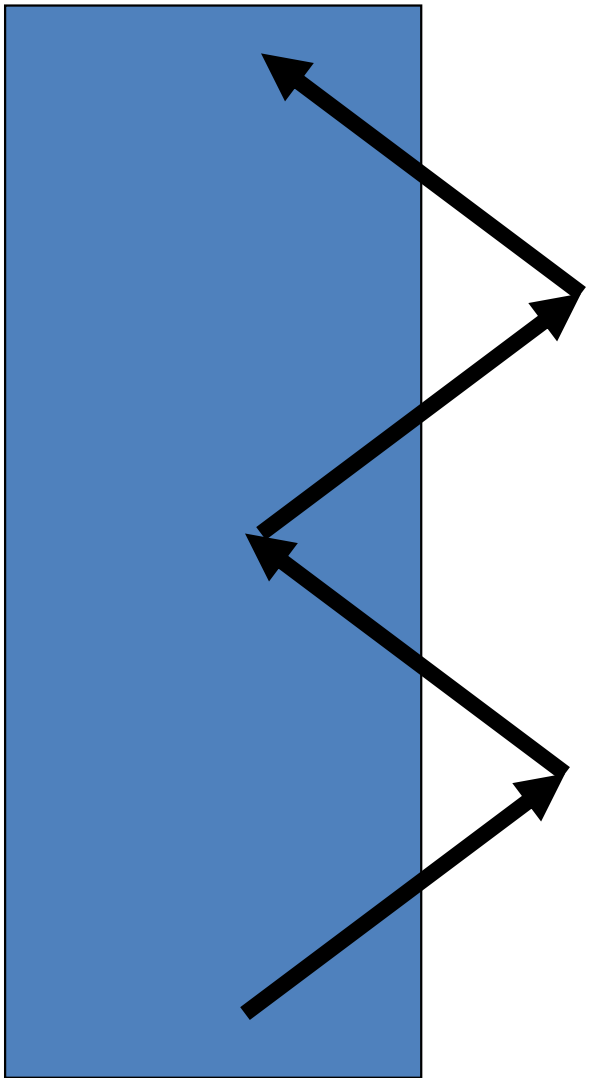


Zigzag Line following Idea

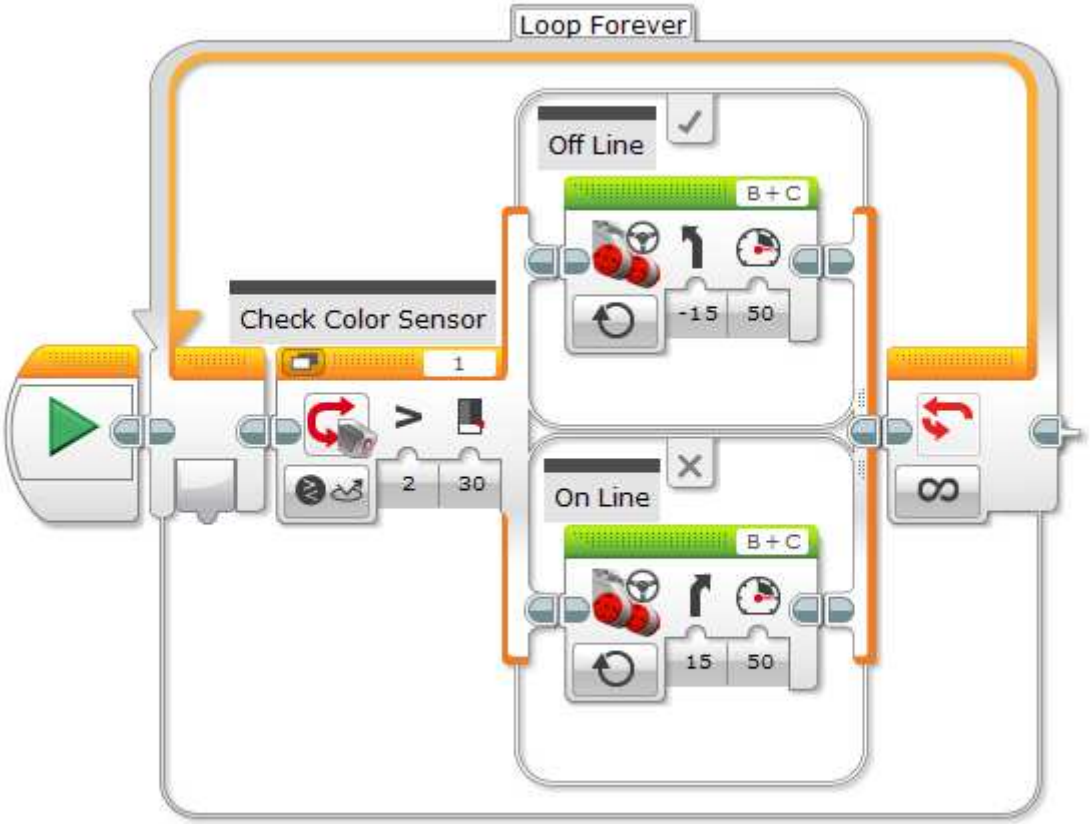
Left side following



Right side following

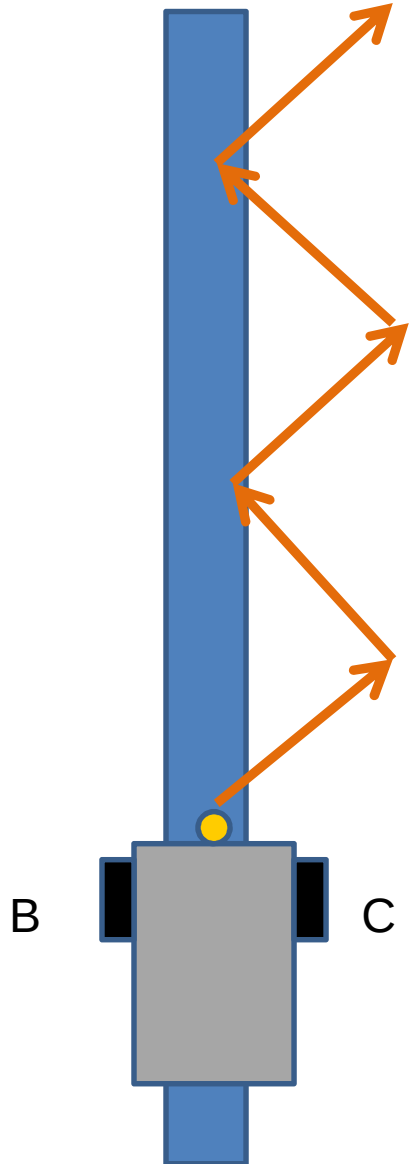


Simple Line Following Algorithm Program: LineFlowZZ

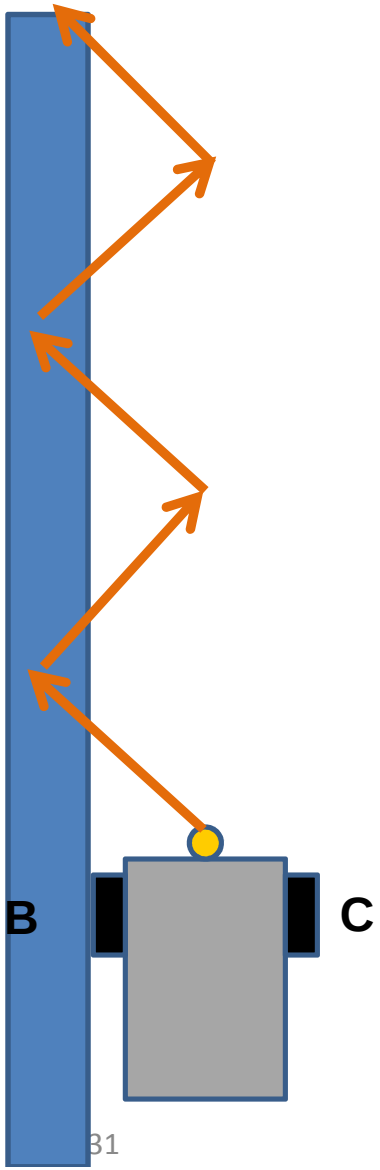


