

# Fun with LEGO MindStorms EV3 for Absolute Beginners.

(Teacher/Mentor Edition 3.11 - September 2018)

Ying Chen, Yaya Lu and DrGraeme

<https://www.DrGrae.me>

Copyright [CC BY-NC-ND 4.0](https://creativecommons.org/licenses/by-nc-nd/4.0/)

Previous (Second Edition) versions of this course are also  
available as a playlist on YouTube:

<http://bit.ly/1LkfNm2>

and as pdf, ePub and Kindle eBooks:

<http://bit.ly/1MHwhU5>

as well as a MOOC at Udemy:

<http://bit.ly/1FG7fpd>

# Introduction and Overview



Ying Chen gives a brief overview of our “Robotics for Absolute Beginners, using LEGO MindStorms EV3-G”. She includes some of the reasons we have put this course together, and what is included. To start the course, click on, or type in to your browser, the link below.

<https://bit.ly/2sWAq48>

# Obtaining Your Free LEGO Editing Software - Tutorial



To allow us to teach Botticelli (and other Robots we will build later) what to do, we need to have special software installed inside our Laptop or Desktop computer. The first video tells us more about what software we need, and why we need it.

<https://bit.ly/2JDE4KL>

We need to download and install the free LEGO EV3 Home Edition Editing Software on our own Laptop or Desktop before we can teach our Robot how to move. The following video shows an installation on a Windows 7 computer. Installations on other computers are roughly similar.

<https://bit.ly/2JEsTBF>

# Build Your First Robot - Tutorial



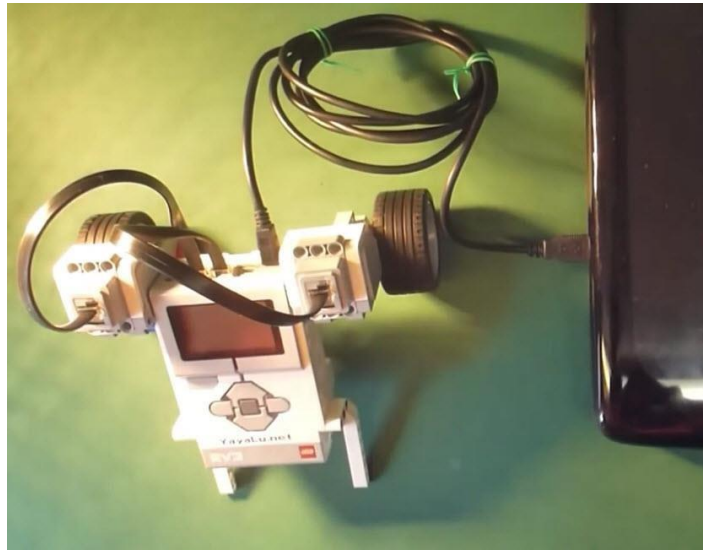
Let us build our very first Robot. It is just about the simplest Robot we can build with the LEGO EV3 set. It will be your pupil. You will be its teacher. In the next couple of lessons you will find out how to teach it to do what you tell it to do. But that will come later. Let us start by making our first Robot, Botticelli, right now. To do this, click on, or type into your browser the link below.

<https://bit.ly/2w5lPTu>

We would like to thank Yaya Lu, who built Botticelli under our cameras. You can find out more about her by clicking on, or typing into your browser, the link below.

<http://bit.ly/1hbLWRI>

# Teaching Your Robot to Move - Tutorial



Now that we have installed the software, we need to find out how to use it. This tutorial teaches us how to connect Botticelli to our Laptop or Desktop computer, and how to teach Botticelli to move by typing in our first program to our laptop or desktop computer. To see the video of parts 1 and 2, use the link below.

<https://bit.ly/2JR85pM>

Our LEGO EV3 computer brick has an “operating system” that is just called “firmware”. Occasionally LEGO issues updated firmware for the EV3 bricks. If you see a notice telling you that the firmware on your brick needs updating, this video shows you how to update your EV3 computer brick. To see the video of part 3, use the link below.

<https://bit.ly/2Mrao1f>

Now that we have the software working, we can find out if Botticelli obeys our command to move. This video also shows us how to save our program (so we can play with it again later), and also how to turn off Botticelli. To see the video of part 4, use the link below.

