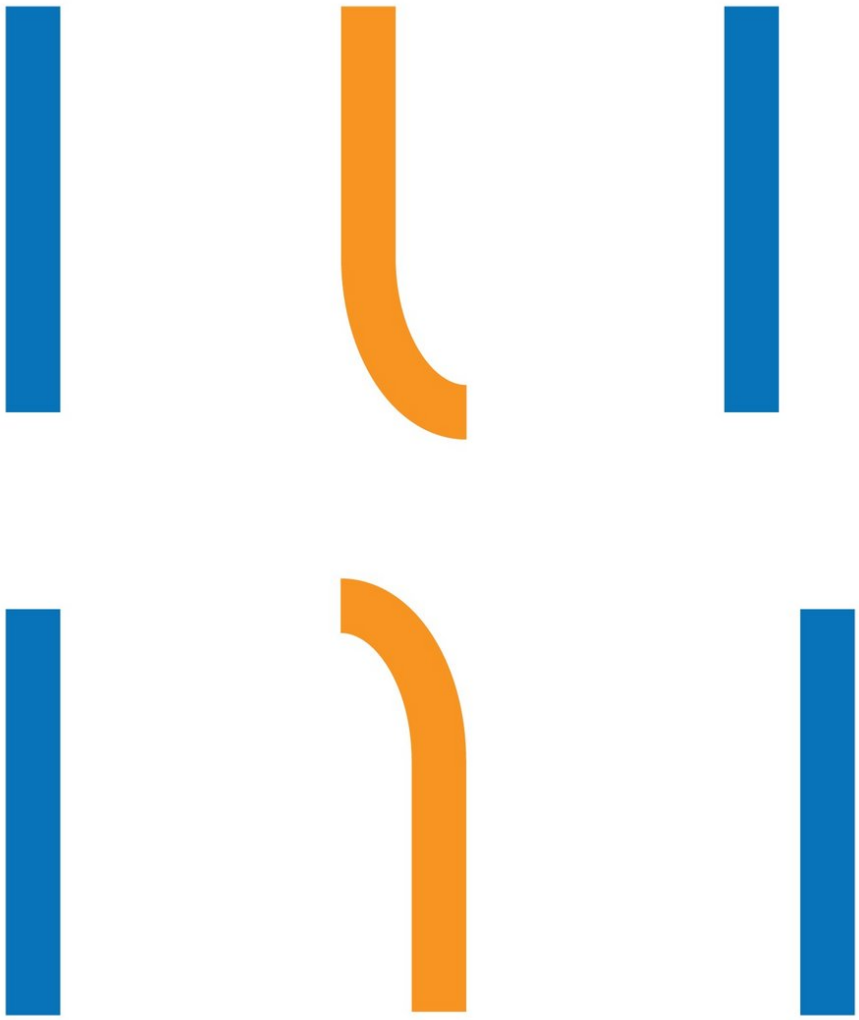
B - Broken Track

There's a gap in the track! We need to make our robot even more intelligent so it won't get stuck, and can find the track again on its own.



