

OZOBOT BASIC TRAINING LESSON 2

HOW DOES OZOBOT MAKE DECISIONS?

What students will learn

- How does Ozobot make decisions?
- What are the chances of Ozobot going one way or another?
- How do the probabilities change depending on the type of maze?
- How can we make sure that Ozobot takes the path we want?

Topics

- Math: random behavior
- Math: fractions
- Math: probabilities
- Robotics: line-following on digital devices
- Computer science: visual coding

Maze challenge

Use codes to direct Ozobot to a specific point in a warehouse.

Real-life connection

- Covering examples in probability theory and statistics
- Explaining what a statistician does

Age

Grades 3-7

Ozobot skill level

Beginner

STEM topics

- advanced math concepts: probabilities and law of large numbers, randomness
 - computer science: use visual codes to program the robot
 - inter-disciplinary concept: use programming and robotics to find a math problem solution
- connection to real-life applications

Common Core Standards

CCSS.MATH.PRACTICE.MP1 Make sense of problems and persevere in solving them.

CCSS.MATH.PRACTICE.MP2 Reason abstractly and quantitatively.

CCSS.MATH.PRACTICE.MP4 Model with mathematics.

CCSS.MATH.PRACTICE.MP5 Use appropriate tools strategically.

CCSS.MATH.CONTENT.3.NF.A.1 Develop understanding of fractions as numbers.

CCSS.MATH.CONTENT.3.NF.A.3 Explain equivalence of fractions in special cases.

CCSS.MATH.CONTENT.4.NF.A.2 Compare two fractions with different numerators and different denominators.

CCSS.MATH.CONTENT.4.NF.B.3.D Solve word problems involving addition and subtraction of fractions.

CCSS.MATH.CONTENT.5.NF.A.1 Use equivalent fractions as a strategy to add and subtract fractions.

CCSS.MATH.CONTENT.5.NF.B.6 Solve real world problems involving multiplication of fractions and mixed numbers

CCSS.MATH.CONTENT.6.SP.B.5 Summarize numerical data sets in relation to their context

CCSS.MATH.CONTENT.7.SP.C.7 Develop a probability model and use it to find probabilities of events.

Touching on the following high school standards:

CCSS.MATH.CONTENT.HSS.MD.A.1 Calculate expected values and use them to solve problems.

CCSS.MATH.CONTENT.HSS.MD.B.5 Use probability to evaluate outcomes of decisions.

Materials

- Ozobots (about 1 per group of 3 students)
- Digital tablet (iOS or Android operating system), charged and screen brightness set to 100%
- Ozobot app (download for free on iOS app store or google play, go to settings and select: "keep tablet awake"), one per group
- Markers in colors black, red, light blue and light green (we recommend you use Ozobot markers. Alternatively, choose Sharpie's wide chisel tip or Crayola classic markers), one set per group
- Printouts #1 and 2. One copy per group of printout #1 and 3 copies per group of printout #2. You may want to have a couple of extra printouts of #2 in case students make a mistake.
- Printout of OzoCodes reference chart (www.ozobot.com/gamezone/colorlanguage), one per group
- Optional: printout of lesson PDF, one per group, if students are learning self-guided

Estimated duration

1 or 2 class sessions

LESSON

1. Calibration on the tablet

Just like on paper, Ozobot can follow lines and read codes on a tablet as well. There are some differences though. Ozobot does not need to turn on the lights underneath since there is so much light coming from the tablet already. Make sure that the brightness of your tablet is set to as bright as possible so Ozobot can see well enough.

Also, the calibration routine is different. On your tablet, do the following:

Open the Ozobot app, go to home if you are not there already, and press the "Ozobot Tuneup" button. Make sure the screen brightness is set to 100%. On the Tune Up page, press the "Calibrate Sensors" button. Follow the 3 steps shown on the bottom of the screen.

You will have to calibrate this way every time you start playing on a tablet. This also means that you will have to calibrate every time you switch from playing on paper to playing on a tablet. And the reverse is also true: you will have to calibrate on paper (see lesson 1 on how to do that) every time you switch from playing on a tablet to playing on paper.