<https://bit.ly/2JLyou9>

# Teaching Botticelli to Move, Smile and Speak - Tutorial



Let us pretend that an Alien Ambassador has come to Earth. We don't know whether the Alien is dangerous or not. We will send Botticelli to approach the Alien instead of us, because if anything goes wrong it will be a Robot and not us that will be zapped. We need to teach Botticelli to move, smile and speak. We will need to figure out how far to send Botticelli so that it does not collide with the Alien Ambassador – that might start an intergalactic war!

<https://bit.ly/2LT3ouD>

Before Botticelli starts, it should seem to be nice and friendly - Smile Botticelli!

<https://bit.ly/2laPc3f>

Next we want our Alien to go to the “Red Carpet” in front of the Alien. We must be very careful not to collide with the Alien (might cause an intergalactic war!!!)

<https://bit.ly/2H0lxWi>

When the Robot reaches the Alien Ambassador, we want Botticelli to say a polite “Hello”, change its smile to a “waiting patiently” smile, and wait for a reply.

<https://bit.ly/2MtYogT>

Unfortunately, we have had a lot of problems with Alien's Universal Translators not working properly. Botticelli has waited, and has not received a reply. So maybe we will have to tell Botticelli to look disappointed, say a polite "Thank you" and "Goodbye".

<https://bit.ly/2HNS1QF>

Next we have to get Botticelli back to safety away from the Alien. It will look disappointed at not being able to speak with the Alien. It will back away from the Alien, so it can keep an eye on the Alien to make sure nothing goes wrong. Bring Botticelli back home to safety.

<https://bit.ly/2LRekas>

If you have access to an A1 printer, you could download and print out this arena (.pdf format) that we use.

<http://bit.ly/1KYACot>



# Changing Botticelli into LucyBot Tutorial



Botticelli is a really nice Robot, but we found that it had problems going backwards on some carpets that had ridges, so to fix this we will redesign our Robot by adding a back wheel and changing the motors. We will name our new Robot LucyBot.

<https://bit.ly/2ybk110>

Next we need to add a back wheel to LucyBot. LEGO provides two different EV3 sets. The two sets contain different building components. The back wheels of each set are different. Watch one of the two videos below to find out how to add a back wheel to LucyBot.

**If you are using the Education set,** use the link below.

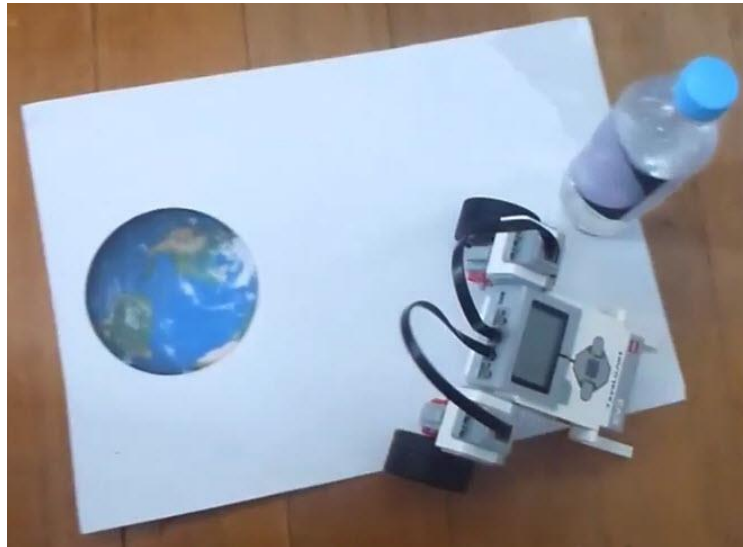
<https://bit.ly/2y8HBeN>

**If you are using the Home set,** use the link below.

<https://bit.ly/2JOC0NX>



# Going Around the Moon Tutorial & Challenge



Let us pretend that LucyBot leaves the “Earth”, goes out to one side of our “Moon”, goes around the Moon, and comes back to land safely on Earth. There is more in this video below.

<https://bit.ly/2sWkxdZ>

First, we want to teach LucyBot to go out in to space, alongside our Moon.

<https://bit.ly/2la6mxF>

Next, we need to teach her to move in a gentle curve.

<https://bit.ly/2HOXDda>

Coming safely back to land on Earth is really important!