Right side or Left side following?

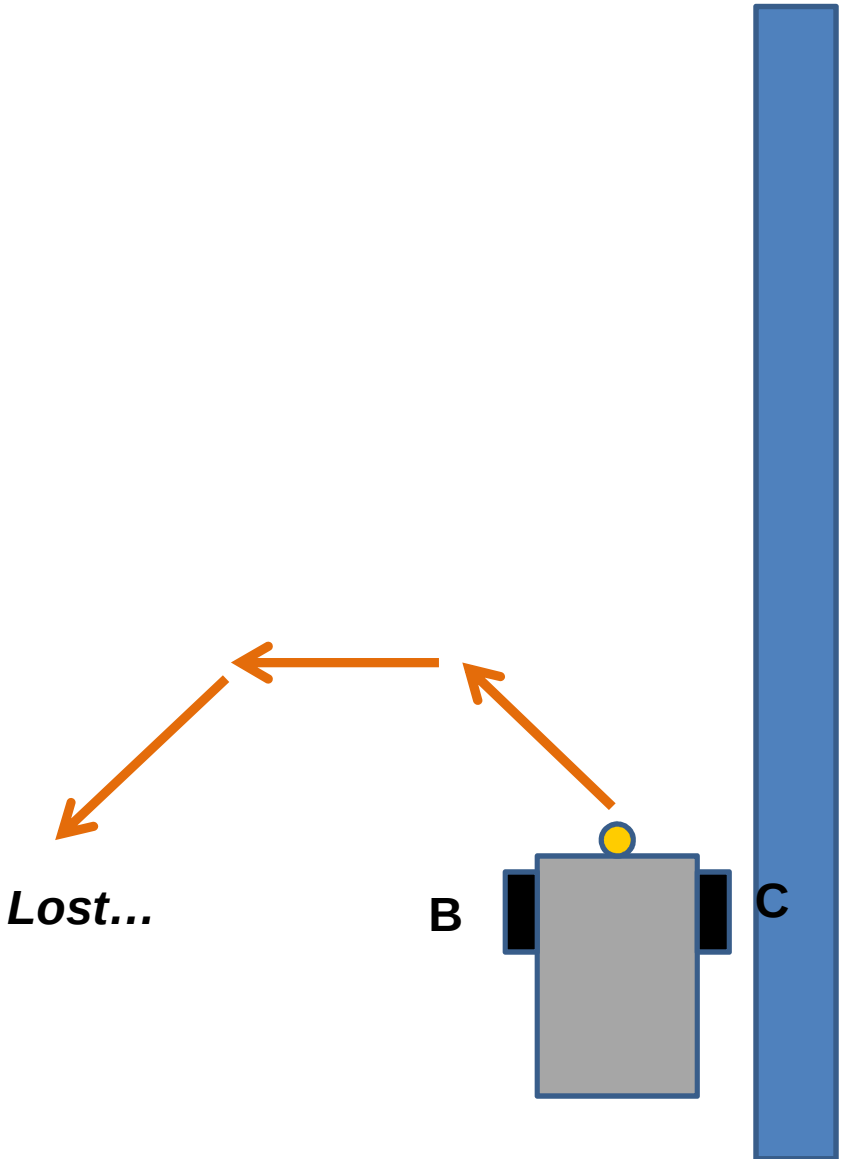
How and Where to start the robot?

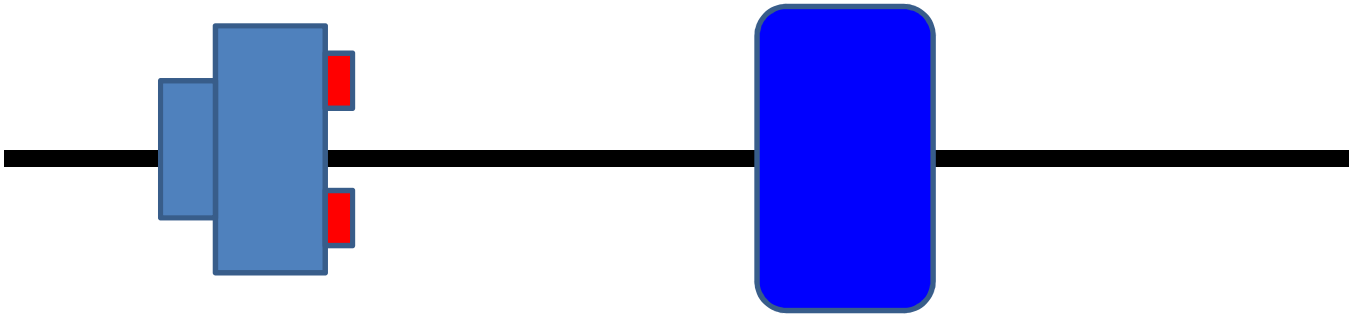


How and Where to start the robot?



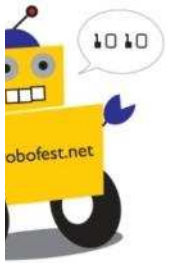
How and Where to start the robot?





