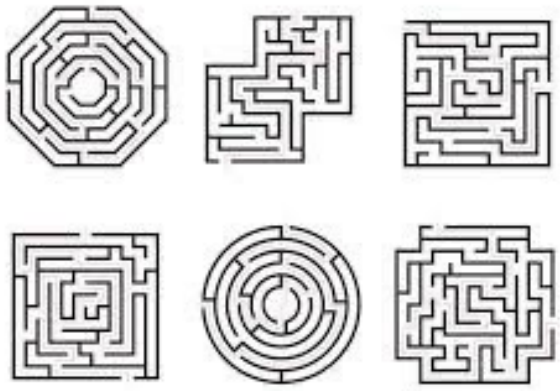
# Lego Robotics Camp

Day 4: Follow that Color!

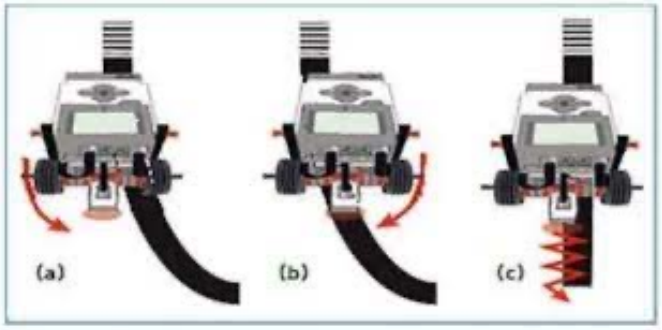
# Review

- Yesterday we:
  - Learned about using sensors and handling simple events
  - Practiced using conditionals and loops
  - Designed simple algorithms for solving mazes



# Today's Plan

- Today we will:
  - Learn about **functions**
  - Practice using the color sensor to follow lines and detect colors
  - Get more practice with conditionals and loops
  - Design simple algorithms for line following



# Functions

- Functions help reduce redundant code in our programs
- Make code easier to understand and less error prone
- Consider this example:

- What if we wanted to make our robots sing?

I am not throwin' away my shot
I am not throwin' away my shot
Hey yo, I'm just like my country
I'm young, scrappy and hungry
And I'm not throwin' away my shot

I'ma get a scholarship to King's College
I probably shouldn't brag, but dang, I amaze and astonish
The problem is I got a lot of brains but no polish
I gotta holler just to be heard
With every word, I drop knowledge
I'm a diamond in the rough, a shiny piece of coal
Tryna reach my goal my power of speech, unimpeachable
Only nineteen but my mind is older
These New York City streets get colder, I shoulder
Every burden, every disadvantage
I have learned to manage, I don't have a gun to brandish
I walk these streets famished
The plan is to fan this spark into a flame
But damn, it's getting dark, so let me spell out my name
I am the A-L-E-X-A-N-D-E-R we are meant to be
A colony that runs independently
Meanwhile, Britain keeps shittin' on us endlessly
Essentially, they tax us relentlessly
Then King George turns around, runs a spendin' spree
He ain't ever gonna set his descendants free
So there will be a revolution in this century
Enter me, he says in parentheses
Don't be shocked when your history book mentions me
I will lay down my life if it sets us free
Eventually, you'll see my ascendancy and

I am not throwin' away my shot
I am not throwin' away my shot
Hey yo, I'm just like my country
I'm young, scrappy and hungry
And I'm not throwin' away my shot

# My Shot

- What if we wanted to make our robots sing?
- How would you make your robots sing My Shot?
- It would be tedious…
- How could we simplify?
- Can we reduce repeated code?
- How?
- Loops wouldn't work this time…

I am not throwin' away my shot
I am not throwin' away my shot
Hey yo, I'm just like my country
I'm young, scrappy and hungry
And I'm not throwin' away my shot

I'ma get a scholarship to King's College
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I am not throwin' away my shot
I am not throwin' away my shot
Hey yo, I'm just like my country
I'm young, scrappy and hungry
And I'm not throwin' away my shot

# Another Example

Boom, boom, ain't it great to be crazy
Boom, boom, ain't it great to be crazy
Giddy and foolish all day long
Boom, boom, ain't it great to be crazy?