<https://bit.ly/2JLEpXL>

How many ways can you teach your Robot to “Go around the Moon”? In the past our students have made many marvelous attempts at teaching their Robots to go in an imaginary journey around the moon - here are a few we managed to capture. The first video shows some of the first Robot journeys.

<https://bit.ly/2yegXEs>

If our Robotics Session was a longer one, some students had time to be more ambitious. Take a look at these, especially the last one, where everything went wrong,

but like the [Astronauts in Apollo 13](#), he persevered, and eventually overcame his problems and got back to Earth - even if he is the only student in  $\frac{3}{4}$  of a decade of assisting multiple schools that I have seen bring his Space Craft in to Earth backwards!

Incredible persistence!

<https://bit.ly/2Mp9Qsy>

If you have access to an A3 printer, an arena that we have used for this tutorial is available for download, click below.

<http://bit.ly/1MPpZ7T>

Alternately, you could reuse the arena that we have already used in the “Alien” tutorial on page 6 of this publication. The download link for this arena is shown below.

<http://bit.ly/1KYACot>

## A Robot Floor Cleaner - Challenge



Our pretend “floor” is divided into squares, and to “clean” this floor LucyBot must pass over each square. To see an overview of this Challenge, click on the link below.

<https://bit.ly/2JP4gRU>

The squares can be passed in any order. Because this is a Challenge, we are not giving you detailed instructions about how to teach LucyBot to clean the floor. However you might get some good ideas by watching the very different ways that other students, using other Robots, have “cleaned their floors”. These videos are from (in order) Margate School, Huonville School, a TAG workshop and Mt. Nelson School.

<https://bit.ly/2LMJK1J>

<https://bit.ly/2MsPpeA>

<https://bit.ly/2JOG3eF>

<https://bit.ly/2sYrF9P>

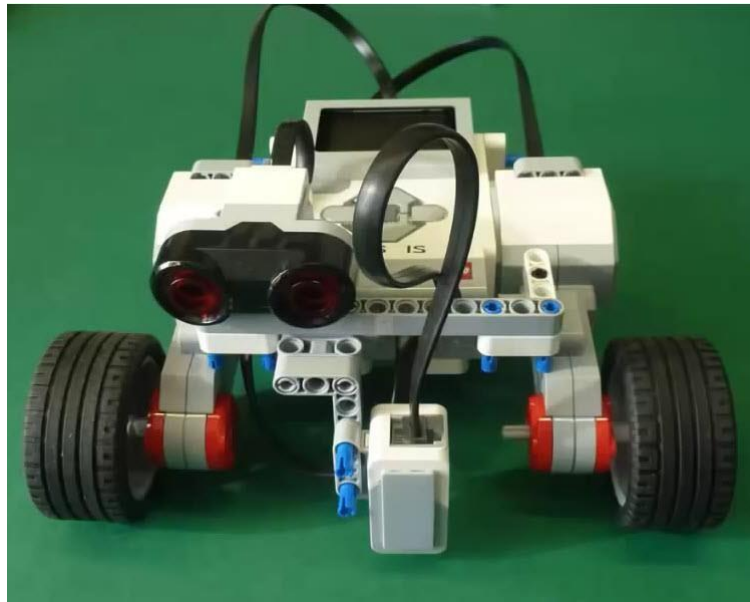
If you want some extra help in this Floor Cleaner Challenge, then the hints in the following link may prove useful.

<https://bit.ly/2HOrAtX>

If you have access to an A1 printer, a pdf template that we have used for this tutorial can be downloaded from this link (Google Chrome, Firefox, Safari and Edge seem to work better than Internet Explorer for downloading this template).

<http://bit.ly/1hHHZmF>

# Building Your Third Robot - Tutorial



Because your Robot was probably wrecked in the previous Tug-of-War Challenge, we suggest you build the three wheeled Robot YayaBot, which can be used in quite a few of the following Challenges which teach your Robot to see light, and not bump into walls. Let us take a look at what YayaBot looks like, click on the link below, or type this link in to your web browser.

<https://bit.ly/2LSIwSn>

We can build YayaBot from both the LEGO EV3 Education and Home sets. To see the first video that shows how to build YayaBot, click below.

<https://bit.ly/2l8Z5hK>

Because the Education and Home sets are different, the second half of building YayaBot is different for the Education and Home sets.

