COSC1107 Computing Theory

(We will commence soon. We are just allowing a few minutes for people to join and set up. *Please mute your microphone unless you are speaking.* You can raise your hand or use the chat at any time.)

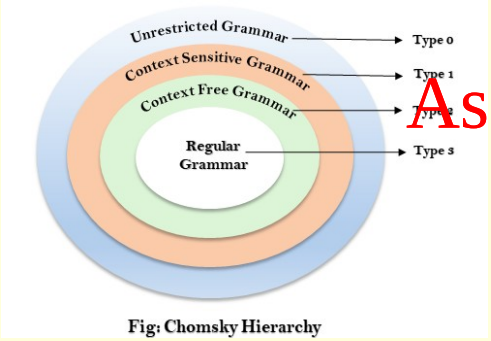
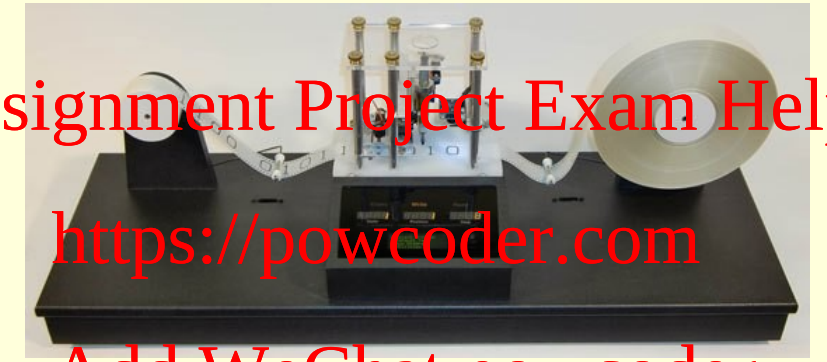


Fig: Chomsky Hierarchy



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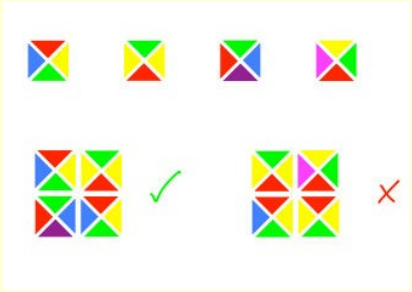

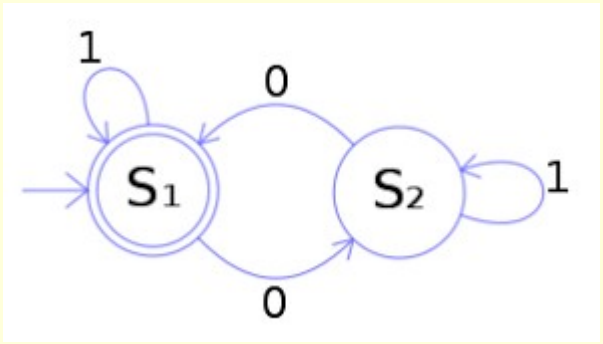

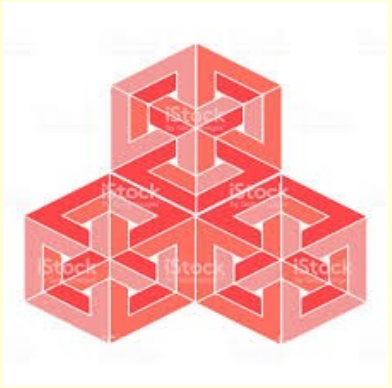

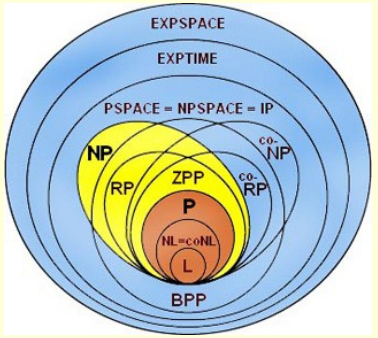

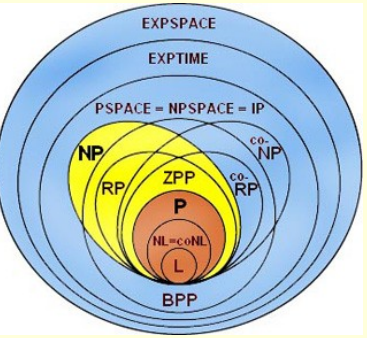

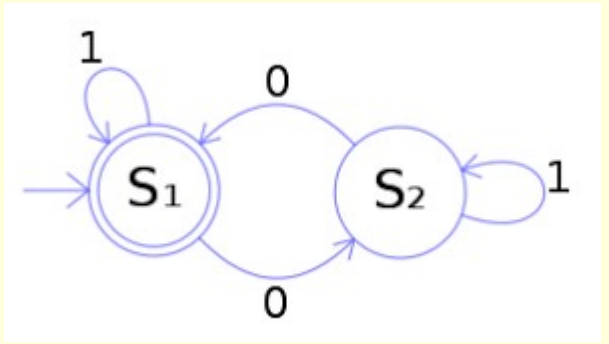

COSC1107

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Computing Theory

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Turing Machines

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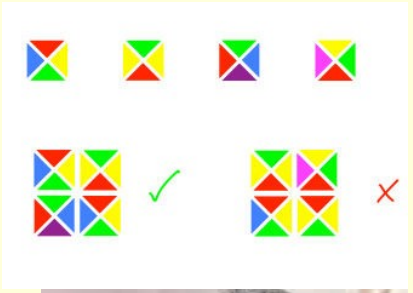
Week 4



