HW3. Computing with SCs

10.27.25

I. SC Arithmetic

At any stage you may define a new boxed circuit from a previously established circuit. You may assume boxed circuits for **XOR** and **half-adder.** You will also want to introduce boxed circuits for specific mathematical functions as the need arises.

Design SCs that compute the following functions.

1. +1 B
2. +2 B
3. $2x$ B
4. $2x$+1 B [Use one $2x$ circuit and one +1 circuit]
5. $2(x+1)$ B [Use one $2x$ circuit and one +1 circuit]
6. $x+y$ B

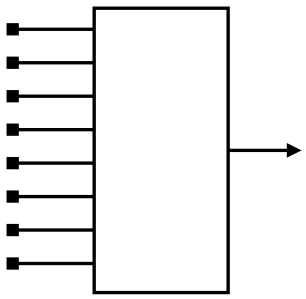
For each of the following functions, is it possible to compute this function with an SC? If so, construct the circuit. If not, explain why in a short paragraph: be as clear and precise as you can.

7. +3 T
8. $2x$ T
9. $x + y$ T
10. $x \bullet y$ B (multiplication)

II. SC Perception

For each of the following problems assume a SC that has 8 inputs and 1 output, like the schematic circuit below. Think of these as computing **perception**: they take as their input an array of stimulations (like hitting the retina) and they output a symbol which represents a specific shape or category.

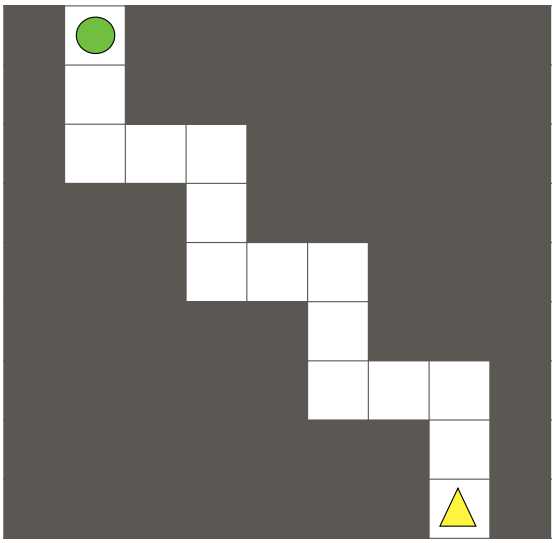
11. **Change detector.** Design a machine that obeys the following rule: output 1 iff the current input differs in any way from the previous input.
12. **Motion detector.** Let an *object image* be a string of exactly three consecutive 1's. Design a machine that obeys the following rule: output 1 iff there is an object image anywhere in the input moving upwards 1 unit per unit of time.



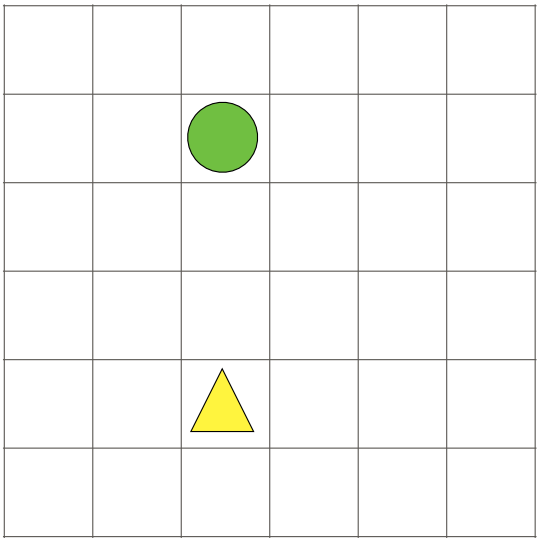
II. SC Navigation

For each of the following navigation tasks: can it be completed by a combinatorial circuit embedded in a turbot? If so, give the circuit. If not, explain why in a short paragraph.

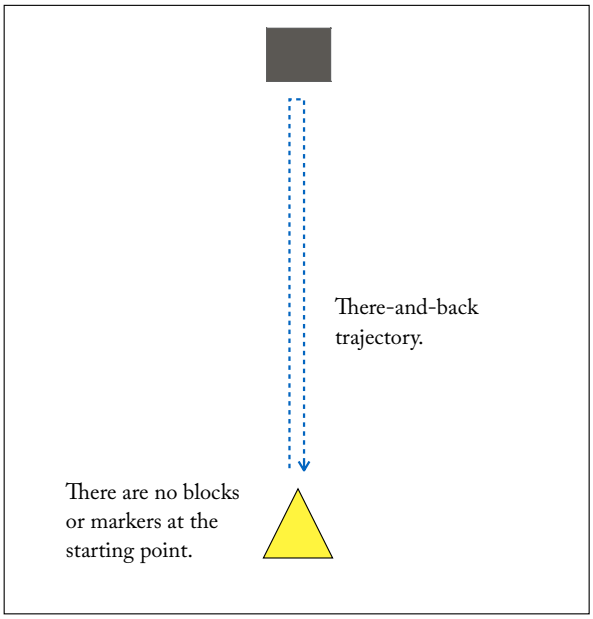
13. **Zig-Zag:** reach the goal and **keep going**.



14. **Three ahead:** reach the goal and **stop**.



15. **Mad Max:** go to a block directly ahead, but an unknown distance away, then return to the starting point and **stop**.



Note 1: SC Turbots have two outputs, one for each wheel.

Note 2: The goal (the green circle) is invisible to the turbot; it reads as an empty block.

III. Reflection

Short paragraph answers.

16. SCs are more computational powerful than CCs: SCs can solve problems that CCs cannot. What physical abilities would you add to an SC if you wanted to make it even more powerful?

17. Could there be an intelligent being with no memory?