Mission 5:

FOLLOW THE PARADE ROUTE AND STOP WHEN AN OBJECT IS SENSED IN FRONT



Parade Program

Endless loop

{

If sonar sensor detects an object

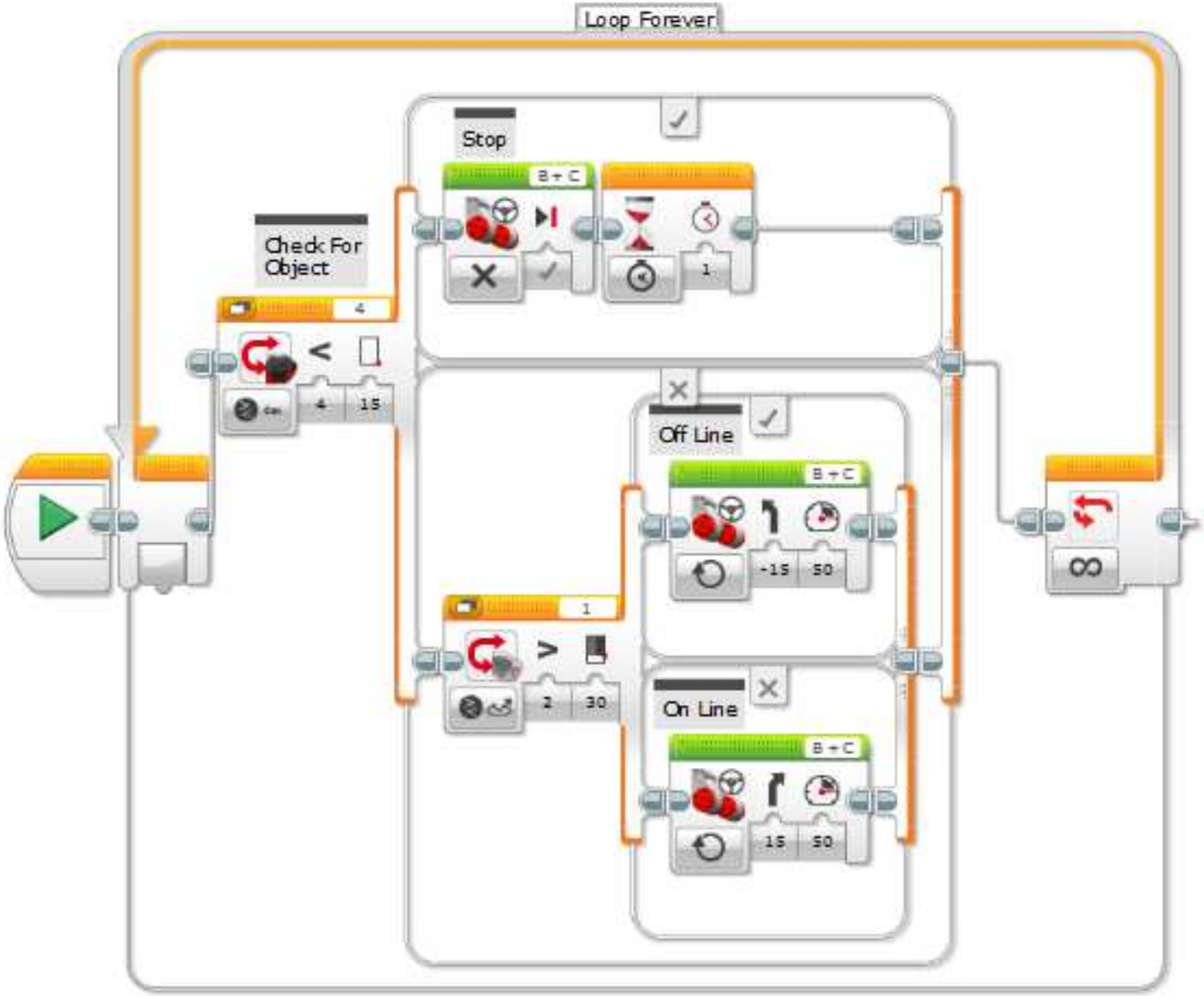
Stop!!!!!

