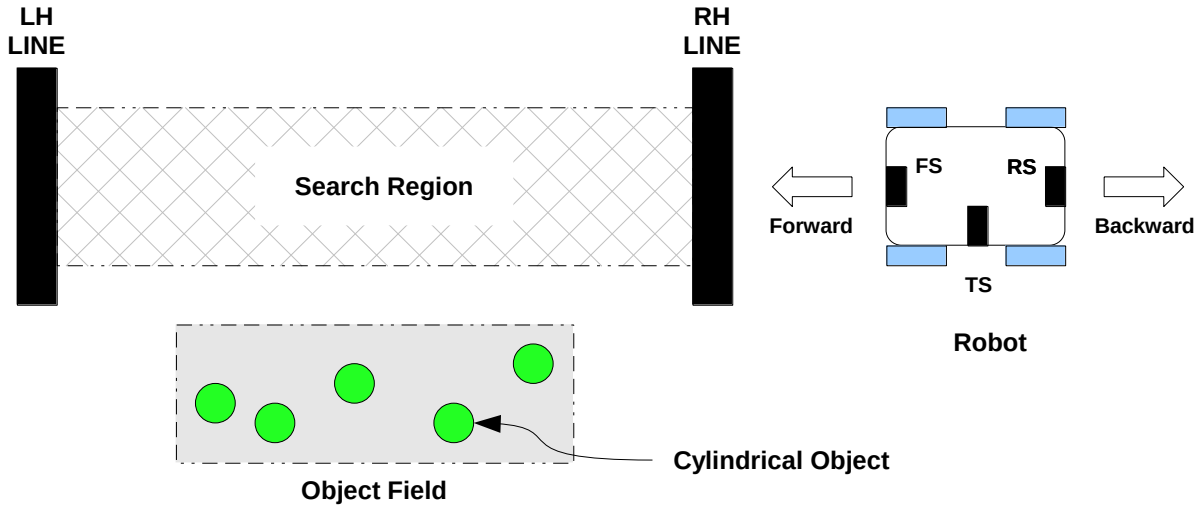
You are to design the brain of a mobile robot that searches for cold (< 4°C) cylindrical objects. The robot starting position and search region are show below. Five cylindrical objects are positioned in the object field. Each cylindrical object repeatedly goes up and down in temperature, periodically rising to a maximum temperature of 25°C before cooling to a minimum temperature of 0°C.

Your robot is to carry out the following actions, in the order listed:

1. Enter the search region by moving ***forward*** across the black line denoted as "RH LINE" in the schematic below. This action is considered complete when the robot is ***entirely*** inside the search region.
2. Make ***one*** forward pass, traveling across the search region while scanning for cold cylindrical objects in the object field, until the ***front*** of the robot reaches the black line denoted as "LH LINE." If a cylindrical object with a temperature ***below*** 4°C is detected while making this forward pass, the robot should halt all motion and wait indefinitely in front of that object. When the object's temperature rises above 4°C, resume scanning for additional cold cylindrical objects while moving in the ***forward*** direction.
3. Make ***one*** backward pass, traveling across the search region and scanning for cold cylindrical objects, until the ***rear*** of the robot reaches the black line denoted as "RH LINE." As before, if a cylindrical object with a temperature ***below*** 4°C is detected while making this backward pass, the robot should stop indefinitely in front of that object. When the object's temperature rises above 4°C, resume scanning for additional cold cylindrical objects while moving in the ***backward*** direction.
4. Once the backward pass has been completed, and the rear of the robot is on the line denoted as "RH LINE," shut down the robot.




Three inputs direct your robot's operation:

- FS is a signal from the *front sensor* that represents whether the front of the robot has detected a black line. It is asserted (=1) if the front of the robot is on the line and is reset (=0) otherwise.
- RS is a signal from the *rear sensor* that represents whether the rear of the robot has detected a black line. It is asserted (=1) if the rear of the robot is on the line and is reset (=0) otherwise.
- TS is a signal from the *temperature sensor* that indicates if a cold cylindrical object has been detected in the object field. It is asserted (=1) if an object with a temperature of less than 4°C has been found, and is reset (=0) otherwise.

Two outputs are to be switched on and off by your controller:

- DIR is a *directional output* that indicates the direction of robot motion. It is asserted (=1) when the robot is to move forward and is reset (=0) when the robot is to move backward.
- GO is a *movement output* that acts as an ON-OFF switch for robot propulsion. It is asserted (=1) when the robot is to move (motor turning) and is reset (=0) when the robot is to stop.

The following constraints are placed on your finite state machine (FSM) design:

- The robot can only travel straight forward or straight back; it cannot turn.
- ***Do not change states*** if two or more inputs are simultaneously active (=1).
- To stop (halt) the robot, deactivate both outputs (=0).
- To shut down the robot, deactivate both outputs (=0) ***and*** prevent any transitions out of the shut-down state.

You are to design a logic system that realizes the controller described above:

A. Identify all the input and output signals of the state machine and state the physical meaning for their binary representations, e.g.

   FS = 0 Front sensor off

   FS = 1 Front sensor on; black line detected at front of robot

B. Sketch a state transition diagram for your FSM. Be sure to include a legend that identifies your inputs and outputs.

*C.* Generate a state transition table (*next-state* table) for your FSM.

D. Write Arduino code that implements the FSM you have designed. Use the Arduino pins specified below.

| Pin | Input/Output |
|---|---|
| 2 | FS |
| 3 | RS |
| 4 | TS |
| 11 | DIR |
| 12 | GO |