If your Ozobot still behaves strangely, try moving away from any bright lights. Ozobot's sensors are very sensitive and too much light from the surroundings will confuse Ozobot.

Ok, now we are ready to go!

2. Random Behavior

Open the Ozobot app on a tablet, go to home if you are not there already, and go to OzoLuck. Choose 2 outcomes on the bottom of the screen, pick the equilibrium maze and press "GO". You have entered the maze game screen. To pick a game, press "LOAD" on the top of the screen which brings up all the available games. Pick "Numbers" from the list.

Let's imagine that you're on a game show and there are two doors, door 1 and door 2. There is a prize behind one of the doors, but which one should you pick? Let Ozobot decide. Place Ozobot on the start symbol in the top middle portion of the screen and press "START". Which way does Ozobot go?

Ozobot has two options: take a left or right turn. Does Ozobot always take a left or always take a right? Press "STOP" and repeat the experiment a few times. What can you observe?

Does this remind you of anything? It's a bit like flipping a coin. There are two options: heads or tails. Before flipping, there is no way of knowing which face you will get. It's simply a matter of chance.

It is the same situation here: Ozobot seems to take some left and some right turns, but there is no logic behind those decisions. When you place Ozobot on the start, there is no way of knowing which way Ozobot will turn. Ozobot's decisions are random.

3. What are the chances?

Let's go back to the coin example. If you flip a coin 2 or 3 times you might get all heads or all tails. But if you try long enough, then you would expect to get as many heads as tails. So about half of the time you will get heads and the other half tails.

It's the same with Ozobot. Even though we don't know the decision at the moment we place Ozobot on the start, we can guess from playing often enough that Ozobot will not favor one door over the other. So, we can assume that half of the time Ozobot will go left and the other half of the time right. Speaking in probabilities, this means the probability of going left is $1/2$ and the probability of going right is also $1/2$.

This is the "Law of Large Numbers". It says that if we try long enough, then events that have the same likelihood even out. For Ozobot that means, you will see that in about half of your tries Ozobot decides to go left, and in about half of the tries Ozobot turns right.

4. What if Ozobot has three options?

We will use the OzoDraw Challenge in the Ozobot app now. Go to "Home" in the Ozobot app by pressing the "HOME" button in the upper left corner. From

there, go to OzoDraw, then to Challenge mode and pick the first challenge in the list (the one that looks like a cross).

The start is on the left. Place Ozobot on the start and observe Ozobot's behavior at the intersection. There are three options: turn left, turn right and go straight. Which one will Ozobot take?

Repeat the experiment a couple of times. Now calculate the probabilities of going left, right or straight.

See solution 1 at the end of this lesson.

Is going left more likely now than when there were only two options? Explain.

Grade 4+ extension: add all three probabilities, what do they add up to?

See solution 2.

5. Other examples of random behavior

What other examples of random behavior with the same likelihood do you know?

See solution 3.

6. What if we use a code?

Go back to the challenge on the tablet. Now let's imagine that the track we see is a road and Ozobot has to get from "Start" to "Finish". If Ozobot turns left or right, there is a dead-end and Ozobot becomes stuck. Use the "go straight" code to make Ozobot reach the Finish every time you play. Drag the code from the "Available Codes" on the top right onto the track.

You may notice that the straight code is blinking and doesn't look like the codes we used on paper in lesson 1. The blinking codes are called "flash codes" and the codes we used on paper are called "static codes". The go straight flash code we are using here does exactly the same as the static code: it makes Ozobot go straight at the next intersection. Be careful though, as with all codes, don't place it too close to an intersection.

If you need help with this challenge, press the "Solution" button. After placing the code, put Ozobot on the "Start" and see if Ozobot reaches the "Finish." Let Ozobot repeat the

journey several times to see if Ozobot reaches the “Finish” every time. Now you can see that Ozobot does not have a choice anymore. Ozobot is going straight every time. This means the behavior is not random anymore. Ozobot understands our instructions and executes them.

After placing the code correctly, what is the probability of reaching “Finish?”