Otherwise

Follow the black line

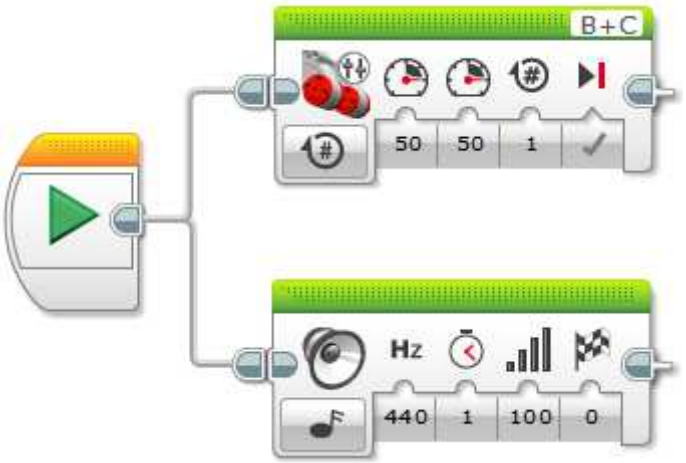
}

Program: Roboparade



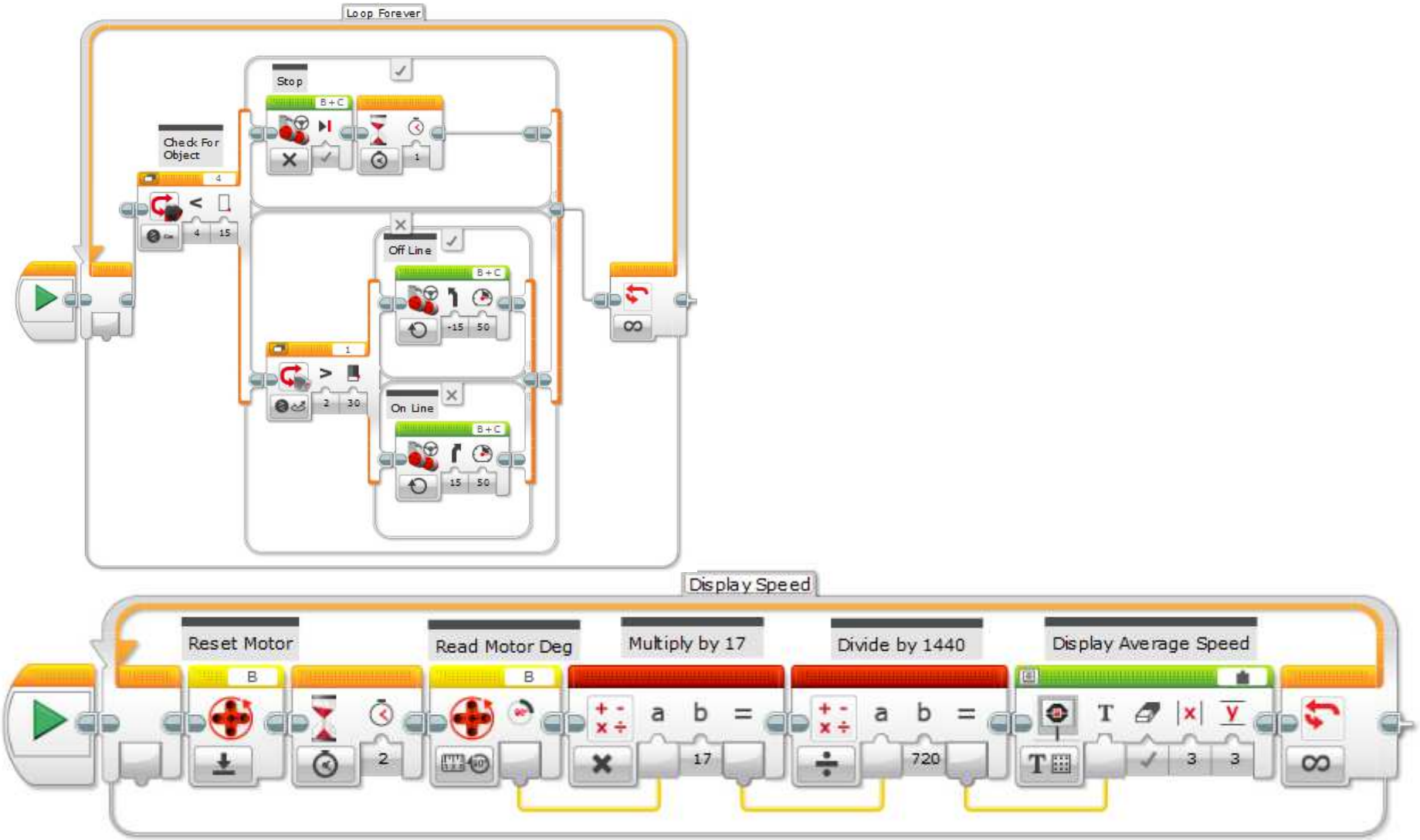
How to connect a parallel sequence beam?

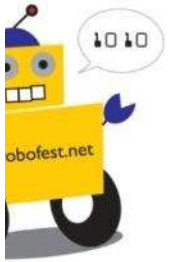
- Two methods
  - Spilt sequence beam



  - Add additional Start Blocks

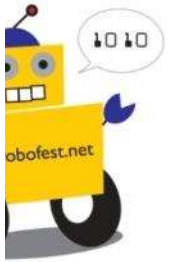
Mission 6: RoboParade with Speed Display (every 2 seconds) – RoboParadeSD





How to improve your robot and computer program for the Parade

- Go to www.robofest.net
  - Click on Tech Resources button on the left
  - There will be a PPT with more ideas and tips for Roboparade



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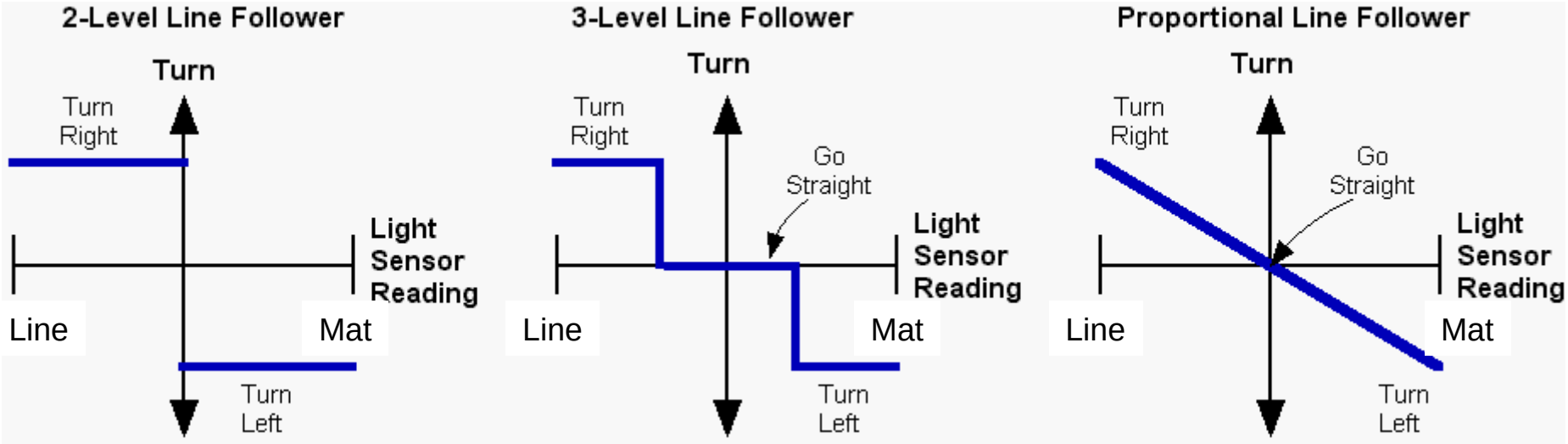
Mission 7:

Smoother line following using a Color Sensor

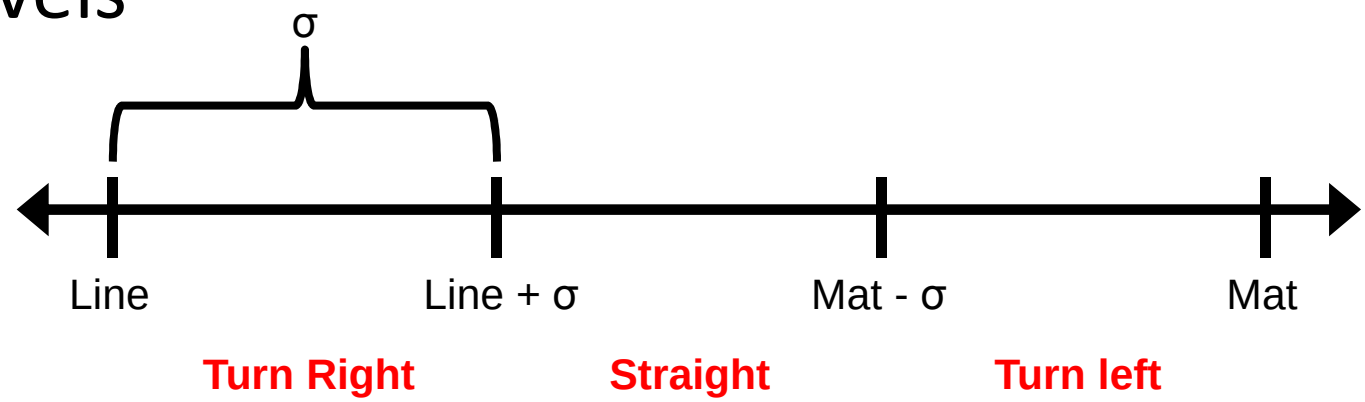
How to improve our line following algorithm