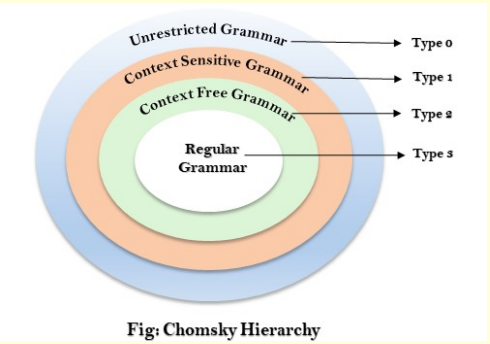


Fig: Chomsky Hierarchy

James Harland

james.harland@rmit.edu.au

* With thanks to Sebastian Sardina

Intro music 'Far Over' playing now …

Acknowledgement

RMIT University acknowledges the people of the Woi wurrung and Boon wurrung language groups of the eastern Kulin Nations on whose unceded lands we conduct the business of the University. RMIT University respectfully acknowledges their Ancestors and Elders, past and present.

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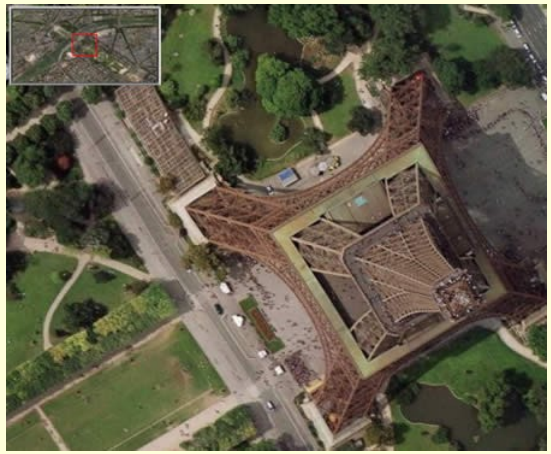
RMIT also acknowledges the Traditional Custodians and their Ancestors of the lands and waters across Australia where we conduct our business.

(add your name here to volunteer for this or email me)



Overview

- Questions?
- Turing Machines
- Questions?
- Platypus Game
- Questions?

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Questions?

Questions?

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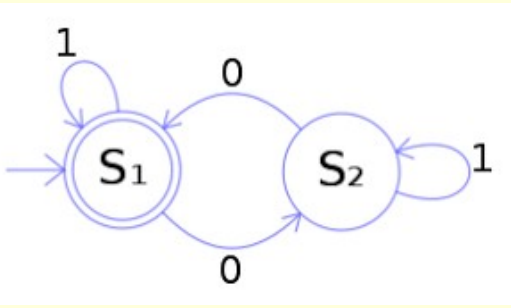
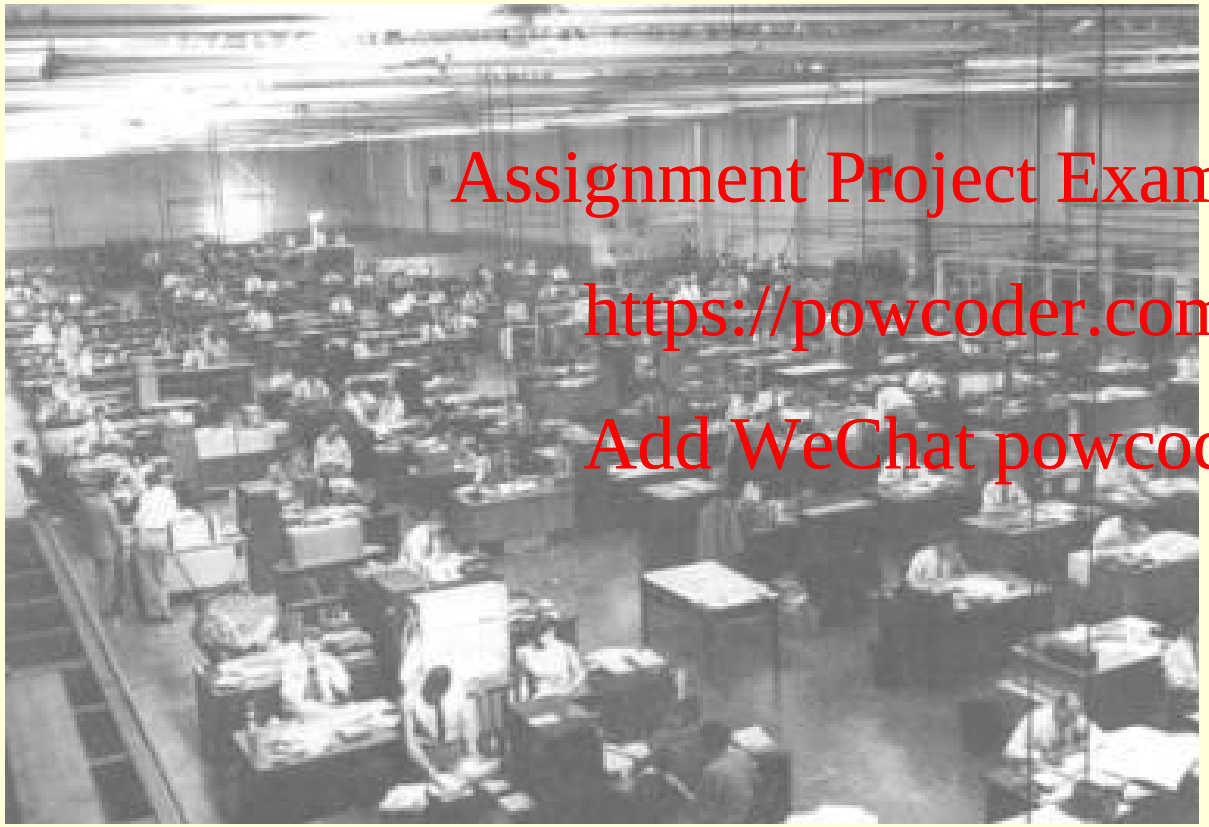
Questions?



