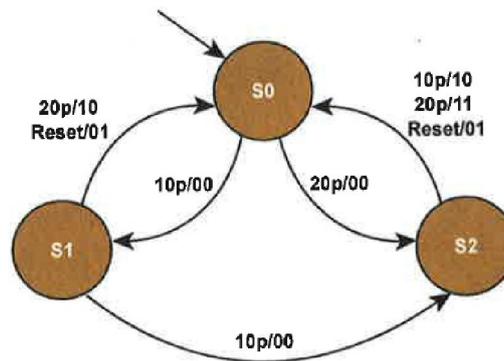


## Mealy machines

A mealy machine is a type of FSM with an output, names after its inventor George Mealy. A Mealy machine has outputs that are determined **both by its current state and the current input**. For each state and input, no more than one transition is possible

### Example

The controller for a vending machine is implemented as a Mealy machine as shown in the finite state diagram below. The initial state is shown with an arrow, and each transition shows both the input and the output. A packet of crisps will be dispensed when the customer has inserted three 10p coins or a 10p coin and a 20p coin. If two 20p coins are inserted, the machine will give 10p change. For example, 10p/00 means that 10p has been input and the controller does not dispense the packet of crisps and does not give change. 20p/11 means that 20p has been inserted and the machine dispenses the crisps and gives change. A Reset button gives change if the customer presses it when they have entered less than 30p.



The transition table representing this Mealy machine is as follows:

Input	Current state	Output	Next state
10p	S0	00	S1
20p	S0	00	S2
10p	S1	00	S2
20p	S1	10	S0
10p	S2	10	S0
20p	S2	11	S0
Reset	S1	01	S0
Reset	S2	01	S0

### Question

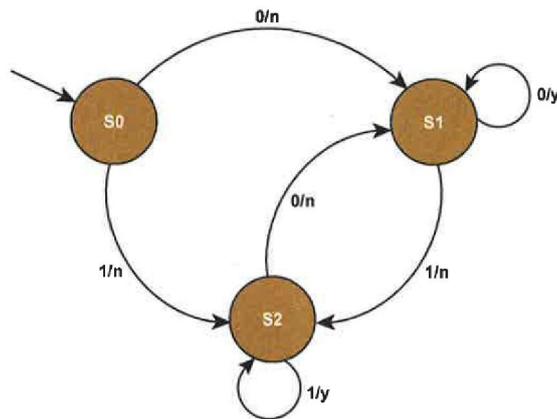
Looking at the outputs above, what does:

An output of 11 mean?

an output of 10 mean?

## Example

The FSM below represent a Mealy machine which accepts any number of inputs of 0 or 1. If the last two symbols input are 00 or 11, the final outputs **y** (yes), otherwise the final output is **n** (no).



The corresponding state transition table is shown below:

Input	Current state	Output	Next state
0	S0	N	S1
1	S0	N	S2
0	S1	Y	S1
1	S1	N	S2
0	S2	N	S1
1	S2	y	S2

You can show the output for any input string. Suppose you input the string 0 0 1 0 1 1,

Write these input down and underneath them, complete the state sequence and the output rows, column by column, working along the row, for each input, write down the next state arrived at and the output

Input =	0	0	1	0	1	1	
State sequence =	S0	S1	S1	S2	S1	S2	S2
Output =	n	y	n	n	n	y	

↑     ↑     ↑     ↑     ↑     ↑  
 (Arrows point from the output row to the state sequence row)

The final output from this string is y, at the final state S2.