- Zig-zag method can cause a bumpy response
- We can improve the performance by using a more sophisticated algorithm



3-Level Line Follower

- Divide light sensor reading range into three levels

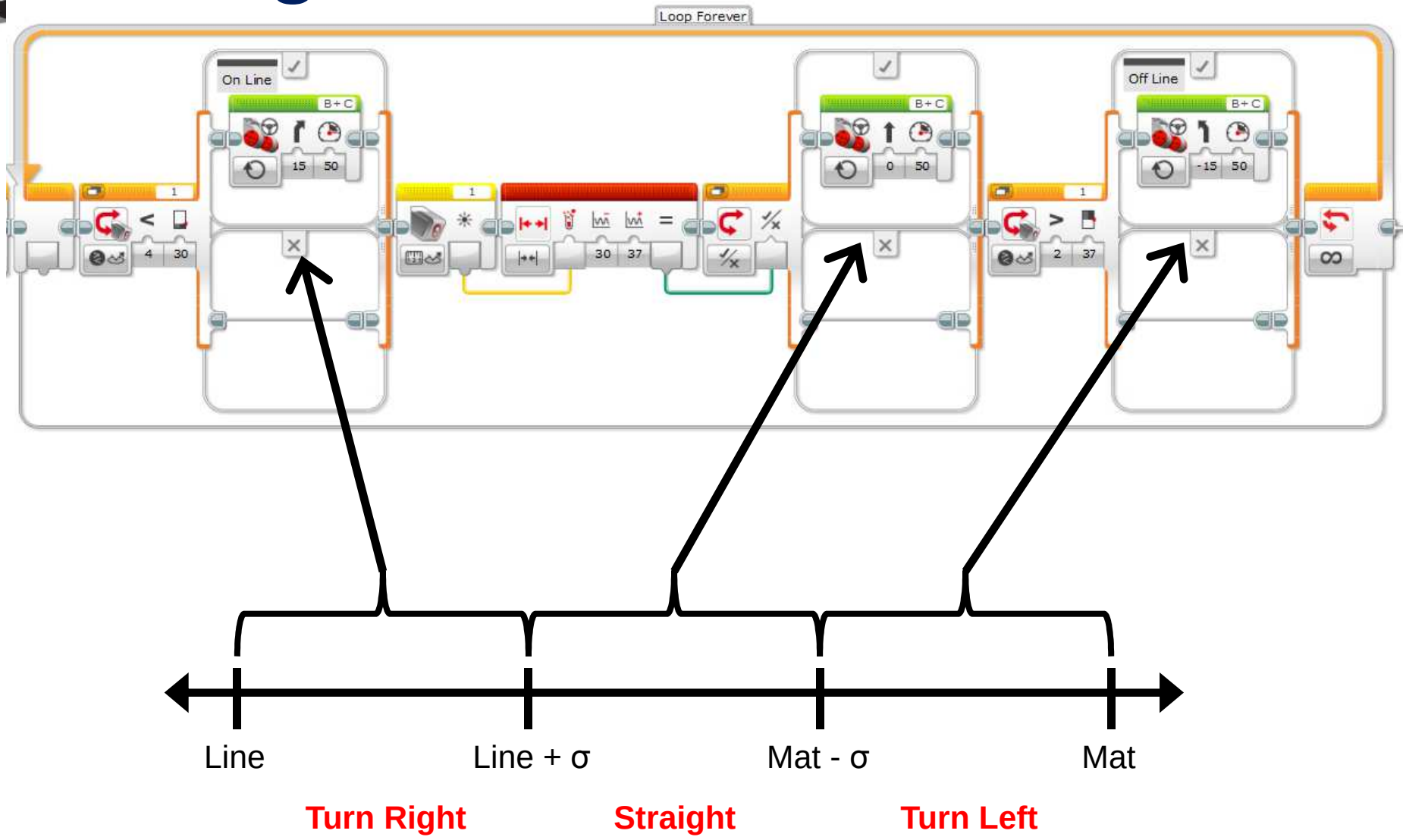


- For your robot

Line = _____ Mat = _____ σ = _____

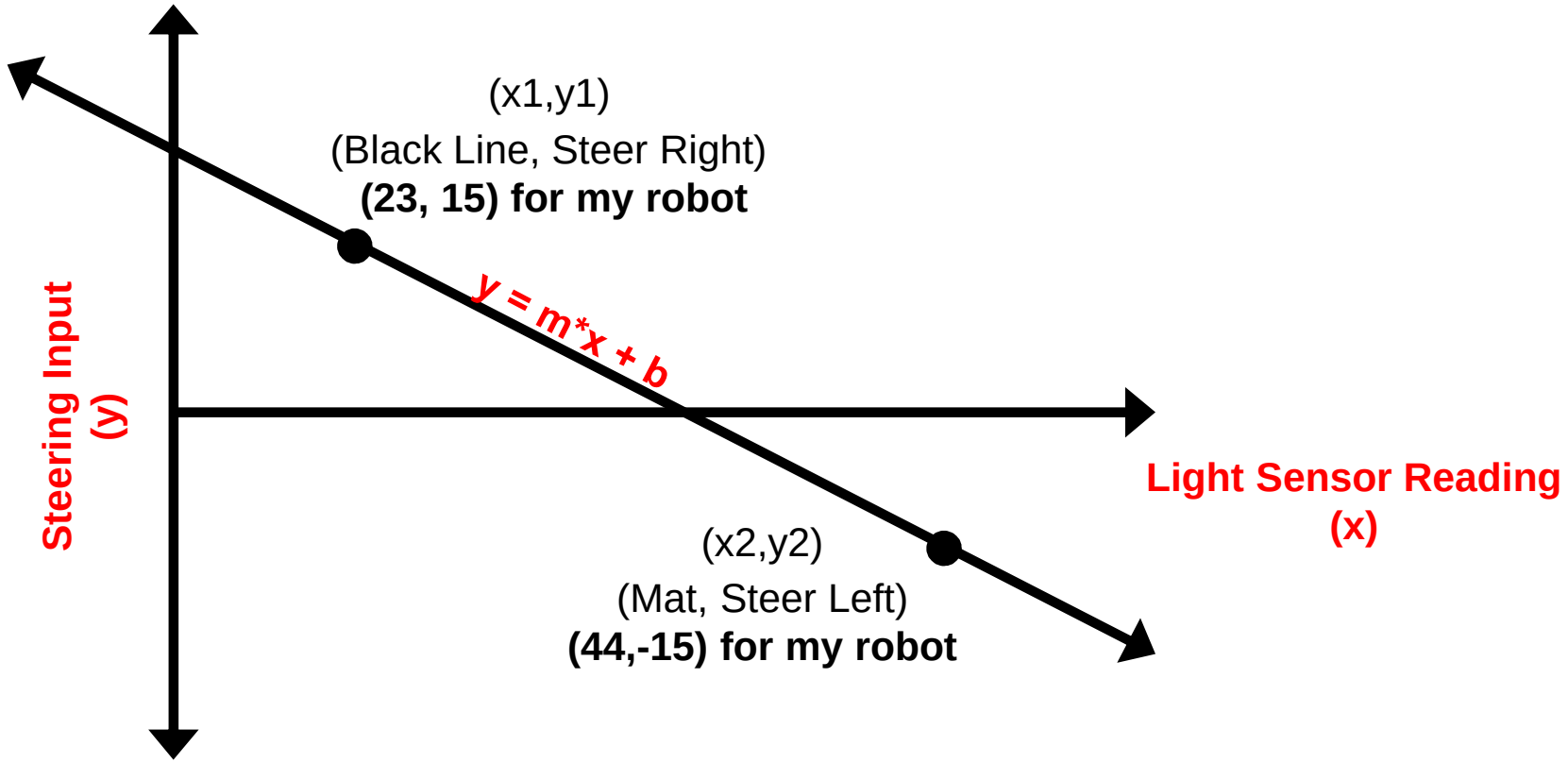
Line + σ = _____ Mat - σ = _____

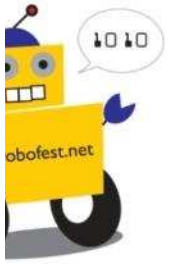
Program: LineFollowThreeState



Proportional Control Line Follower

- Use linear relationship between the light sensor reading and steering





Proportional Control Line Follower

- Find the line slope (m)

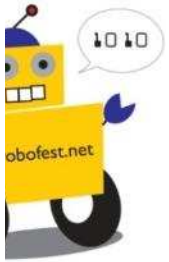
$$m = \frac{rise}{run} = \frac{y2 - y1}{x2 - x1}$$

- Find the y-axis intercept

$$y - y1 = m(x - x1)$$ (Point slope form)