Way down South where bananas grow
An ant stepped on an elephant's toe
The elephant cried with tears in his eyes
"Why don't you pick on someone your own size?"

Boom, boom, ain't it great to be crazy
Boom, boom, ain't it great to be crazy
Giddy and foolish all day long
Boom, boom, ain't it great to be crazy?

Way up North where there's ice and snow
There lived a penguin and his name was Joe
He got so tired of black and white
He wore pink pants to the dance last night!

Boom, boom, ain't it great to be crazy
Boom, boom, ain't it great to be crazy
Giddy and foolish all day long
Boom, boom, ain't it great to be crazy?

# Another Example

Boom, boom, ain't it great to be crazy
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Boom, boom, ain't it great to be crazy
Boom, boom, ain't it great to be crazy
Giddy and foolish all day long
Boom, boom, ain't it great to be crazy?

Chorus

Way up North where there's ice and snow
There lived a penguin and his name was Joe
He got so tired of black and white
He wore pink pants to the dance last night!

Boom, boom, ain't it great to be crazy
Boom, boom, ain't it great to be crazy
Giddy and foolish all day long
Boom, boom, ain't it great to be crazy?

# Another Example

Chorus:
Boom, boom, ain't it great to be crazy
Boom, boom, ain't it great to be crazy
Giddy and foolish all day long
Boom, boom, ain't it great to be crazy?

(Chorus)

Way down South where bananas grow
An ant stepped on an elephant's toe
The elephant cried with tears in his eyes
"Why don't you pick on someone your own size?"

(Chorus)

Way up North where there's ice and snow
There lived a penguin and his name was Joe
He got so tired of black and white
He wore pink pants to the dance last night!

(Chorus)

# Functions

- Calling functions are just like saying "(Chorus)"
- Suppose we wanted to change the chorus by a few words
- We would only have to change it once rather than several times
- Functions provide the same capabilities in our programs

# Functions

- Let's look at a previous example
- Recall bump_maze
- What code is repeated?

```
#Initialize the touch sensor
touch_sensor = TouchSensor(Port.S1)
while not touch_sensor.pressed():
        robot.drive(200,0)
        wait(10)
robot.straight(-20)
robot.turn(90)
while not touch_sensor.pressed():
        robot.drive(200,0)
        wait(10)
robot.straight(-20)
robot.turn(90)
while not touch_sensor.pressed():
        robot.drive(200,0)
        wait(10)
robot.straight(-20)
robot.turn(-90)
robot.straight(300)
```

# Functions

- Let's look at a previous example
- Recall bump_maze
- What code is repeated?

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touch_sensor = TouchSensor(Port.S1)
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robot.turn(90)
while not touch_sensor.pressed():
        robot.drive(200,0)
        wait(10)
robot.straight(-20)
robot.turn(-90)
robot.straight(300)
```

# Functions

- Let's look at a previous example
- Recall bump_maze
- What code is repeated?

- If we rewrite it using functions, this gets a lot simpler
- Repeated code goes in function
- Can call function as much as we want in our program

```
#Initialize the touch sensor
touch_sensor = TouchSensor(Port.S1)

def forward_until_wall():
    while not touch_sensor.pressed():
        robot.drive(150,0)
        wait(10)
    robot.straight(-20) # backup