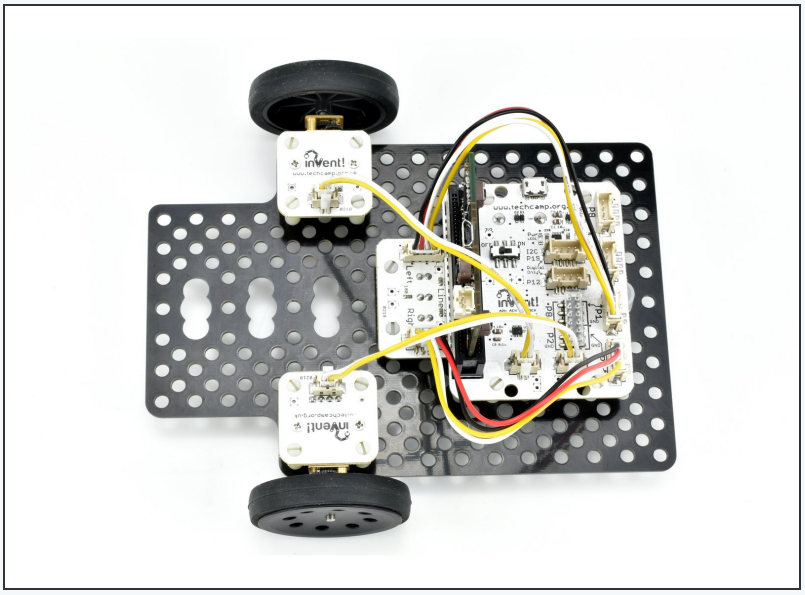
INTRODUCTION

There's a gap in the track! We need to make our robot even more intelligent so it won't get stuck, and can find the track again on its own.

Step 1

Assemble the Robot

- We only need the **line follower** module for this lesson - **assemble your robot** like the picture!



Step 2

Delays Cause Problems

- Dealing with breaks in the track is difficult. We can't just drive forward for 1 second using a **sleep**, as we won't be able to sense the line **at the same time.**
- **Build** the test program in the picture.
- It would be great if this program **drove forwards** and then **stopped** on the line - try it, see what happens.
- It only works if one of the sensors is **exactly on the line after 1 second** - this is not very likely!
- This is because the sleep **stops anything else from happening** whilst it is waiting for 1 second - so all the time we are driving forwards, we **can't check the sensors** - that's no good!
- Things that stop other things from happening are called **'blocking'** - they **block** everything else until they are finished.

```
    while(running_time()-p[0]<4000):v=[p0(),p1()];p[5]=v[
    p[6]=(p[5]+p[3])/2;p[7]=(p[4]+p[2])/2;p[8]=p[5]-p[3];
    while(p0()>p[7]and p1()>p[6]):d(0 if p0()<p[7] or p1(
def digital_read_line(s): return 1 if (s==0 and p0()>p[7]
def analog_read_line(s): v=p0()if s==0 else p1();return 1
# Invent! Code End
# Start your code below here!

calibrate_line_sensors()

drive_motor(0,100)
sleep(1000)
if digital_read_line(0)==0 or digital_read_line(1)==0:
    drive_motor(0,0)
```

Step 3

Delay Differently

- We need to come up with a way to wait whilst **still being able to do other things.**
- **Replace** the sleep(1000) line with a for loop that runs 10 times, with a **sleep(100)** line inside it.
- This code will wait for **1 second**, just like before.

```
def digital_read_line(s): return 1 if (s==0 and p0()>p[7
def analog_read_line(s): v=p0()if s==0 else p1();return
# Invent! Code End
# Start your code below here!

calibrate_line_sensors()

drive_motor(0,100)

for i in range(0,10):
    sleep(100)

if digital_read_line(0)==0 or digital_read_line(1)==0:
    drive_motor(0,0)
```

Step 4

Using a Counter

- We now need to add a **variable** that acts as a **counter** - it will count how many milliseconds of delay have happened.
- Above the for loop, **make a new variable called t** and set it equal to 0.
- Inside the loop, **increase t by 100**
- t will now **count** the number of milliseconds of wait time!

If you're feeling clever, you can **change the for loop** to do this without even creating another variable, and using i to track the amount of time instead.....

```
    while(p0()>p[7]and p1()>p[6]):d(0 if p0()<p[7] or p1
def digital_read_line(s): return 1 if (s==0 and p0()>p[7
def analog_read_line(s): v=p0()if s==0 else p1();return
# Invent! Code End
# Start your code below here!

calibrate_line_sensors()

drive_motor(0,100)

t=0
for i in range(0,10):
    sleep(100)
    t=t+100

if digital_read_line(0)==0 or digital_read_line(1)==0:
    drive_motor(0,0)
```