$$y = mx + (-m * x1 + y1)$$ (Rearrange to y=mx+b)

$$b = -m * x1 + y1$$ (Find expression for b)



Proportional Control Line Follower

- An example

(x1,y1) = (23, 15)

(x2,y2) = (44, -15)

$$m = \frac{rise}{run} = \frac{y2 - y1}{x2 - x1} = \frac{-15 - 15}{44 - 23} = \mathbf{-1.43}$$

- Find the y-axis intercept

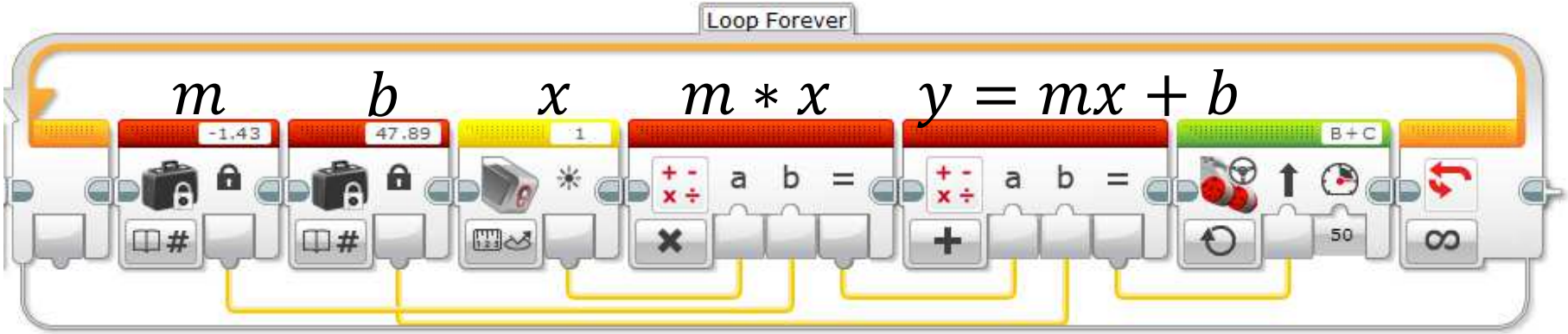
$$y - y1 = m(x - x1)$$ (Point slope form)

$$y = mx + (-m * x1 + y1)$$ (Rearrange to y=mx+b)

$$b = 1.43 * 23 + 15 = \mathbf{47.89}$$ (Find expression for b)

Proportional Control Line Follower

- An example



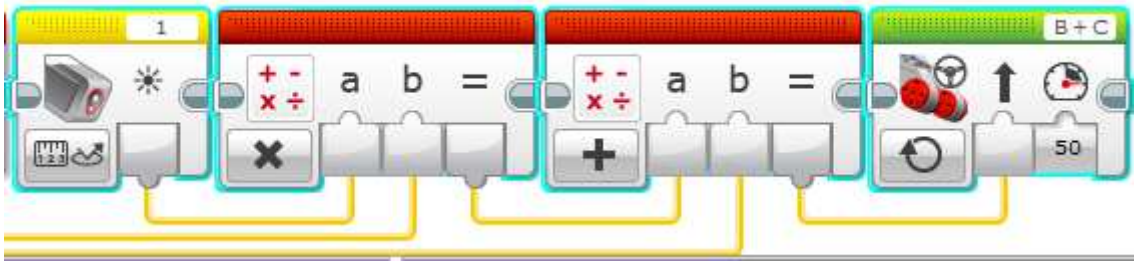
$x = light\ sensor\ reading$

$y = robot\ steering\ angle$

Creating a Custom My Block

- My Blocks allow you to group a number of blocks into a single block
- Let's create P-Control Line Following block