forward_until_wall()
robot.turn(90) # turn right

forward_until_wall()
robot.turn(90) # turn right

forward_until_wall()
robot.turn(-90) # turn left

robot.straight(300)
```

# One More Example

Baby shark, doo, doo, doo, doo, doo, doo
Baby shark, doo, doo, doo, doo, doo, doo
Baby shark, doo, doo, doo, doo, doo, doo
Baby shark

Mommy shark, doo, doo, doo, doo, doo, doo
Mommy shark, doo, doo, doo, doo, doo, doo
Mommy shark, doo, doo, doo, doo, doo, doo
Mommy shark

Daddy shark, doo, doo, doo, doo, doo, doo
Daddy shark, doo, doo, doo, doo, doo, doo
Daddy shark, doo, doo, doo, doo, doo, doo
Daddy shark

Grandma shark, doo, doo, doo, doo, doo, doo
Grandma shark, doo, doo, doo, doo, doo, doo
Grandma shark, doo, doo, doo, doo, doo, doo
Grandma shark

Grandpa shark, doo, doo, doo, doo, doo, doo
Grandpa shark, doo, doo, doo, doo, doo, doo
Grandpa shark, doo, doo, doo, doo, doo, doo
Grandpa shark

# Baby Shark

- Would functions help?  Why or why not?
- Why is this different?

Baby shark, doo, doo, doo, doo, doo, doo
Baby shark, doo, doo, doo, doo, doo, doo
Baby shark, doo, doo, doo, doo, doo, doo
Baby shark

Mommy shark, doo, doo, doo, doo, doo, doo
Mommy shark, doo, doo, doo, doo, doo, doo
Mommy shark, doo, doo, doo, doo, doo, doo
Mommy shark

Daddy shark, doo, doo, doo, doo, doo, doo
Daddy shark, doo, doo, doo, doo, doo, doo
Daddy shark, doo, doo, doo, doo, doo, doo
Daddy shark

# Functions with Parameters

- Sometimes we need to pass additional information to our functions
- What might we pass to our "chorus" function for Baby Shark?

Baby shark, doo, doo, doo, doo, doo, doo
Baby shark, doo, doo, doo, doo, doo, doo
Baby shark, doo, doo, doo, doo, doo, doo
Baby shark

Mommy shark, doo, doo, doo, doo, doo, doo
Mommy shark, doo, doo, doo, doo, doo, doo
Mommy shark, doo, doo, doo, doo, doo, doo
Mommy shark

Daddy shark, doo, doo, doo, doo, doo, doo
Daddy shark, doo, doo, doo, doo, doo, doo
Daddy shark, doo, doo, doo, doo, doo, doo
Daddy shark

# Functions with Parameters

- Sometimes we need to pass additional information to our functions
- What might we pass to our "chorus" function for Baby Shark?
- Shark name

Parameter

- Chorus(*name*):

    <name> shark, doo, doo, doo, doo, doo, doo
    <name> shark, doo, doo, doo, doo, doo, doo
    <name> shark, doo, doo, doo, doo, doo, doo
    <name> shark

Baby shark, doo, doo, doo, doo, doo, doo
Baby shark, doo, doo, doo, doo, doo, doo
Baby shark, doo, doo, doo, doo, doo, doo
Baby shark

Mommy shark, doo, doo, doo, doo, doo, doo
Mommy shark, doo, doo, doo, doo, doo, doo
Mommy shark, doo, doo, doo, doo, doo, doo
Mommy shark

Daddy shark, doo, doo, doo, doo, doo, doo
Daddy shark, doo, doo, doo, doo, doo, doo
Daddy shark, doo, doo, doo, doo, doo, doo
Daddy shark

# Baby Shark Revisited

Baby shark, doo, doo, doo, doo, doo, doo
Baby shark, doo, doo, doo, doo, doo, doo
Baby shark, doo, doo, doo, doo, doo, doo
Baby shark

Mommy shark, doo, doo, doo, doo, doo, doo
Mommy shark, doo, doo, doo, doo, doo, doo
Mommy shark, doo, doo, doo, doo, doo, doo
Mommy shark

Daddy shark, doo, doo, doo, doo, doo, doo
Daddy shark, doo, doo, doo, doo, doo, doo
Daddy shark, doo, doo, doo, doo, doo, doo
Daddy shark

Chorus(name):

<name> shark , doo, doo, doo, doo, doo, doo
<name> shark, doo, doo, doo, doo, doo, doo
<name> shark, doo, doo, doo, doo, doo, doo
<name> shark

Chorus(baby)

Chorus(mommy)

Chorus(daddy)

# Functions w/Parameters

- How could parameters help us in this example?
- Could we simplify even more?

```
#Initialize the touch sensor
touch_sensor = TouchSensor(Port.S1)

def forward_until_wall():
    while not touch_sensor.pressed():
        robot.drive(150,0)
        wait(10)
    robot.straight(-20) # backup

forward_until_wall()
robot.turn(90) # turn right

forward_until_wall()
robot.turn(90) # turn right

forward_until_wall()
robot.turn(-90) # turn left

robot.straight(300)
```

# Functions w/Parameters

- How could parameters help us in this example?
- Could we simplify even more?