"Computers"

"High tech" circa 1930 ….



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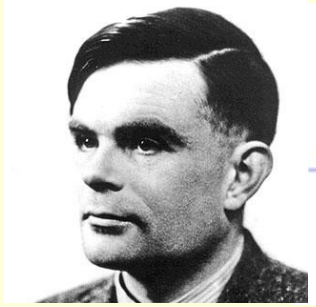
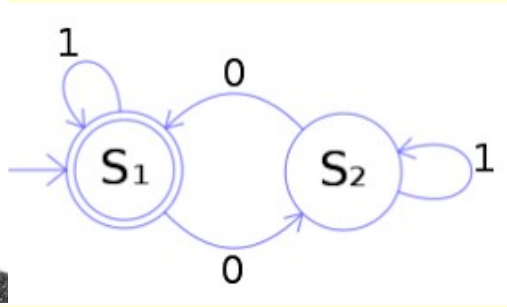
Alan Turing





- English mathematician 1912-1954
- Subject of the 2014 movie '<u>The Imitation Game</u>'
- Invented *Turing machines* in 1936
- Involved in British codebreaking enterprise (Enigma) in World War 2 (1939-1945) at Bletchley Park
- Invented the Turing test for artificial intelligence
- Computer Science's "Nobel Prize" is named the Turing Award
- British Government formally apologised for his treatment in 2009
- 2012 Turing centenary celebrations
- Google Doodle from 23rd June 2012 is here

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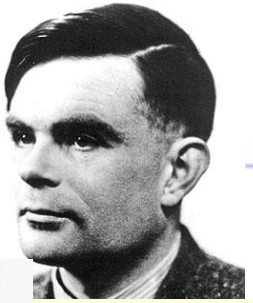
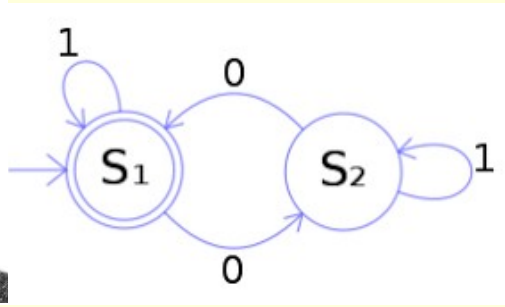
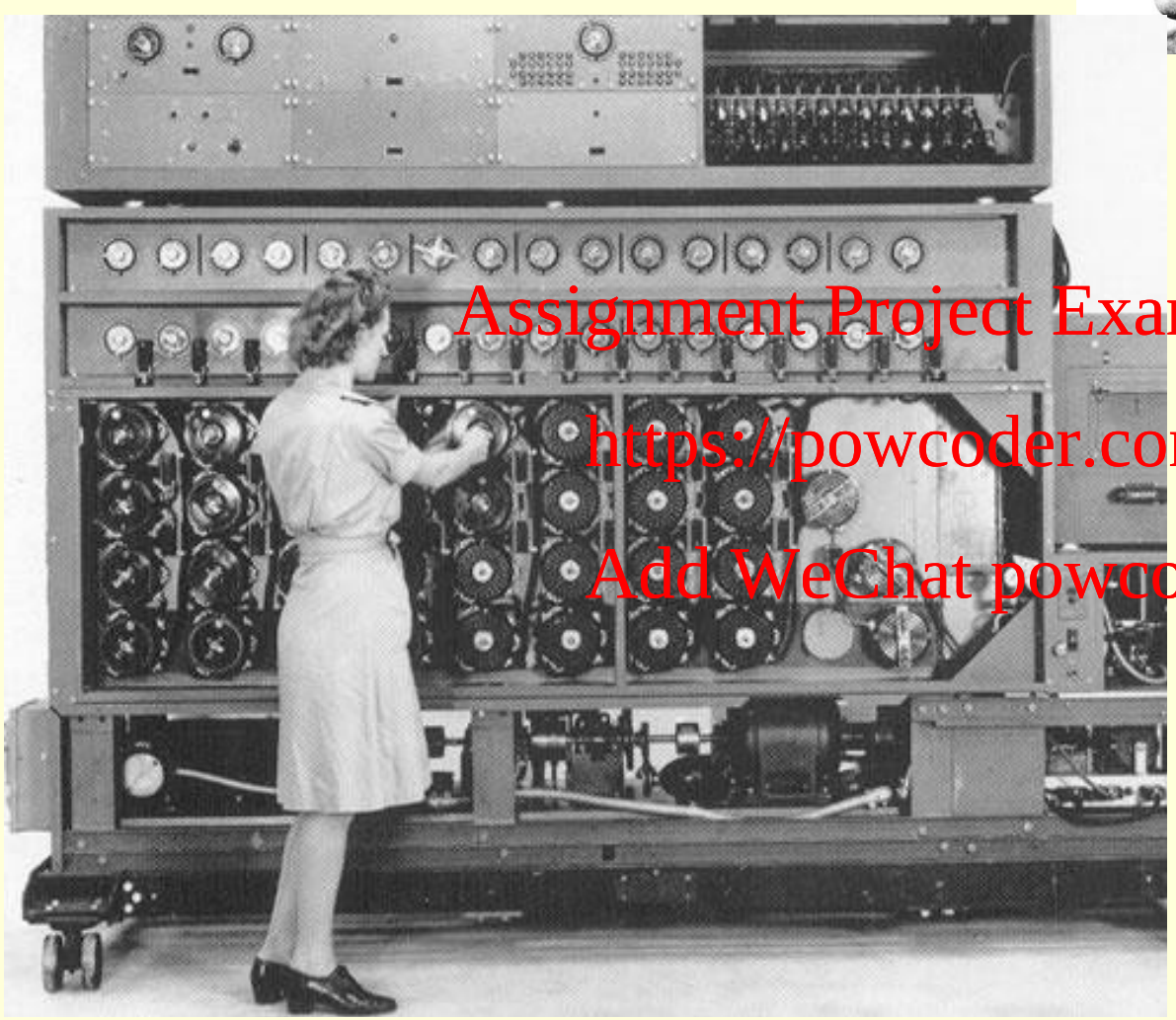
Alan Turing