See solution 4.

Maze Exercise

We have learned about probabilities and this is part of what a statistician does. Where is this being used? Think of election day for example. Statisticians use a complex system of probabilities to predict the winner of an election. This way, we don’t have to wait until every single vote is counted - statisticians can predict the outcome ahead of time.

Another area is the computation of insurance premiums. Statisticians help to figure out how much everybody has to pay so the insurance company has enough money to pay somebody in the case of an accident. Statisticians also work for drug companies and design studies that test if a new drug is safe to use. And there are many, many other applications in which statistics is being used.

For the maze exercise, imagine Ozobot works in a warehouse and has to stock shelves. We are using a paper handout (#1) now, so make sure to calibrate Ozobot on paper before starting the exercise. Ozobot picks up shoes at the start and has to bring a pair to the end of aisle 3. Put Ozobot on the line at the “Place here” arrow, facing right and see where Ozobot ends up. Repeat this a couple of times. Without using any codes, is it likely that Ozobot makes it to aisle 3? Which aisle do you think Ozobot would go to the most and which the least and why?

Now let’s look at the probabilities. What are they for the first intersection (a)?

See solution 5.

And for the second intersection (b)?

See solution 6.

Younger students: is Ozobot more likely to get to aisle 3 than to aisle 2? Or more likely to go to aisle 3 than to aisle 4? Explain.

Advanced students: Since we already know the probability of turning left at the first intersection is $1/3$, we know that the probability of reaching the end of aisle 1 is $1/3$. In the same manner, the probability of reaching the end of aisle 2 is also $1/3$.

To reach aisle 3, we first have to go straight at the first intersection, which happens with $1/3$ probability. Then, Ozobot has to turn left at the second intersection, which happens in $1/2$ of the cases. Therefore, the total probability of reaching the end of aisle 3 is $1/3 * 1/2 = 1/6$.

Similarly, the probability of reaching aisle 4 is also $1/6$.

Do all the probabilities still add up to 1?

See solution 7.

All students: **Let's help Ozobot reach aisle 3 every time with the use of codes. Take handout #2 and use the following codes:**

Try 1: go straight and left.