```
#Initialize the touch sensor
touch_sensor = TouchSensor(Port.S1)

def forward_until_wall():
    while not touch_sensor.pressed():
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        wait(10)
    robot.straight(-20) # backup

forward_until_wall()
robot.turn(90) # turn right

forward_until_wall()
robot.turn(90) # turn right

forward_until_wall()
robot.turn(-90) # turn left

robot.straight(300)
```

# Functions w/Parameters

- How could parameters help us in this example?
- Could we simplify even more?
- How can a parameter help us?

```
#Initialize the touch sensor
touch_sensor = TouchSensor(Port.S1)

def forward_until_wall():
    while not touch_sensor.pressed():
        robot.drive(150,0)
        wait(10)
    robot.straight(-20) # backup

forward_until_wall()
robot.turn(90) # turn right

forward_until_wall()
robot.turn(90) # turn right

forward_until_wall()
robot.turn(-90) # turn left

robot.straight(300)
```

# Functions w/Parameters

- How could parameters help us in this example?
- Could we simplify even more?
- How can a parameter help us?

```
#Initialize the touch sensor
touch_sensor = TouchSensor(Port.S1)

def forward_until_wall(angle):
    while not touch_sensor.pressed():
        robot.drive(150,0)
        wait(10)
    robot.straight(-20) # backup
    robot.turn(angle)

forward_until_wall(90)

forward_until_wall(90)

forward_until_wall(-90)

robot.straight(300)
```

# Functions w/Parameters

- By the way, you've been using functions and parameters all week!
- Examples:
  - robot.turn(90) – 90 is a parameter to turn()
  - robot.straight(300) – 300 is a parameter to straight()

```
#Initialize the touch sensor
touch_sensor = TouchSensor(Port.S1)

def forward_until_wall(angle):
    while not touch_sensor.pressed():
        robot.drive(150,0)
        wait(10)
    robot.straight(-20) # backup
    robot.turn(angle)

forward_until_wall(90)

forward_until_wall(90)

forward_until_wall(-90)

robot.straight(300)
```

# Functions Summary

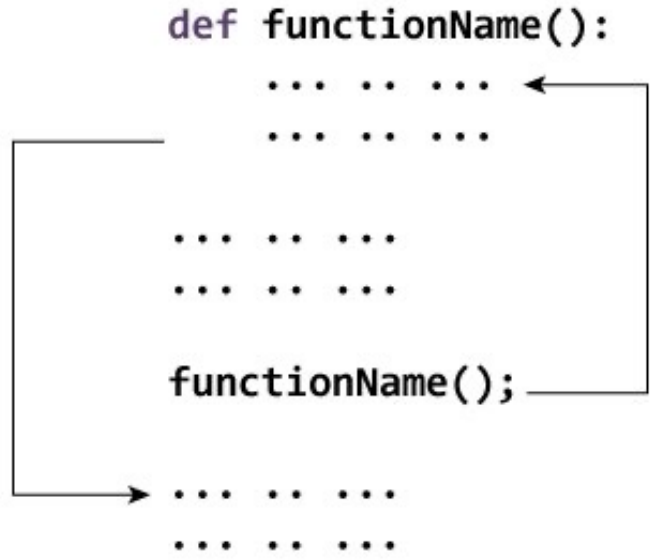
- A function is a block of organized, reusable code that is used to perform a single, related action
- Allow for a high degree of code reusing
- Python gives you many built-in functions like print(), etc.
- You can also create your own functions (called *user-defined functions*)

# User-defined Functions in Python

```
def function_name(parameters):
    statement(s)

#rest of your program
...