Step 5

Counter in the loop

- Now let's use the counter to control the **number of times** the loop runs.
- Instead of the for loop, replace it with a **while loop**.
- For the condition, run the loop while **t<1000**.
- We can now **change** this number to decide how long the wait is! For example, changing to **t<2000** would run the loop for a total of **2000 milliseconds** (2 seconds).

```
    while(p0()>p[7]and p1()>p[6]):d(0 if p0()<p[7] or p1
def digital_read_line(s): return 1 if (s==0 and p0()>p[7
def analog_read_line(s): v=p0()if s==0 else p1();return
# Invent! Code End
# Start your code below here!

calibrate_line_sensors()

drive_motor(0,100)

t=0
while t<1000:
    sleep(100)
    t=t+100

if digital_read_line(0)==0 or digital_read_line(1)==0:
    drive_motor(0,0)
```

Step 6

Sensors in the Loop

- **What's the point** of making a really **complicated delay?**
- Anything we put in the loop will be run **as the delay is happening** - so we can check the sensors **whilst we are driving forwards!**
- Move the **IF statement** checking the sensors **inside the loop**.
- You will need to add in a sleep(2000) line **after** the calibration - the robot always finishes on the line after calibration, so otherwise we won't be able to test our code.
- **Try it out** - the robot should now drive forward and stop exactly on the line, **every time!**
- **Experiment** with changing the length **of the wait loop, so the robot can start further away** from the line and still reach it.

```
    while(p0()>p[7]and p1()>p[6]):d(0 if p0()<p[7] or p1
def digital_read_line(s): return 1 if (s==0 and p0()>p[7
def analog_read_line(s): v=p0()if s==0 else p1();return
# Invent! Code End
# Start your code below here!

calibrate_line_sensors()

drive_motor(0,100)

t=0
while t<1000:
    sleep(100)
    t=t+100
    # Move the if statement in here!

if digital_read_line(0)==0 or digital_read_line(1)==0:
    drive_motor(0,0)
```

Step 7

Stop Waiting Sooner

- We actually don't need the IF statement in the loop - we can **merge** the conditions of the loop and the IF statement together!
- Let's think about this - we want to **run** the loop (and the the motors) if:
  - t<2000, **AND**
  - Sensor A is HIGH, **AND**
  - Sensor B is HIGH
- Luckily, we can use 2 AND operators together to do this! Change your code to look like the picture, and **test it out.**

```
    global p;p=[running_time(),0,1023,1023,0,0,0,0,0,0];d=drive_motor;d
    while(running_time()-p[0]<4000):v=[p0(),p1()];p[5]=v[1]if v[1]>p[5]
    p[6]=(p[5]+p[3])/2;p[7]=(p[4]+p[2])/2;p[8]=p[5]-p[3];p[9]=p[4]-p[2]
    while(p0()>p[7]and p1()>p[6]):d(0 if p0()<p[7] or p1()<p[6] else 3,
def digital_read_line(s): return 1 if (s==0 and p0()>p[7])or(s and p1()
def analog_read_line(s): v=p0()if s==0 else p1();return 100 if(v>p[4]an
# Invent! Code End
# Start your code below here!

calibrate_line_sensors()
sleep(2000)

drive_motor(0,100)

t=0
while t<1000 and digital_read_line(0)==1 and digital_read_line(1)==1:
    sleep(100)
    t=t+100
drive_motor(0,0)
```

Step 8

Merge with Line Follower

- Let's **merge our code** with the 2 sensor line follower program to deal with simple **breaks in the track.**
- **Load** up your code and add the line finder code you just wrote to the **IF** statement where both sensors are **off the track (1).**
- It should **look like the picture!**

```
def digital_read_line(s): return 1 if (s==0 and p0()>p[7])or(s and p1()>p[6])e
def analog_read_line(s): v=p0()if s==0 else p1();return 100 if(v>p[4]and s)or(
# Invent! Code End
# Start your code below here!

calibrate_line_sensors()

def line_follower():
    if digital_read_line(1)==1 and digital_read_line(0)==1:
        t=0
        drive_motor(0,100)
        while t<1000 and digital_read_line(0)==1 and digital_read_line(1)==1:
            sleep(100)
            t=t+100
        drive_motor(0,0)

    if digital_read_line(1)==1 and digital_read_line(0)==0:
        drive_motor(1,50)
        drive_motor(2,-50)

    if digital_read_line(1)==0 and digital_read_line(0)==1:
        drive_motor(1,-50)
        drive_motor(2,50)

    if digital_read_line(1)==0 and digital_read_line(0)==0:
        drive_motor(0,50)

while True:
    line_follower()
```