**If you have an Education set**, to see the second part of the YayaBot build, click below

<https://bit.ly/2JVUFsz>

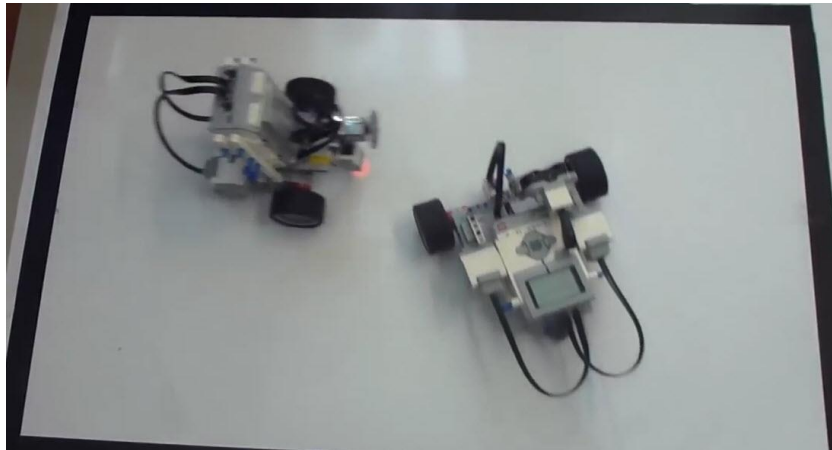
**If you have a Home Set**, to see the second part of the YayaBot build, click below.

<https://bit.ly/2JOtFb4/>

Thanks are due to Yaya Lu, who built this Robot under our cameras. To see more about Yaya, click on the link below.

<http://bit.ly/1hDd23H>

# Robot SUMO – Tutorial



In the Japanese sport of SUMO, players try to push each other out of the ring. This tutorial shows you how to teach your Robot to play Robot SUMO.

Your Robot first goes at high speed across the arena. When it comes to the black ring around the arena, it stops, backs away, turns around, and charges forward again.

After you have programmed your Robot, you can use it to push toys out of the arena. If you are in a classroom, you can compete against other Robots to see which Robot ends up alone inside the arena. To see an overview of Robot-against-Robot SUMO using our LEGO MindStorms EV3 Robot YayaBot, click on the link below, or type it into your web browser.

<https://bit.ly/2JGgMUN>

This video shows how to teach YayaBot to use the color sensor to find the edge of the SUMO ring.

<https://bit.ly/2t3Ee2W>

This video shows you how to write code in EV3-G to help YayaBot stop at the edge of the SUMO ring.

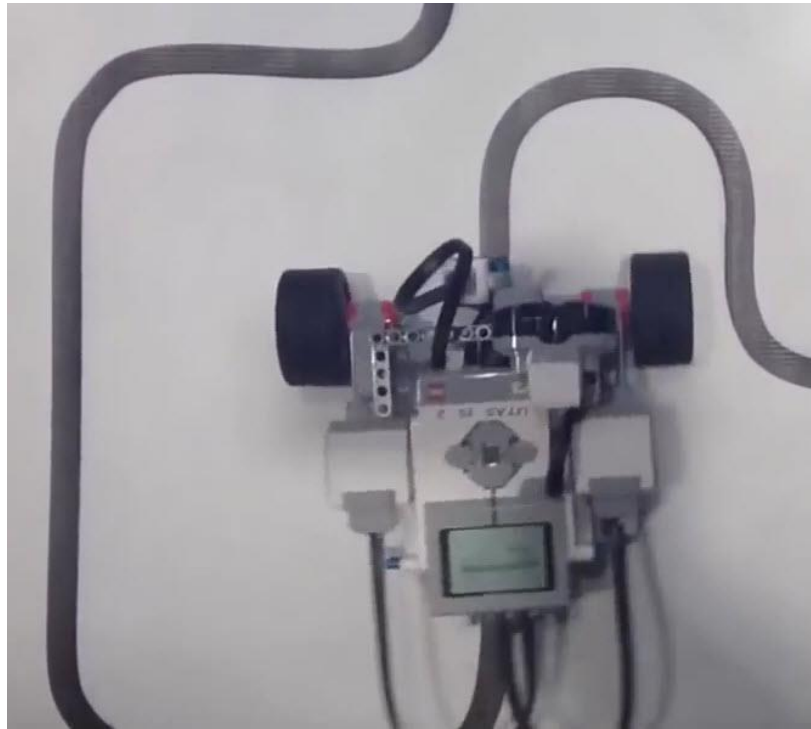
<https://bit.ly/2lbovbH>

How do we teach YayaBot to travel around inside the SUMO ring, trying to push out her opponents? Click on the link below, or type it into your web browser to find out.