## Question

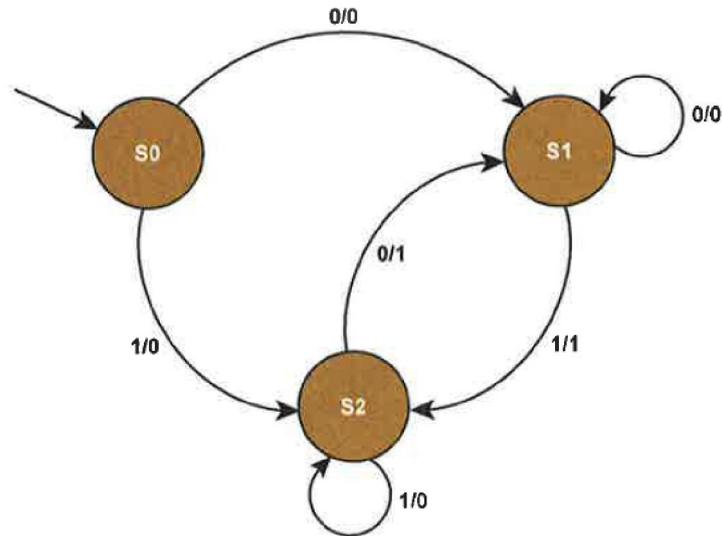
Write out the state sequence for the input 1 0 1 1 0 1. What is the final state and what is the final output?

## Applications of mealy machines

Mealy machines can provide a simple model for cipher machines. Given a string of letters (a sequence of inputs), a Mealy machine can be designed to give a ciphered string (a sequence of outputs). They can also be used to represent traffic lights, timers, vending machines and basic electronic circuits.

### Question

1. This example shows a Mealy machine that represents an exclusive OR of the two most recent values input.



2. Complete the state transition table for the FSM given above

Input	Current state	Output	Next state
0	S0	0	S1
1			
0			
1			
0			
1			

3. Write out the state sequence for the input string 0 0 1 0 0 1

## Exercises

1. A Mealy machine is to be designed so that its final output is a 1 when at least three ones have been entered in sequence.

(a) With the aid of the state transition table below, draw the finite state diagram representing the Mealy machine. [3]

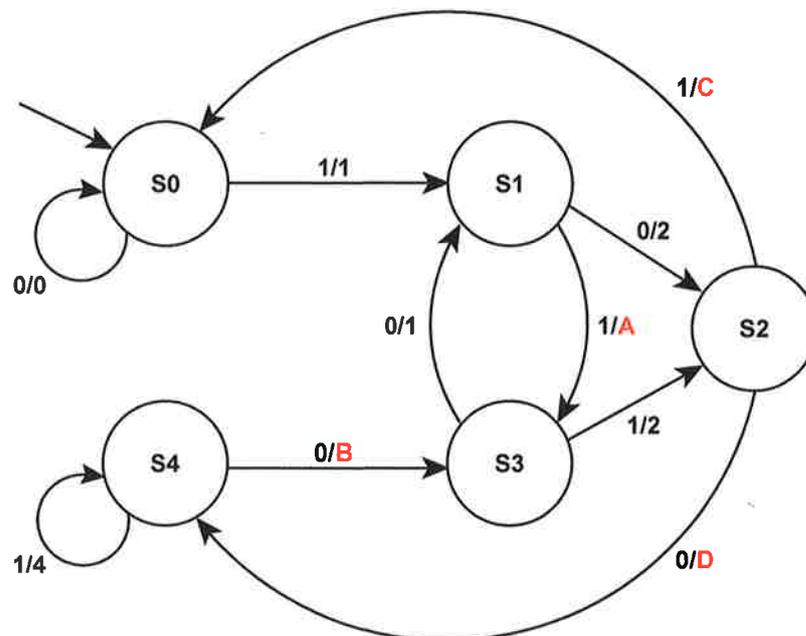
Input	Current state	Output	Next state
0	S0	0	S0
1	S0	0	S1
0	S1	0	S0
1	S1	0	S2
0	S2	0	S0
1	S2	1	S2

(b) Write the state sequence showing the output for each of the following input sequences:

(i) 110111 [2]

(ii) 101101 [2]

2. The following Mealy machine accepts as input a string of binary digits. The output is the remainder, given in decimal, when the string of binary digits is divided by 5. Thus for example an input string of binary digits 10 will give an output of 2, and an input string of 1011 will output 1.



(a) What are the outputs **A**, **B**, **C** and **D**? [4]

(b) (i) The binary string 1010011 is input. List the state sequence. [2]

(ii) What is the output from the string? [1]