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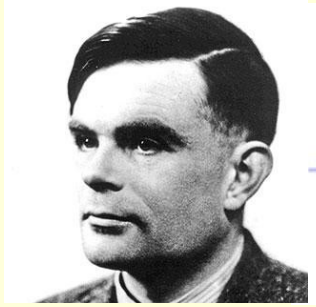
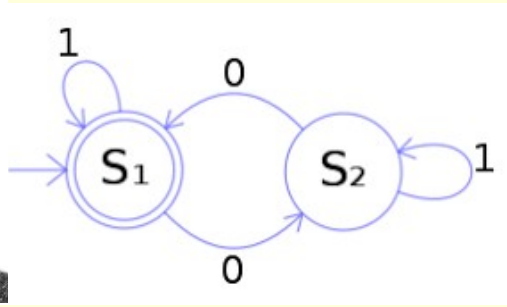
'Bombe': machine designed by Turing to crack Enigma code ~1940

Turing machines





- Formal model of computation, but intuitive and simple to understand
- Powerful enough to do **any** computation (!!)
- Encode both data *and programs* as strings

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- **Church-Turing thesis**: Anything that can be done by an algorithmic process can be done by a Turing machine
  (so "computable" means "can be done via Turing machine")

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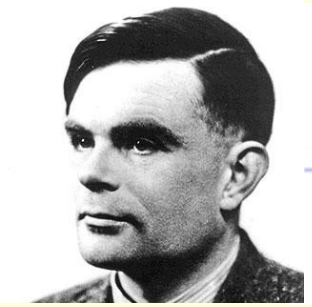
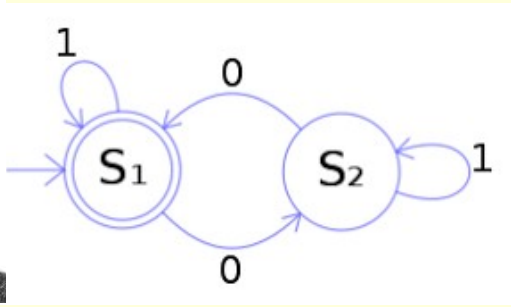
- **There are problems which are undecidable** (or non-computable) (!!!)

- **Universality:** There is a universal Turing machine which can simulate any Turing machine (**programmable** machines)

"One machine to rule them all, one machine to find them; one machine to rule them all, and …

Turing machines





- Turing machines are very **simple** (especially when compared to other formalisms for computation)
- Based on observations of **human calculation** processes
- Intended as a natural generalisation of pen & paper
- Seem to capture the **essence of computation**
- Stripped back to what is absolutely necessary
- **Surprise is that something so simple is so powerful …**