<https://bit.ly/2JNIE6v>

For SUMO contests, we usually use any of our free down-loadable A1-printable arenas that have black surrounds, e.g. [SUMOV4](#), [Alien-Arena-A1-V3](#), [AlienA3V4](#) or [Floor-Cleaner-Arena-V4](#). An A1-sized piece of paper or cardboard, with black paint or black electrician's tape around the edges would serve just as well.

# Follow the Edge of a Line - Tutorial



"Following a line" is a classic problem in Robotics. In this tutorial we learn how to teach YayaBot to follow the edge of a line using one Color Sensor. It is important that there is a clear distinction in shade between the background color and the line itself. This skill has a potential use in many competitions (e.g. RoboCup Jr. and First LEGO League).

To see an overview of this line-following tutorial, click on the link below, or type this link in to your web browser.

<https://bit.ly/2t99qOs>

To find out the theory of how we could use YayaBot's Color Sensor to detect the edge of a line, click below.

<https://bit.ly/2taADzY>

To find out which EV3-G coding commands we can use to teach YayaBot to find the edge of a black line when starting from a white surface, click below.

<https://bit.ly/2t5jasI>

To find out how to bring all these EV3-G programming commands together, to teach our Robot to follow the edge of a line, click below.

<https://bit.ly/2MpZwRn>



We can set up a tape maze using electrician's tape, and foam or wooden panels. This video shows how.

<https://bit.ly/2sYvqMv>

How do we follow colored lines using our EV3 Robot using its color sensor? The next video shows what happens when we try to do just that.

<https://bit.ly/2t8Ct4t>

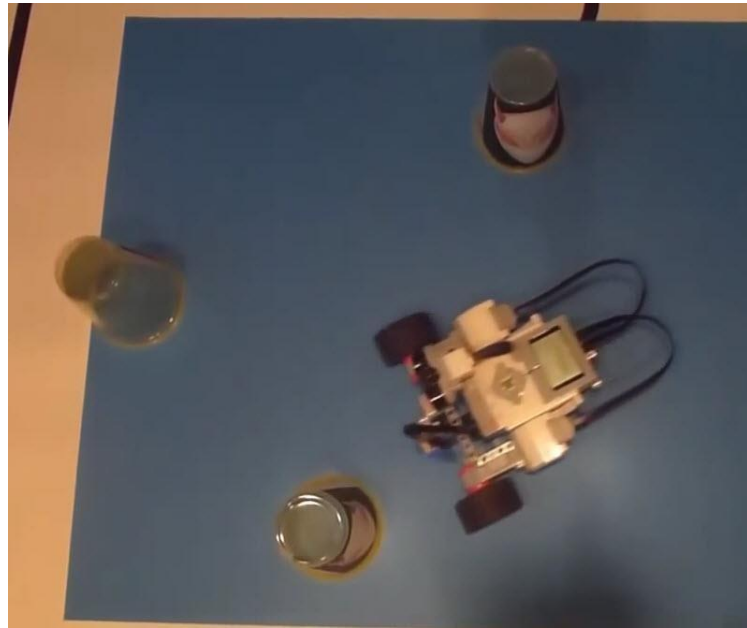
We can also print out templates for use in Robot line-following, if an A3 printer is available. These templates can be combined in many different ways to challenge our Robots, as shown in the next video.

<https://bit.ly/2t3FumG>

Walled mazes are alternatives to the flat mazes we have used so far. This video shows how we have used walled mazes made from individual tiles. The tiles are color-coded to assist following maze plans, and have the added advantage that they stack easily and compactly for storage and transport. The tiles are the same size as the rooms in the International RoboCup Junior Rescue B event, so these mazes could be used as the first of the many steps necessary to prepare a Robot for this and similar robotics competitions that use walled mazes.

<https://bit.ly/2JYFvTg>

# Toys in the Swimming Pool - Tutorial



This tutorial follows on from the "Robot SUMO" tutorial, which you should complete before enjoying this tutorial.