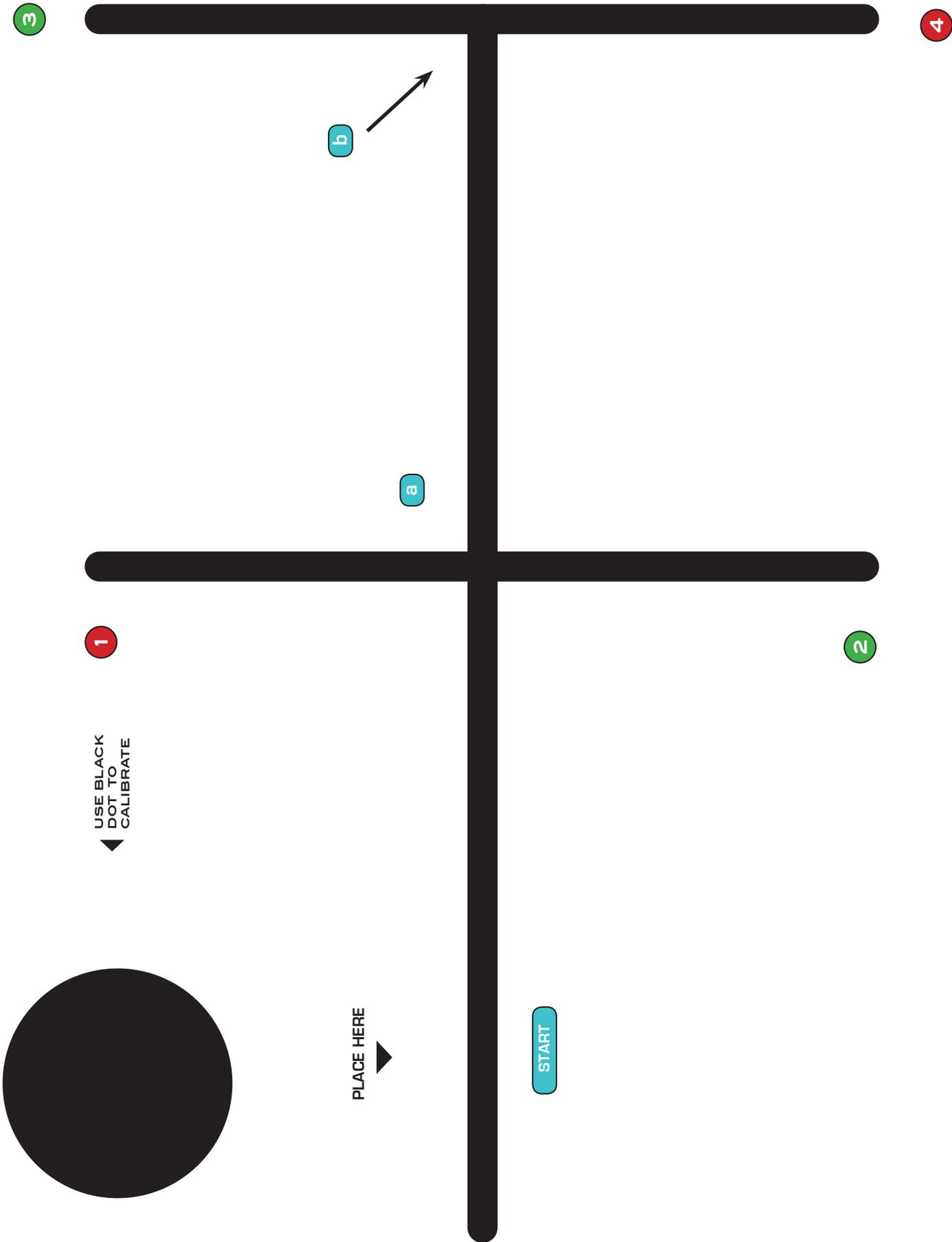
Fill in these two codes into two of the available spaces and cover the unused spaces with black marker. Place Ozobot on the line at the "Place here" arrow, facing right, and see if Ozobot makes it to the end of aisle 3.