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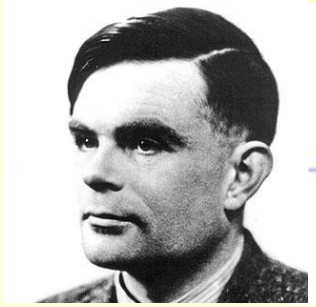
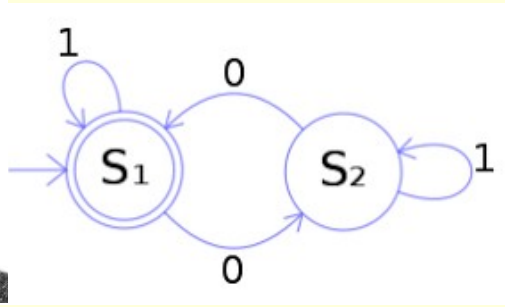
Turing machines





Add a tape to a finite state automaton

- Input is a string
- Output is yes or no*
- String is processed **as dictated by the machine**
- Memory is the current machine state + **tape (infinitely long)**
- Output is based on the last state reached*

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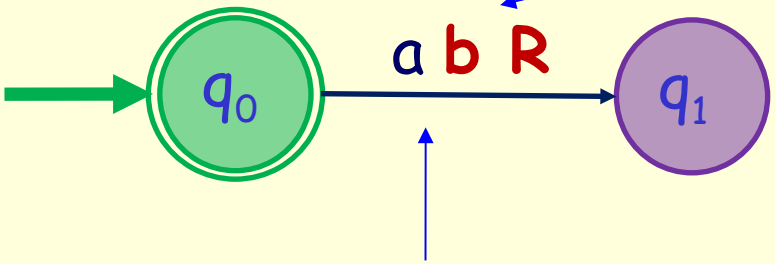
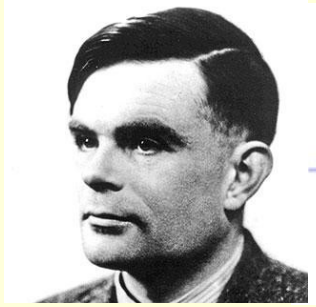
Input character → **2 tape operations (write, move)**

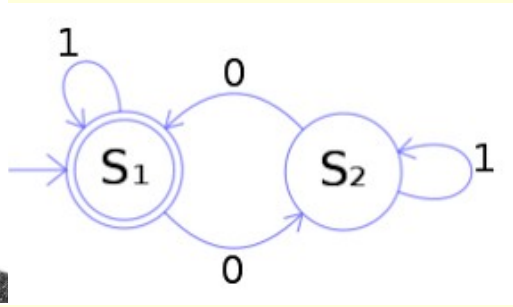


Arrow indicates state change

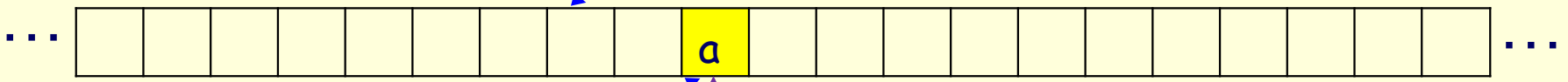
*There is another sense as well which we will cover later

Turing machines





Tape



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Tape pointer

Current 'cell'

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q_0

Current state

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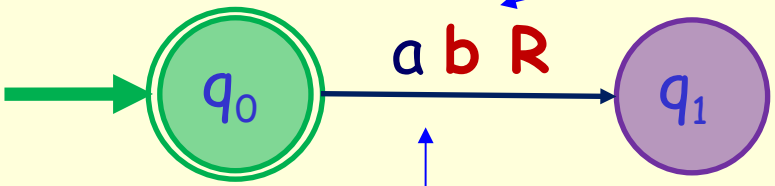
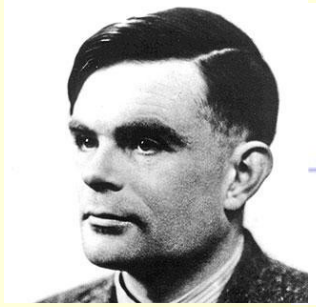
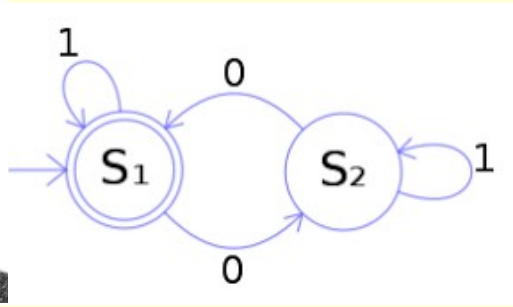
Input character – 2 tape operations (write, move)

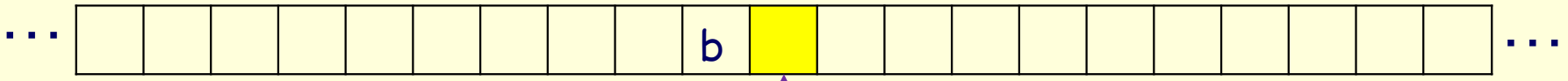


Arrow indicates state change

Turing machines







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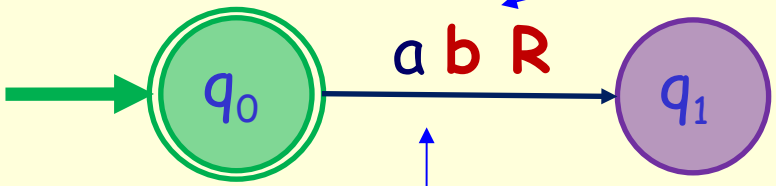