#now you can call your function
function_name(parameters)
```



# BREAK

# Using Sensors

Infrared

Ultrasonic

Touch

Gyro

Color

# Color Sensor

- Measure light intensity of reflected light using a scale from 0 (very dark) to 100 (very light)
- Measure intensity of ambient light from 0 (very dark) to 100 (very light)
- Detect any one of seven colors (black, blue, green, yellow, red, white, brown), or detect no color

# Our Robots

- Our goal is to make our robots follow a black line
- Stop at the red line
- Use functions when possible to keep code simple

- Let's learn about the color sensor

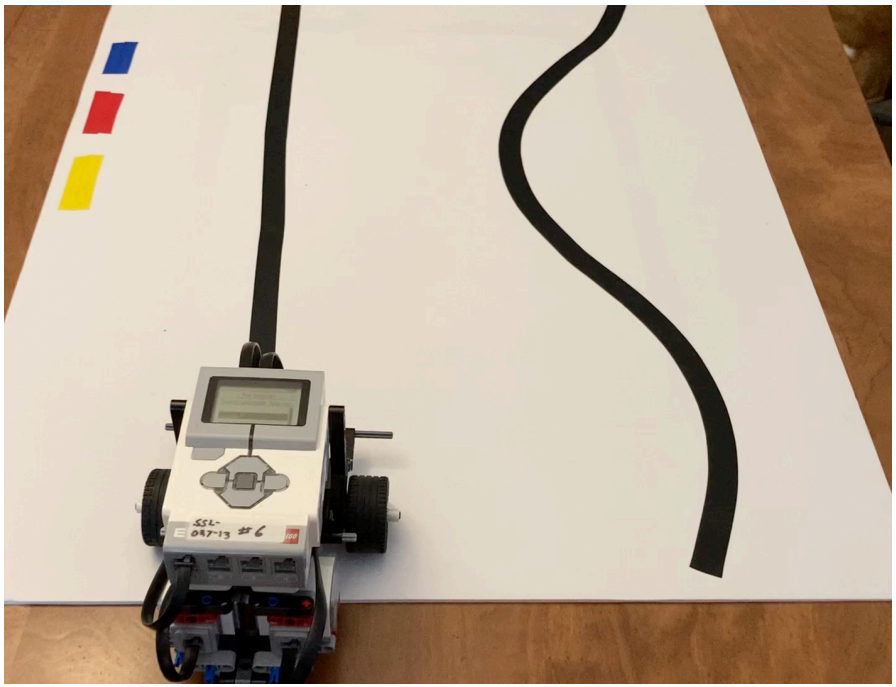
# color_tester

```
color_sensor = ColorSensor(Port.S1)

