The Quantum Circuit Challenge

Challenge 1 - Up, down, left, right: Create a quantum circuit that puts the qubit into each of the 4 states up, left, down, right (in any order, look at the picture on the top left to see what state you are in)

Challenge 2 - Making randomness: Build a circuit and choose a measurement at the end so that the result of the measurement is random.

This means that when you run the same circuit a few times the measurement at the end will sometimes say "up" and sometimes say "down" OR, sometimes it will say "left" and sometimes say "right".

Challenge 3 - Doing and undoing: Start your circuit with an X gate. Then, add gates so that the effect of your circuit is to do nothing at all.

Challenge 4 - Doing and undoing: Start your circuit with a Z gate and then an H gate. Then, add gates so that the effect of your circuit is to do nothing at all.

Challenge 5 - Flipping without X gates: Create a circuit that takes in an "up" state and sends out a "down" state, but, create this circuit without ever using an X gate!

Challenge 6 - Useless gates: Create a circuit where the X gate doesn't do anything. you'll need at least one gate before the X gate so that the qubit going into the X gate isn't in the "up" state!

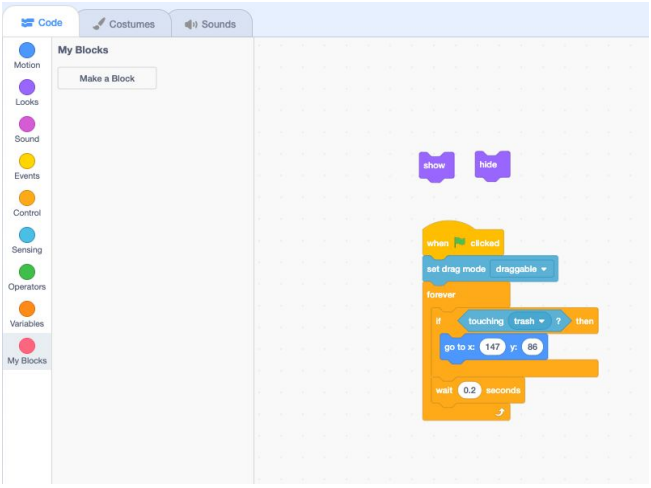
Challenge 7 - XH vs HX: Find two gates which create different circuits when put in a different order.

Challenge 8 - XH vs HX: Find two gates which create the same circuit when put in a different order.

Hint - try a circuit with an X gate then an H gate, and compare this to an H gate and then an X gate. Try this again with X and Z.

Challenge 9 - Create your own gate:

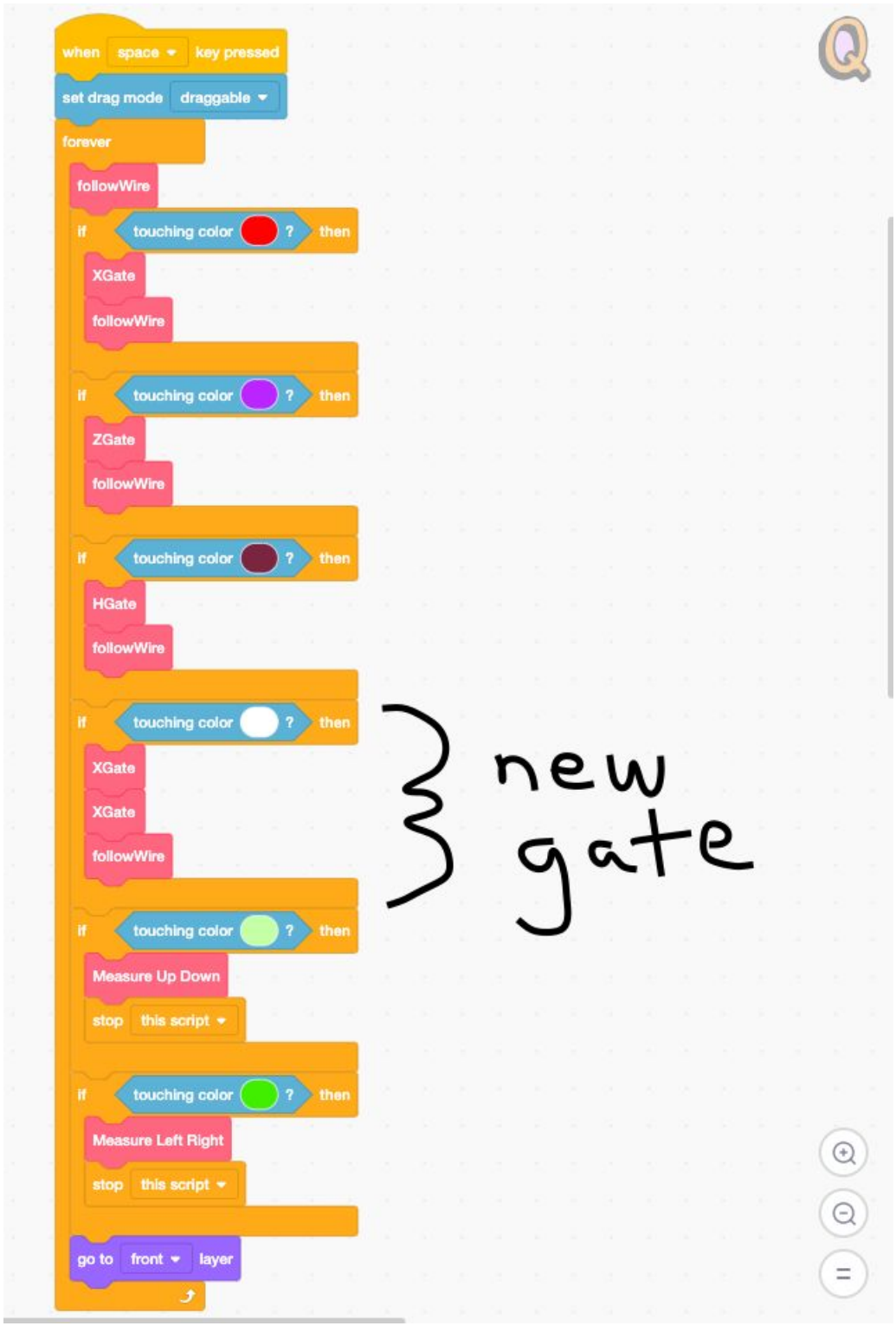
To get started, look for the "my gate" sprite. In the code tab you'll notice a "show" block and a "hide" block. Click the "show" block.



A new sprite will appear in the circuit editor. You can go to the "costumes" tab to change the appearance of your gate (Make sure to keep your gate as a square and don't change the size, or the circuit won't work properly!)

Next go to the Q sprite. You'll need to use an "if" statement so the qubit checks if it is touching the new gate sprite. Then inside the if statement build your quantum gate! You can create a new gate by putting together a few of the existing gates.

Here's an example:


when space key pressed
set drag mode draggable
forever
followWire
if touching color ? then
XGate
followWire
if touching color ? then
ZGate
followWire
if touching color ? then
HGate
followWire
if touching color ? then
XGate
XGate
followWire
if touching color ? then
Measure Up Down
stop this script
if touching color ? then
Measure Left Right
stop this script
go to front layer
new gate

Remember that you can always restart by creating a new remix of the original project: https://scratch.mit.edu/projects/400546699/

Challenge 10: Once you've created your own quantum gate, you're ready to share your Scratch project!

Add your project to the "One Qubit Circuit" Scratch studio: https://scratch.mit.edu/studios/26808197/

Next, check out 2-3 other projects in the Scratch studio. Without looking inside their code, can you figure out what their mystery gate is? How is it built out of the X,H, and Z gates? Post your guess in the comments on their Scratch project page.