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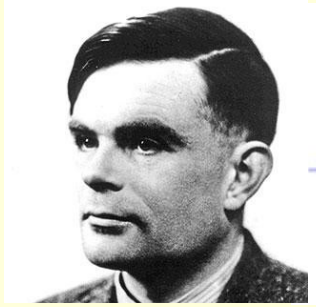
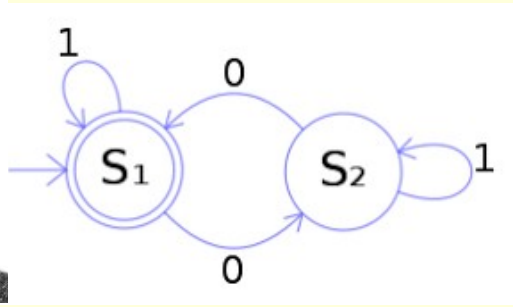
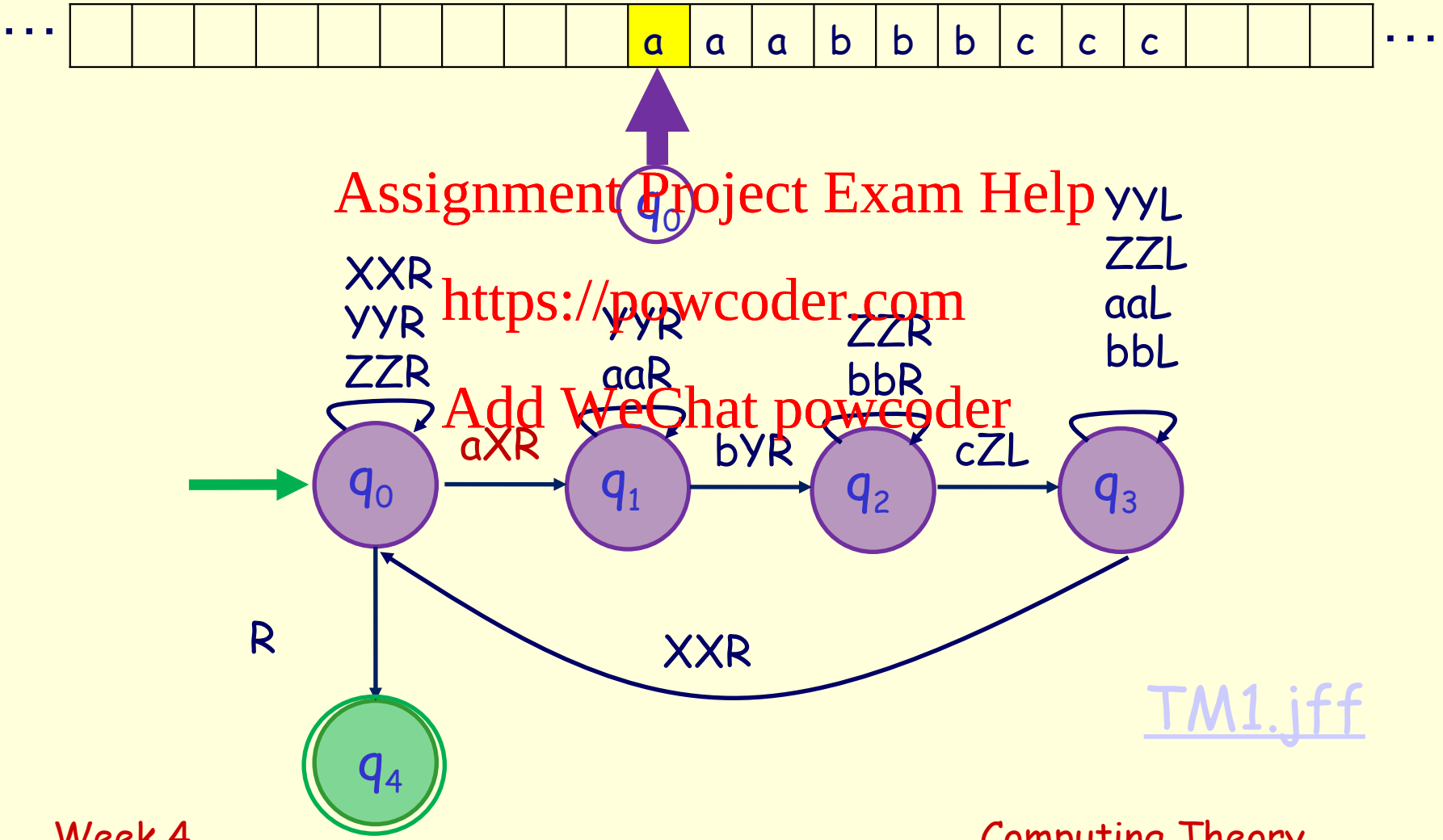
Turing machines