Step 9

A Few Changes

- We need to make a few **changes** to make our code work with the line follower:
- Add a **delay** of **200** milliseconds before the while loop (this makes sure both sensors are not on the line)
- We only want to **stop** the motors if **both** sensors are **still off the track** after the wait loop.
- Put the motor stop line in an **if statement**, that checks if both sensors are still **1**
- After we have stopped the motors, we then want to **wait until 1 of the sensors is 0** before we continue
- Add another **while loop** to do this!

```
# Start your code below here!

calibrate_line_sensors()

def line_follower():
    if digital_read_line(1)==1 and digital_read_line(0)==1:
        sleep(200)
        t=0
        drive_motor(0,100)
        while t<1000 and digital_read_line(0)==1 and digital_read_line(1)==1:
            sleep(100)
            t=t+100
        if digital_read_line(0)==1 and digital_read_line(1)==1:
            drive_motor(0,0)
        while digital_read_line(0)==1 and digital_read_line(1)==1:
            pass

    if digital_read_line(1)==1 and digital_read_line(0)==0:
        drive_motor(1,50)
        drive_motor(2,-50)

    if digital_read_line(1)==0 and digital_read_line(0)==1:
        drive_motor(1,-50)
        drive_motor(2,50)

    if digital_read_line(1)==0 and digital_read_line(0)==0:
        drive_motor(0,50)

while True:
    line_follower()
```

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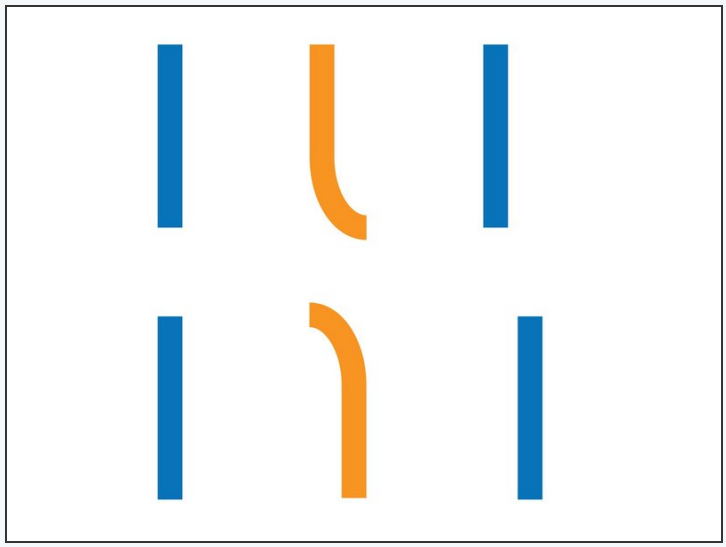
Step 10

Line follower with breaks in track

- Cover a small section of **straight track** (about 5cm) with a **piece of paper, or white PVC tape** and tape it down to test the program.
- You will probably need to make **adjustments** to speeds and timings to make it work **reliably!**
- **Keep experimenting** until it works well.
- Make sure the gap is on a straight section of track - this code won't work on gaps in curves! **Can you work out why?**

Step 11

Curved Breaks



- Once you can cross a gap in straight track, try a gap in **curved track!**
- To do this, you will need to make the robot **move side to side** in the wait loop, instead of just moving forwards.
- This can be done by making the robot **turn** to start with instead of going forwards, and then **changing the direction of turn** inside the loop every so often.
- It works best if the robot goes left and right **several times** , in a kind of sweeping motion.
- You can also experiment with **other types of break** like in the picture - offset lines and breaks that point the robot in the **wrong direction** like the middle example are particularly difficult to get right!