while True:
    if color_sensor.color() == Color.RED:
        ev3.speaker.say("red")
    elif color_sensor.color() == Color.BLUE:
        ev3.speaker.say("blue")
    elif color_sensor.color() == Color.YELLOW:
        ev3.speaker.say("yellow")
    elif color_sensor.color() == Color.GREEN:
        ev3.speaker.say("green")
    elif color_sensor.color() == Color.BLACK:
        ev3.speaker.say("black")
    elif color_sensor.color() == Color.WHITE:
        ev3.speaker.say("white")
    else:
        ev3.speaker.say("unknown")
    wait(1000)
```

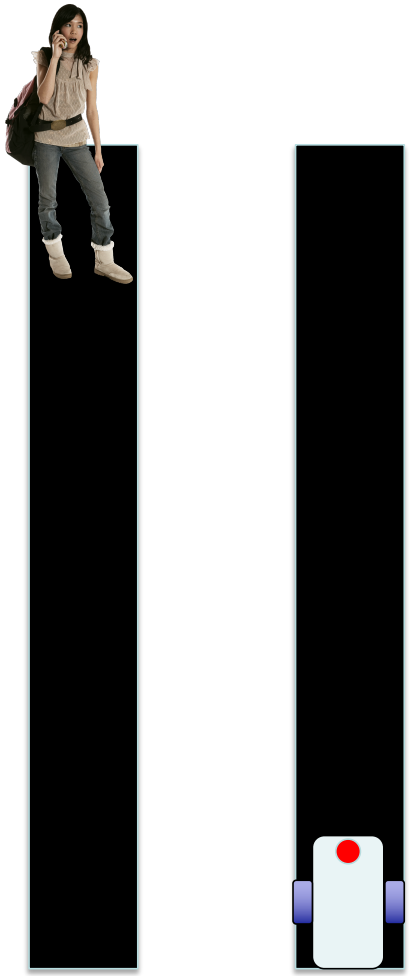
# Line Following

- How can we use this to make our robots follow a line?



# Follow the (middle of) the Line

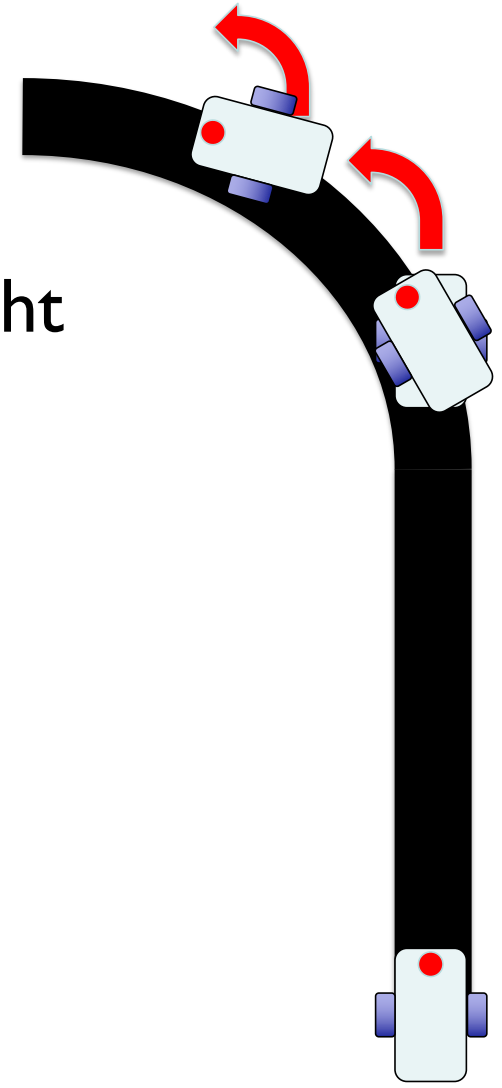
- Humans want to follow the line in the middle.
- Let's have the robot do the same thing using the color sensor
- What type of questions can we ask using this sensor?
  - Are you on the line or not?
  - Or are you seeing black?