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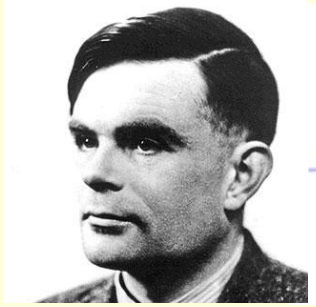
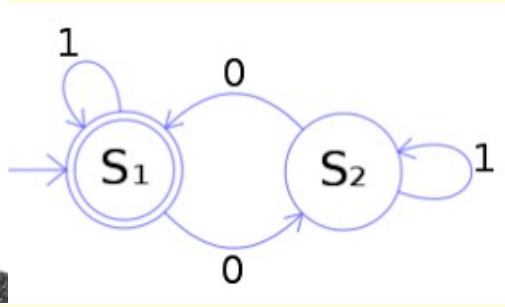
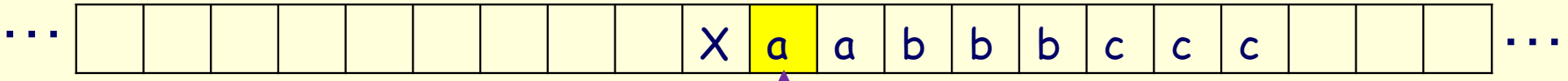
Turing machines







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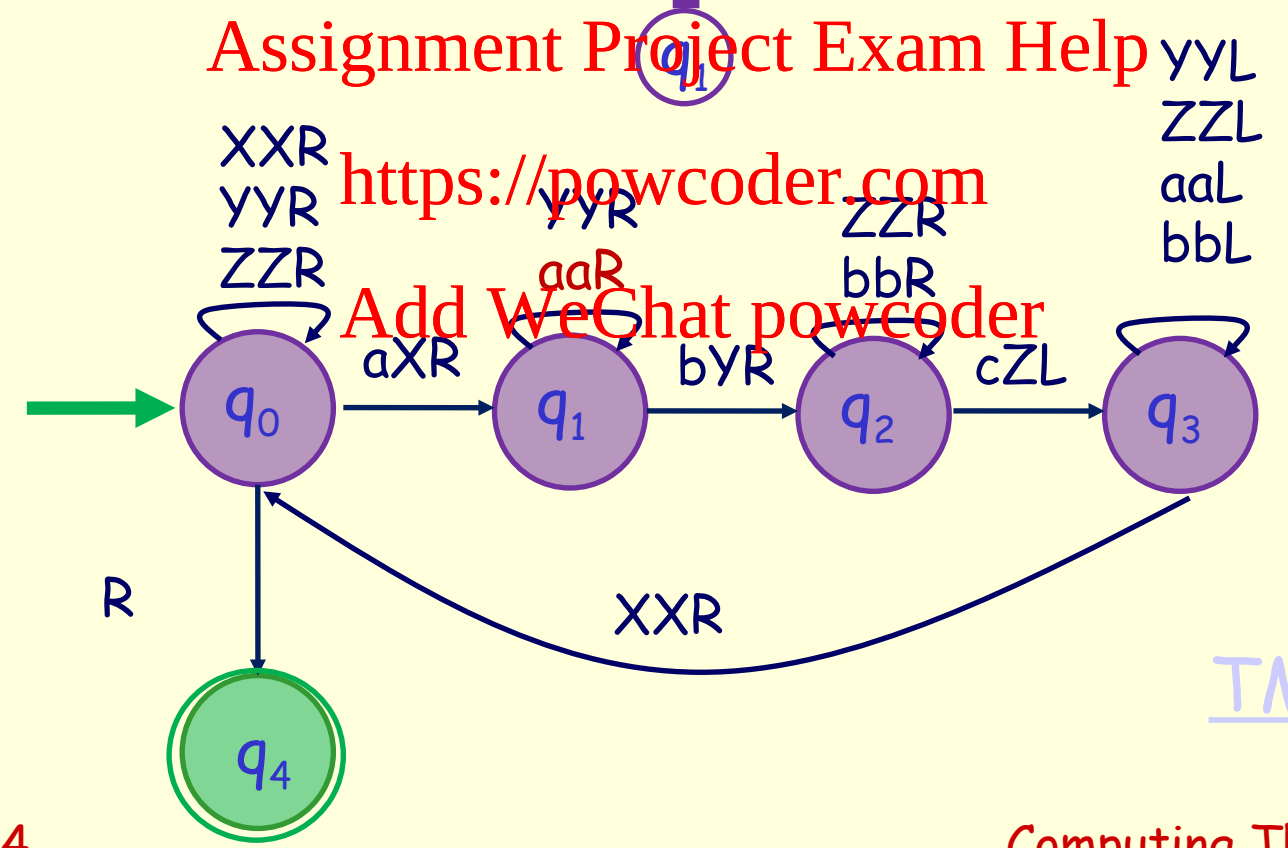