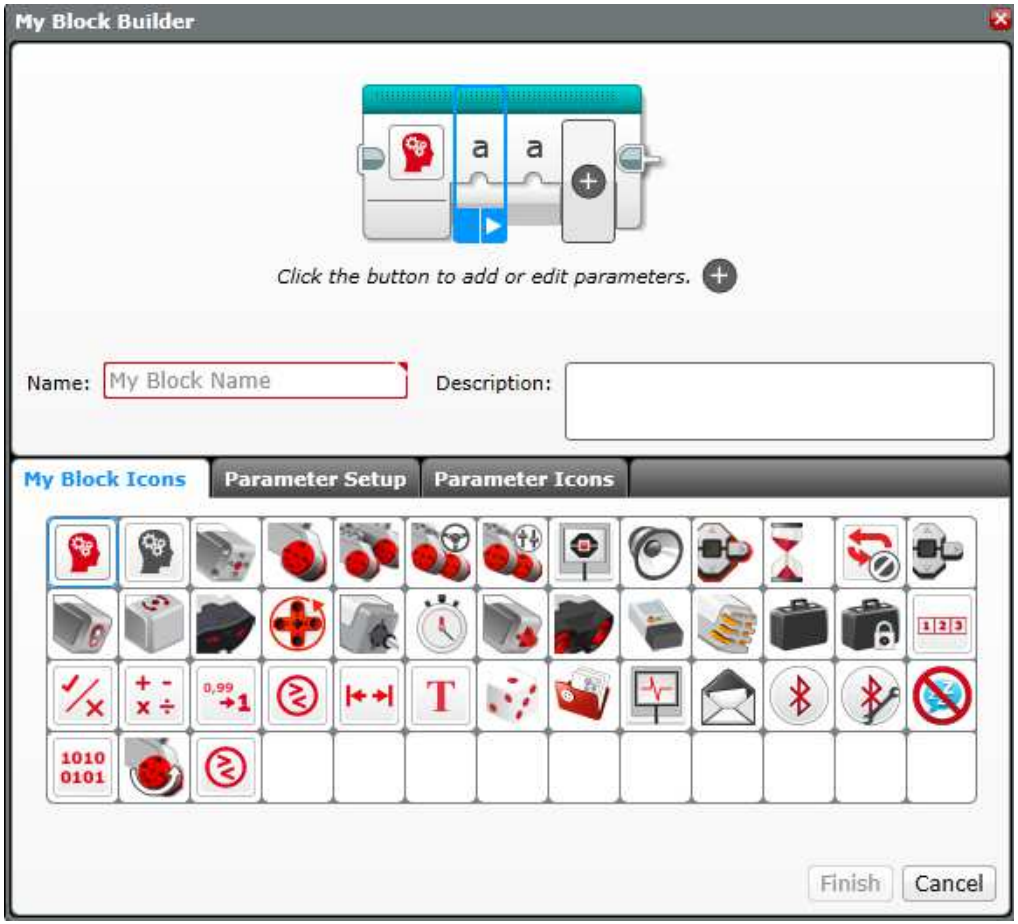
- Step 1: Select the P-Control blocks



Unconnected/broken data wires will be inputs

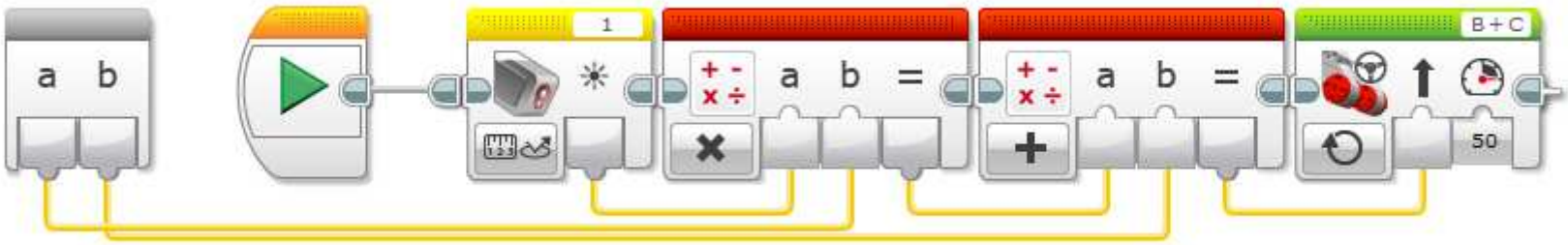
Creating a Custom My Block

- Step 2: Open Tools -> My Block Builder GUI



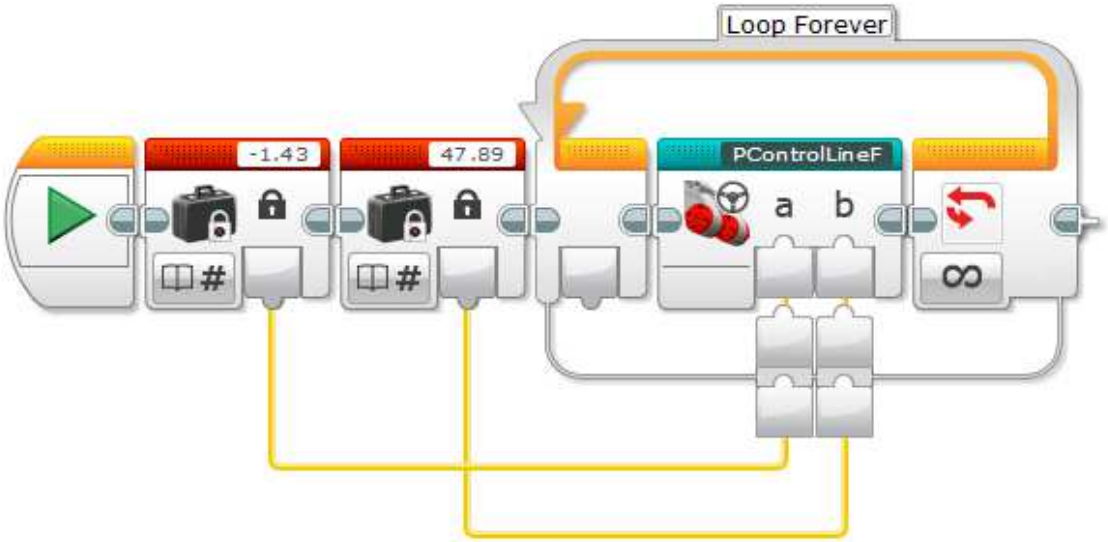
Creating a Custom My Block

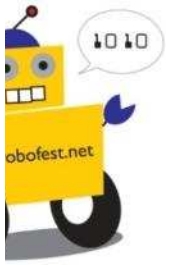
- Step 3: Select Icons, and set up parameters
- Step 4: Name the My Block as PControlLineF



Using A Custom My Block

- Once the your my block is created, it will be placed in your My Block palette
- Now, we can reconstruct the line following using the My Block



