Lincoln Sand

1. Consider a sequential circuit that implements the following function in a self-driving car. In every second, the car's position within the lane is determined with cameras and fed as input to the sequential circuit. Accordingly, the car's steering wheel is moved to one of 2 positions: Left, Right. The car's position can be "Middle of a lane", "Drifting to the right edge of the lane", and "Drifting to the left edge of the lane". If the car is in the "Middle", the steering position is left unchanged. If the car is drifting to one of the edges of the lane, the steering is moved away from the edge, i.e., steering should be moved right if the car is near the left edge of the lane. (40 points)

1. What are the states for the circuit controlling the steering? 2. What are the inputs to the circuit and what values can those inputs have? 3. Draw the finite state table and finite state diagram for this circuit.

1.

State S_0: Steering in the middle position (no change needed).

State S_1: Steering is moved to the left (to correct from drifting to the right).

State S_2: Steering is moved to the right (to correct from drifting to the left).

2.

$X = 0$: The car is in the middle of the lane.

$X = 1$: the car is drifting to the right edge of the lane.

$X = 2$: The car is drifting to the left edge of the lane.

3.

Current State	Input (X)	Next State	Output (Y)
S_0 (Middle)	0	S_0	1 (No change)
S_0 (Middle)	1	S_1	0 (Steer left)
S_0 (Middle)	2	S_2	2 (Steer right)
S_1 (Left)	0	S_0	1 (No change)
S_1 (Left)	1	S_1	0 (Steer left)
S_1 (Left)	2	S_2	2 (Steer right)
S_2 (Right)	0	S_0	1 (No change)
S_2 (Right)	1	S_1	0 (Steer left)
S_2 (Right)	2	S_2	2 (Steer right)

This table produces this FSM behavior:

State S_0 (Middle):

Stays in S_0 on input $X = 0$.

Moves to S_1 on input $X = 1$.

Moves to S_2 on input $X = 2$.

State S_1 (Left):

Moves to S_0 on input $X = 0$.

Stays in S_1 on input $X = 1$.

Moves to S_2 on input $X = 2$.

State S_2 (Right):

Moves to S_0 on input $X = 0$.

Moves to S_1 on input $X = 1$.

Stays in S_2 on input $X = 2$.

2. Consider the following circuit to control a moving walkway. Every 2 seconds, the circuit examines two weight sensors and decides if the walkway will travel Northward or Southward or be turned off. There is a weight sensor in the North half of the walkway and a weight sensor in the South half of the walkway. If both sensors detect zero weight, the walkway is turned off. If the walkway is off and both sensors detect weight, the walkway remains off. If the walkway is off and one of the sensors detects a weight, the walkway starts moving in the opposite direction, i.e., if the North weight sensor detects a weight, the walkway starts moving Southward. Once the walkway is in motion, it retains that motion until both weight sensors detect zero weight. (60 points)

1. What are the states for the circuit controlling the walkway? 2. What are the inputs to the circuit and what values can those inputs have? 3. Draw the finite state table and finite state diagram for this circuit.

1.

State S_0: The walkway is turned off.
State S_1: The walkway is moving Northward.
State S_2: The walkway is moving Southward.

2.

$X = 00$: No weight on either sensor (North sensor = 0, South sensor = 0).
$X = 01$: Weight detected only on South sensor (North sensor = 0, South sensor = 1).
$X = 10$: Weight detected only on North sensor (North sensor = 1, South sensor = 0).
$X = 11$: Weight detected on both sensors (North sensor = 1, South sensor = 1).

3.

Current State	Input (X)	Next State	Output (Y)
S_0 (Off)	00	S_0	Off
S_0 (Off)	01	S_1	Move Northward
S_0 (off)	10	S_2	Move Southward
S_0 (Off)	11	S_0	Off
S_1 (North)	00	S_0	Off
S_1 (North)	01	S_1	Move Northward
S_1 (North)	10	S_1	Move Northward
S_1 (North)	11	S_1	Move Northward
S_2 (South)	00	S_0	Off
S_2 (South)	01	S_2	Move Southward
S_2 (South)	10	S_2	Move Southward
S_2 (South)	11	S_2	Move Southward

This table produces this FSM behavior:

State S_0 (Off):

Stays in S_0 on input 00 and 11.

Moves to S_1 on input 01.

Moves to S_2 on input 10.

State S_1 (North):

Moves to S_0 on input 00.

Stays in S_1 on input 01, 10, and 11.

State S_2 (South):

Moves to S_0 on input 00.

Stays in S_2 on input 01, 10, and 11.