# Follow the (middle of) the Line

1. If we are on black, keep going straight
2. If we are on white, turn left to get back to the line

Seems to work fine here…



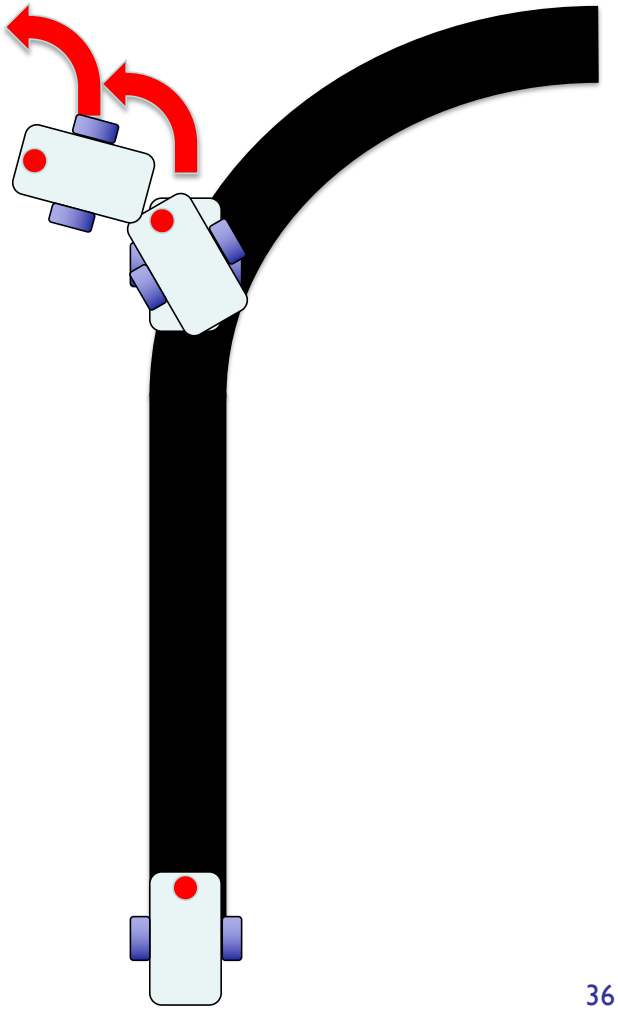
# Follow the (middle of) the Line

1. If we are on black, keep going straight
2. If we are on white, turn left to get back to the line

**Uh oh…**
**Our robot is running away!**

**When the robot leaves the left side of the line, our algorithm no longer works!**

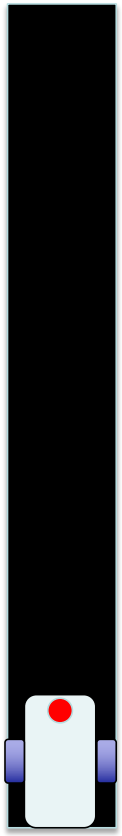
**Why? Now what?**



# Line Following Revisited

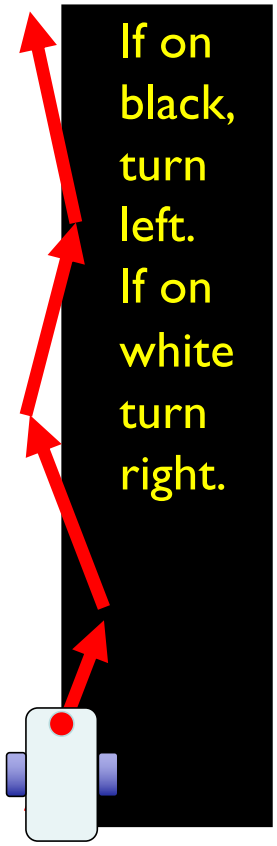
- Why are humans able to follow the middle?
  - They can see ahead
  - They can see the whole line and its surroundings
  - They can see both sides of the line and know which is which

- Why can't the robot do the same thing?
  - Don't know if it's the right or left side of line
  - How do we make sure the robot always veers off on the SAME SIDE of the line?
    - Instead of the middle, have the robot follow edge