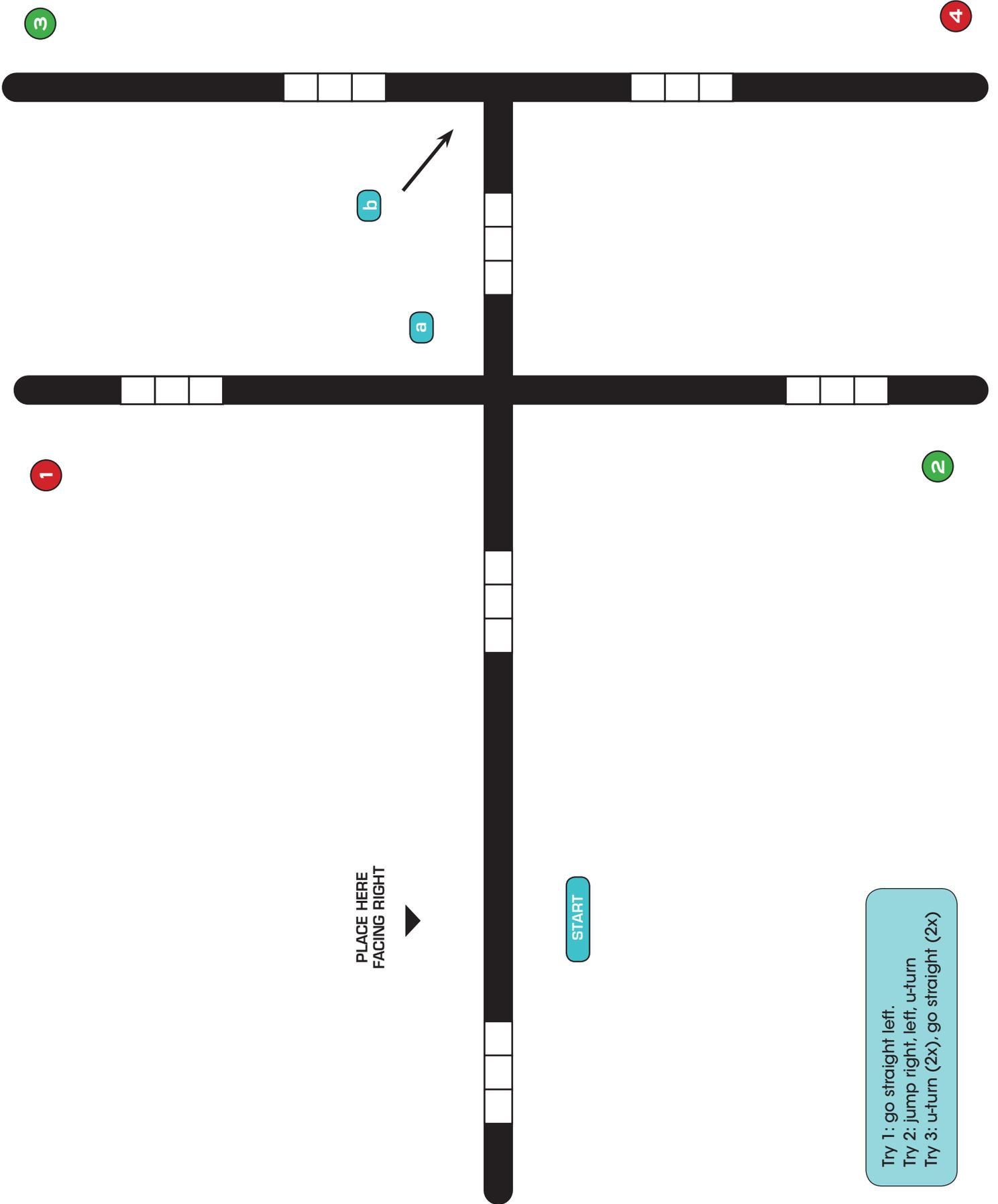
Do the same experiment 2 more times, each time using a fresh copy of handout #2, but with different codes:

Try 2: jump right, left, u-turn

Try 3: u-turn (2x), go straight (2x)

See solution 8.





Try 1: go straight left.
Try 2: jump right, left, u-turn
Try 3: u-turn (2x), go straight (2x)

Solutions:

Solution 1: 1/3, 1/3, 1/3.

Solution 2: they always add up to 1. This is also true for the previous example. The probabilities were 1/2 and 1/2.

Solution 3: For Example:

- Rolling a dice (1/6)
- Drawing from a bowl of numbered balls (f.e. 10 balls, then the probability is 1/10)

Solution 4: The probability of reaching "Finish" is now 1

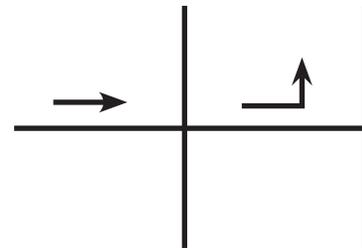
Solution 5: 1/3 left, 1/3 right, 1/3 straight

Solution 6: 1/2 left, 1/2 right

Solution 7: Yes, they do, $1/3+1/3+1/6+1/6 = 1$.

Solution 8:

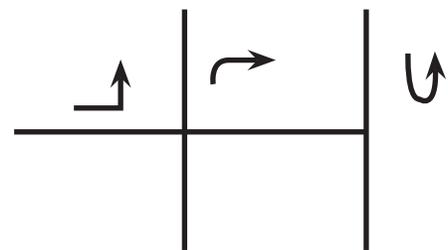
1. Straight



Left



2. Jump Right



Left

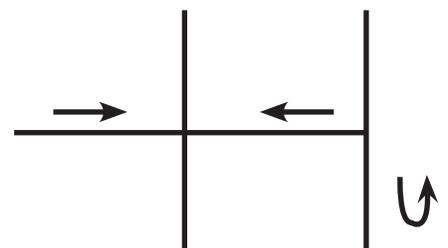


U-turn



3. U-turn

(2x)



Straight

(2x)