<https://bit.ly/2MrxzIP>

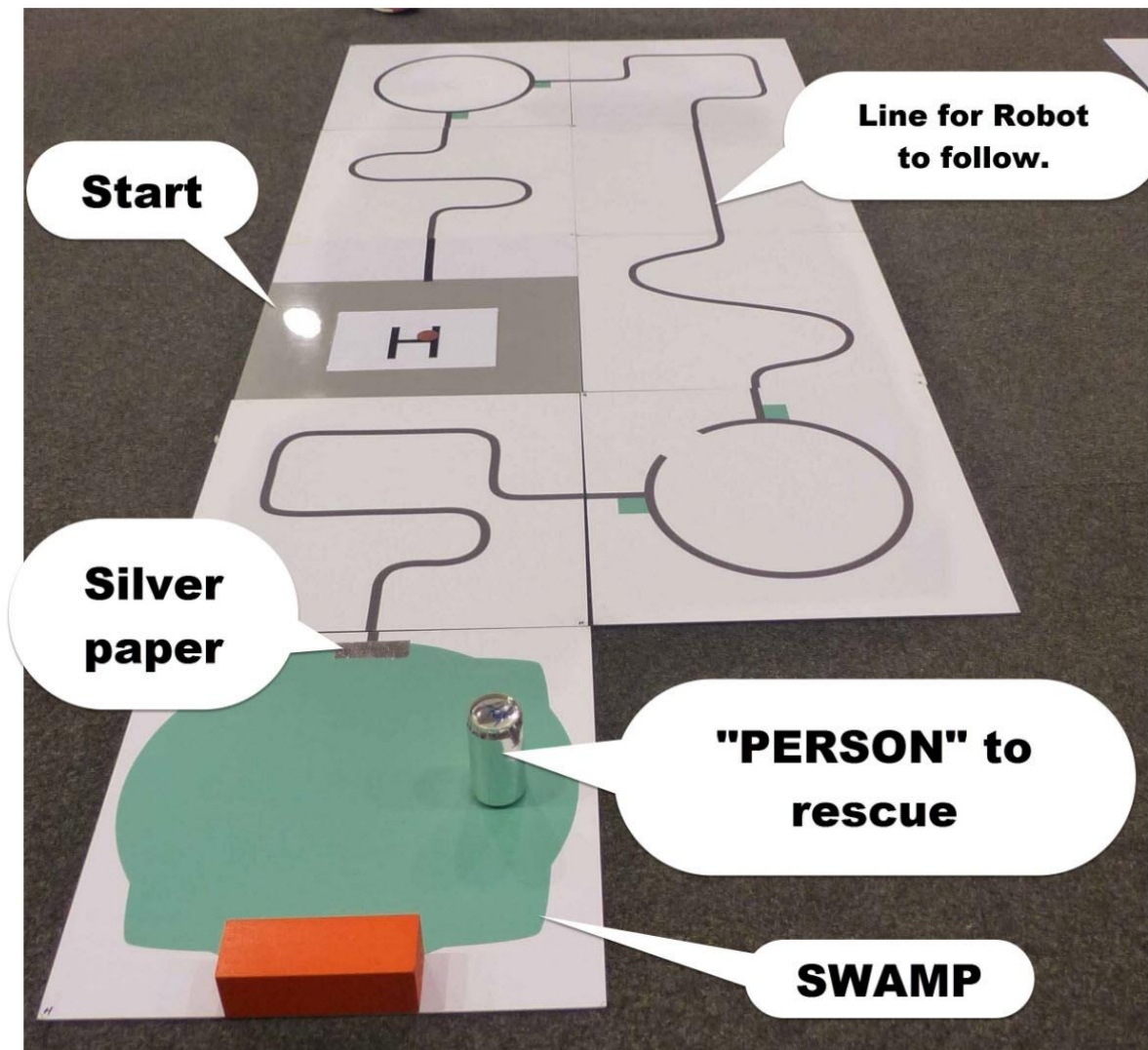
Suppose a class has had some good fun in a swimming pool, but has been careless and left some toys and equipment floating in the pool. The teacher does not have a swimming costume. Let us teach our Robot to help the teacher by pushing all the toys in the swimming pool to the edge where the teacher can collect them without getting wet. If you are in a class, you could have a competition to see which Robot can clear the swimming pool in the shortest time - but, to be fair, make sure all the toys are put back in the same place in the swimming pool between each Robot run! To find out how to clear the swimming pool using your LEGO Robot, click on the link below, or type this link in to your web browser.