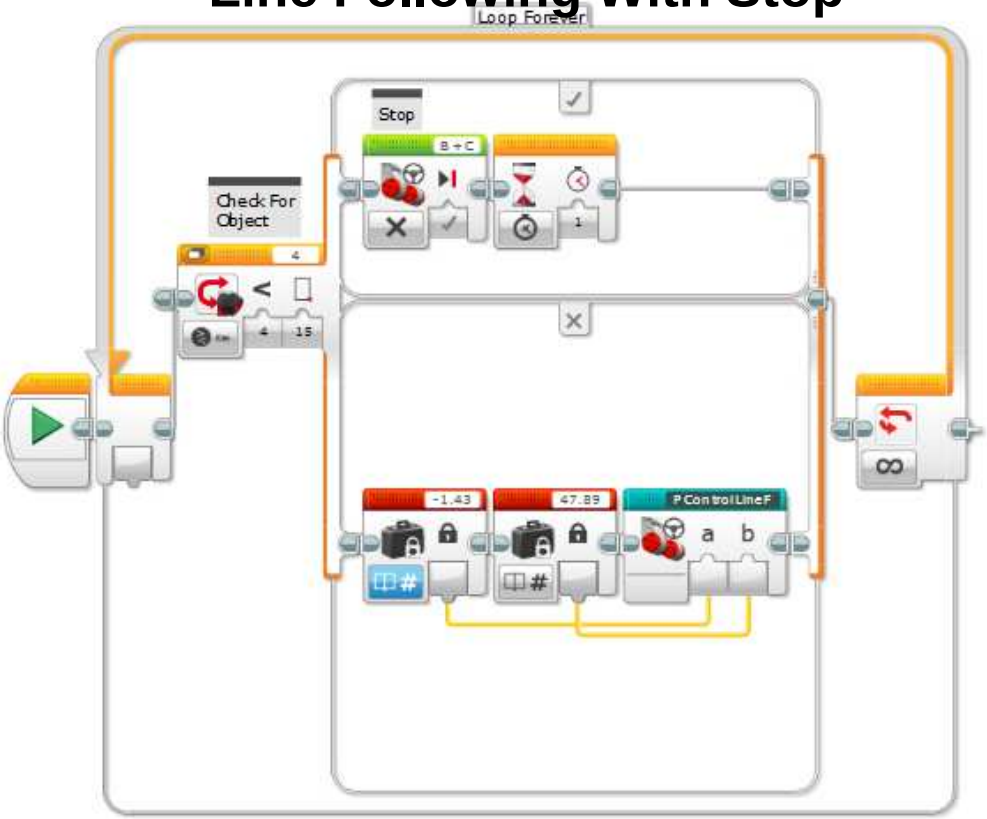


RoboParade Program Concept

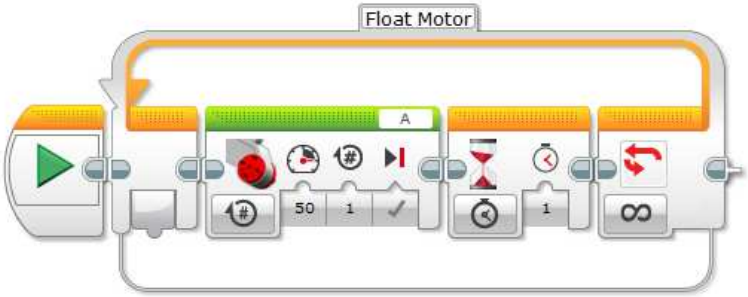
- To successfully complete the RoboParade, you need your robot to…
  - Line Follow
  - Stop safely when needed
  - Display the average speed
  - Perform float operations with other motors
- This can be achieve using parallel sequence beams

RoboParade Program Concept

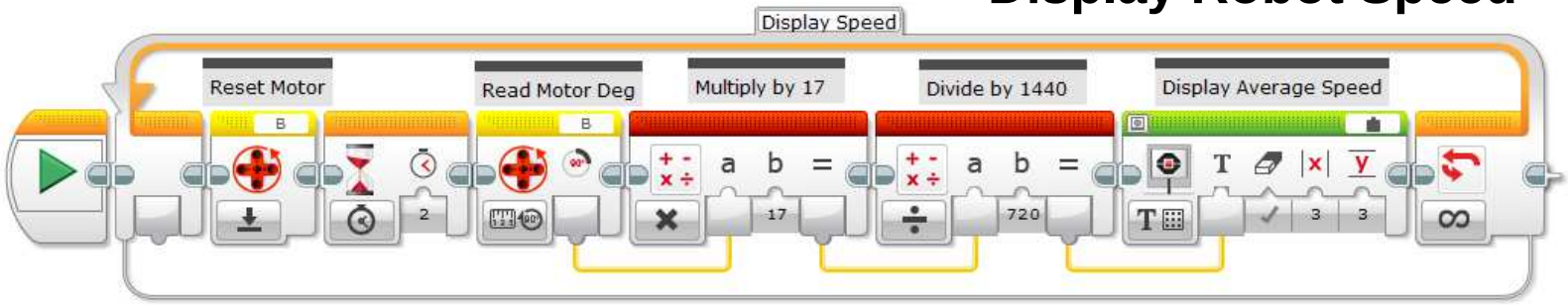
Line Following With Stop

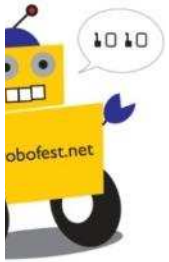


Float Motor



Display Robot Speed





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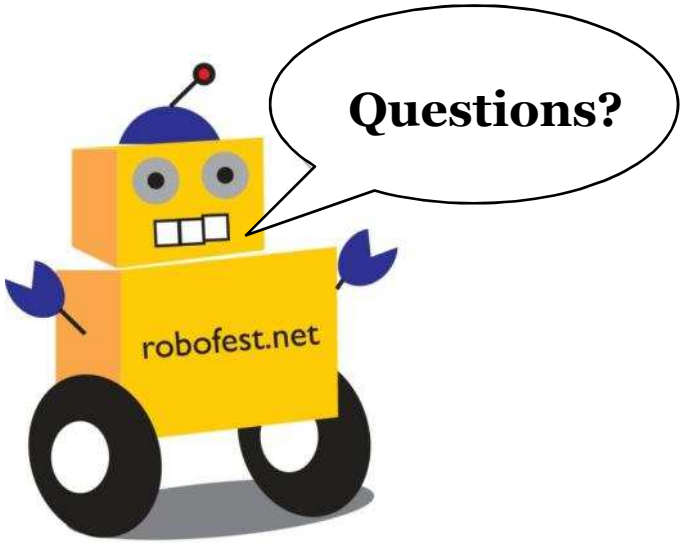
Little Robots, Big Missions



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