  - Robot will always fall off only the same side



# Following the (edge of) lines

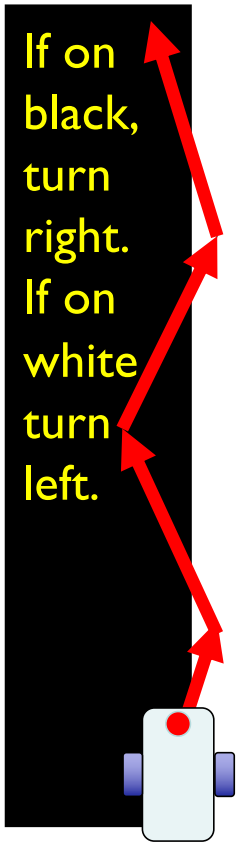
Left side line following



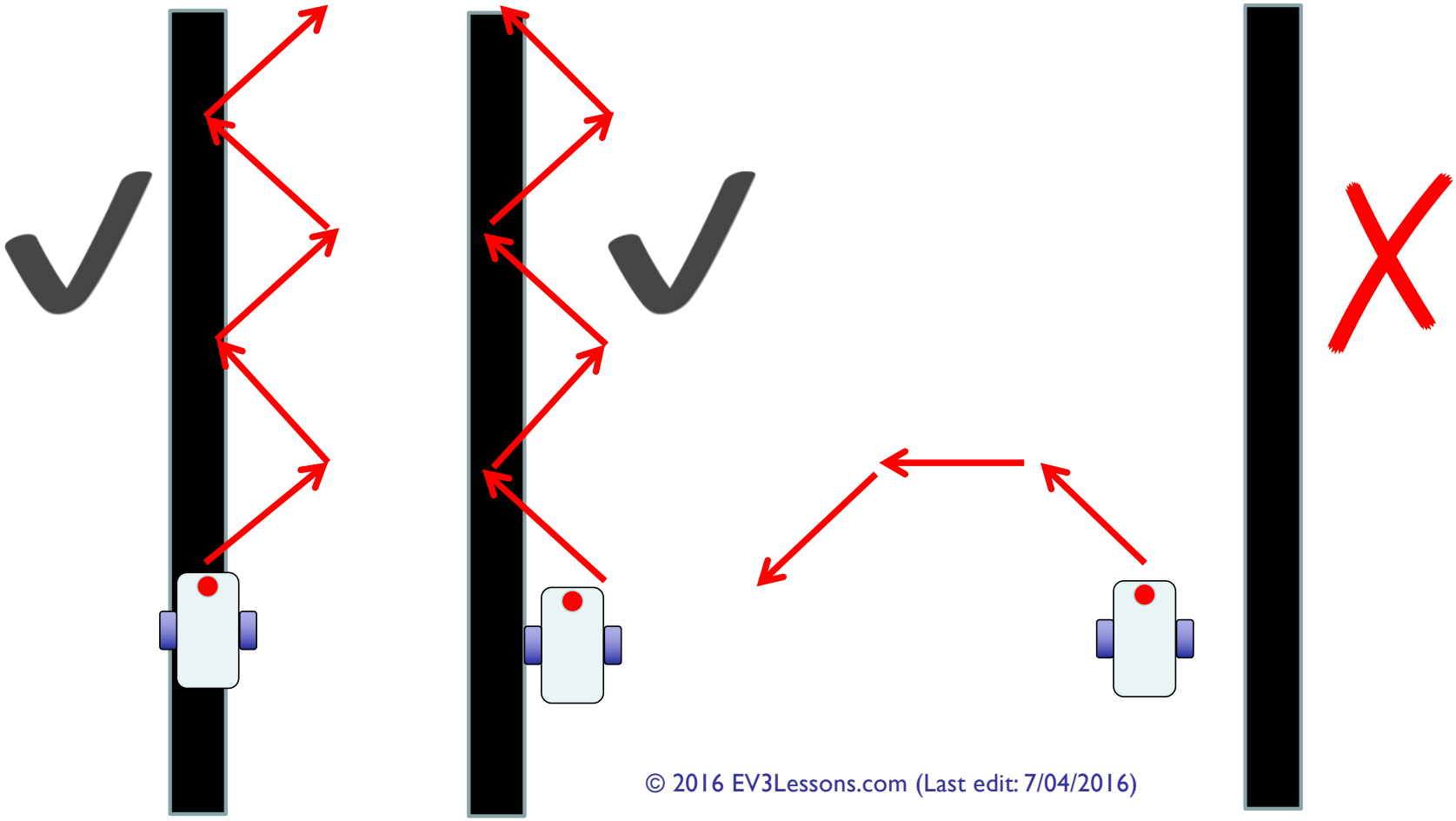

The robot has to choose which way to turn when the color sensor sees a different color.

The answer depends on what side of the line you are following!

Right side line following

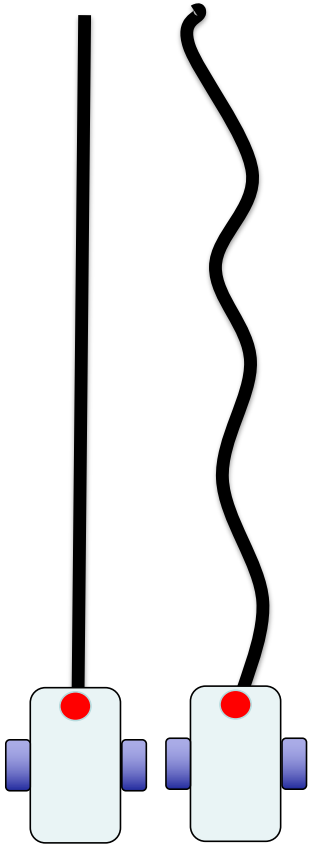


# Always Start on the Correct Side



# Lab Today

- Step 1: Write a program that follows the RIGHT edge of a line.
  - Hints: If your sensor sees black, turn right. If your sensor sees white, turn left. Use loops and conditionals! Start SLOW!
- Step 2: Try it out on different lines.
  - Did your line follower work the same on straight and curved lines?
- Step 3: If not, make adjustments to speed, turn angle, etc.
- Step 4: Make it stop at the red line.
- Step 5: Now try a line with sharp angles. What happens?? Can you use the colored corners to help you?
- Work with a partner!



# LUNCH BREAK