<https://bit.ly/2JNfe7l>

## **Teacher/Mentor Note:**

The LEGO Color sensors are quite sensitive to the hue of the "blue" being used. Comments on the Internet suggest that these sensors are factory "tuned" to the colors used by LEGO in their robotics sets. Following some failures, we have found we get the most reliable results by taking a piece of blue LEGO, chosen from our robotics set, in to the stationery shop with us, and choosing the cardboard sheet that is closest to this LEGO version of "blue".

# The Robot Rescue Challenge – First Look



*A sample RoboCup Junior Rescue Arena.*

In the Junior version of this Rescue Challenge, our brave Robot must follow a very bendy line, go over the “silver edge of the swamp”, and rescue the “person” by pushing them completely out of the “swamp”. The Robot gets extra marks if it leaves the swamp the same way it came in, over the “silver paper”.

This Challenge is a real example of seeing if your Robot can be taught to behave almost intelligently! How to approach this Challenge, together with some hints for coding, can be seen here:

<https://bit.ly/2wFoCS9>

## Avoiding an Obstacle



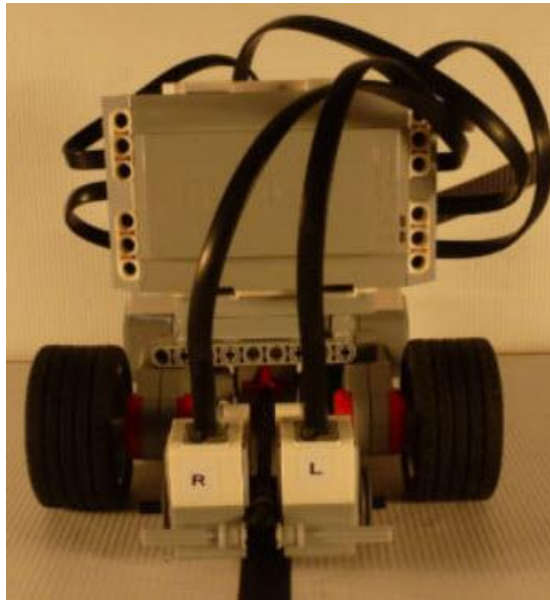
To make rescuing the person from the swamp more difficult, the devious officials at RoboCup Challenges sometimes place obstacles right in the middle of the lines that our Robot has to follow!

To be able to rescue the person from the swamp, we have to be able to teach our Robot how to go around these obstacles, and then start following the line again, so that our Robot can go on to its heroic rescue.

We discuss how to approach this problem here:

<https://bit.ly/2MJxKDa>

## Line Following Using Two Color Sensors.



If you have followed the tutorials so far, you will have added a Color Sensor to your Robot, and successfully programmed it to follow a line – good work! This would enable you to enter a Robot in the Tasmanian RoboCup Junior Rescue Championships that are held about August each year.

Robot runs in the Rescue event are timed, with Robots that are faster having an advantage over slower Robots. Some people think that line-following Robots using two Color Sensors are a little faster than one-Color-Sensor line-following Robots. Let us click on the link below and experiment to see if this idea is true!

<https://bit.ly/2Pvs1xr>

**NOTE:** LEGO only includes one Color Sensor in each Education or Home EV3 set. When we are in a classroom, we can "borrow" the Color Sensors in other sets to allow us to experiment with two color sensors attached to one Robot. If you have a need to purchase additional Color Sensors, we suggest you approach the LEGO suppliers in your country, or, failing that, try one of the International web sites such as <https://www.brickowl.com/catalog/lego-parts> or <https://www.bricklink.com/v2/main.page> (we have no connection with these sites and receive no financial feedback from these sites).



# What is a RoboCup Event Like?



We were lucky enough to be able to afford to attend the RoboCup Nationals in Brisbane, Australia, in 2014. You can get a look at the types of Robots competing, the types of RoboCup Rescue courses, and a brief look at both Robot Soccer and Dance performances by clicking on the link below.

<https://bit.ly/2MGi8jA>

Enjoy! 😊