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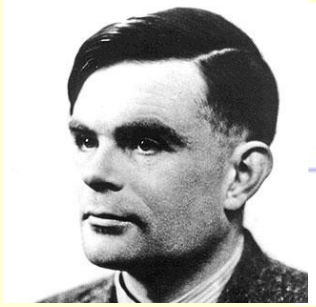
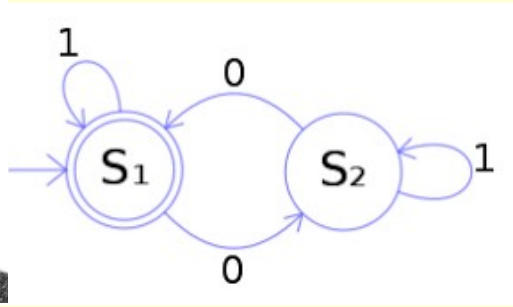
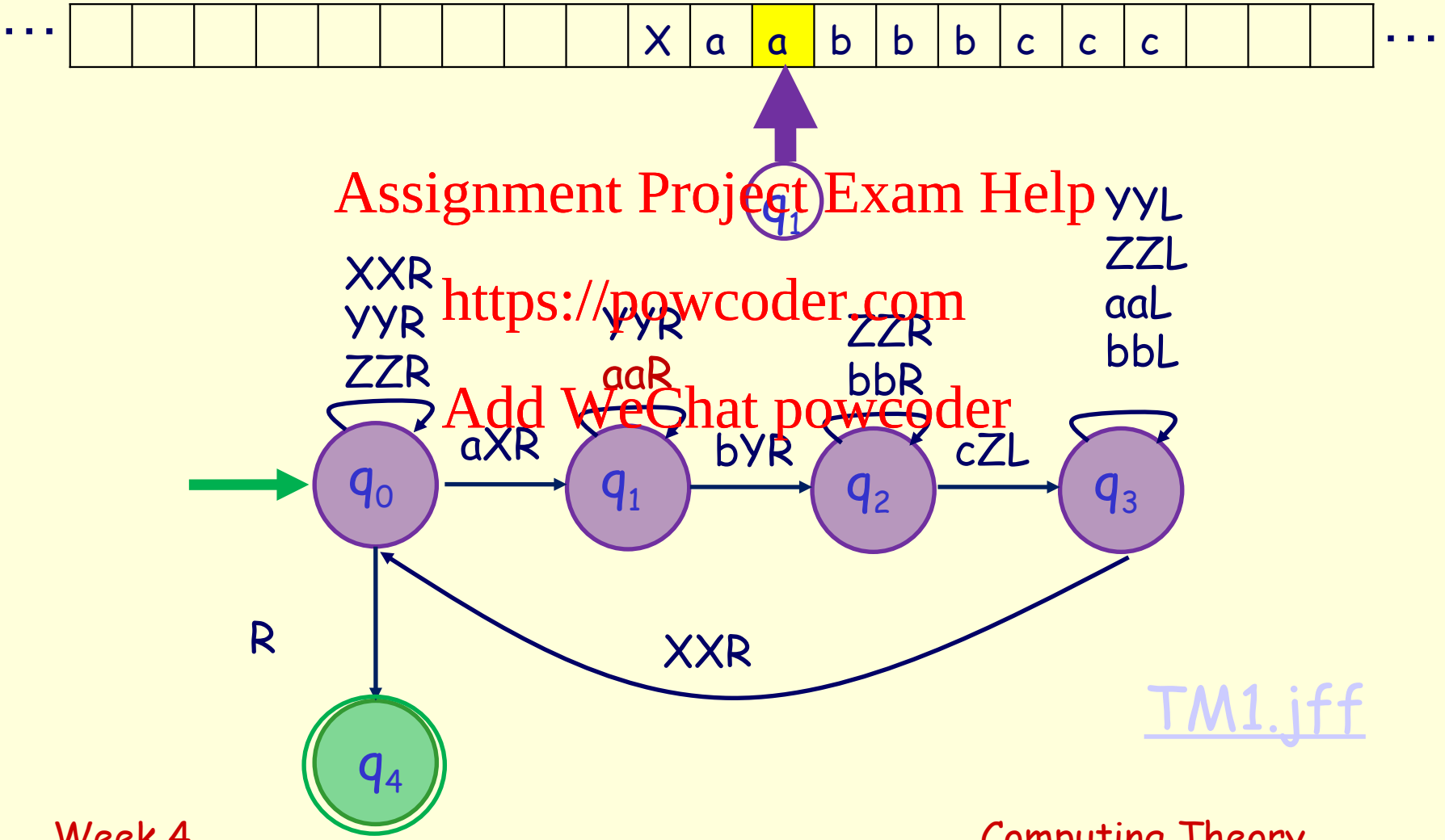
Turing machines







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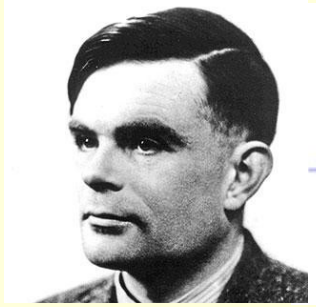

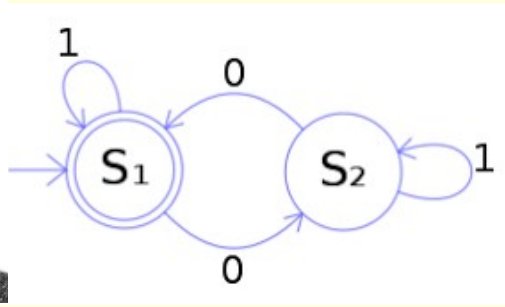

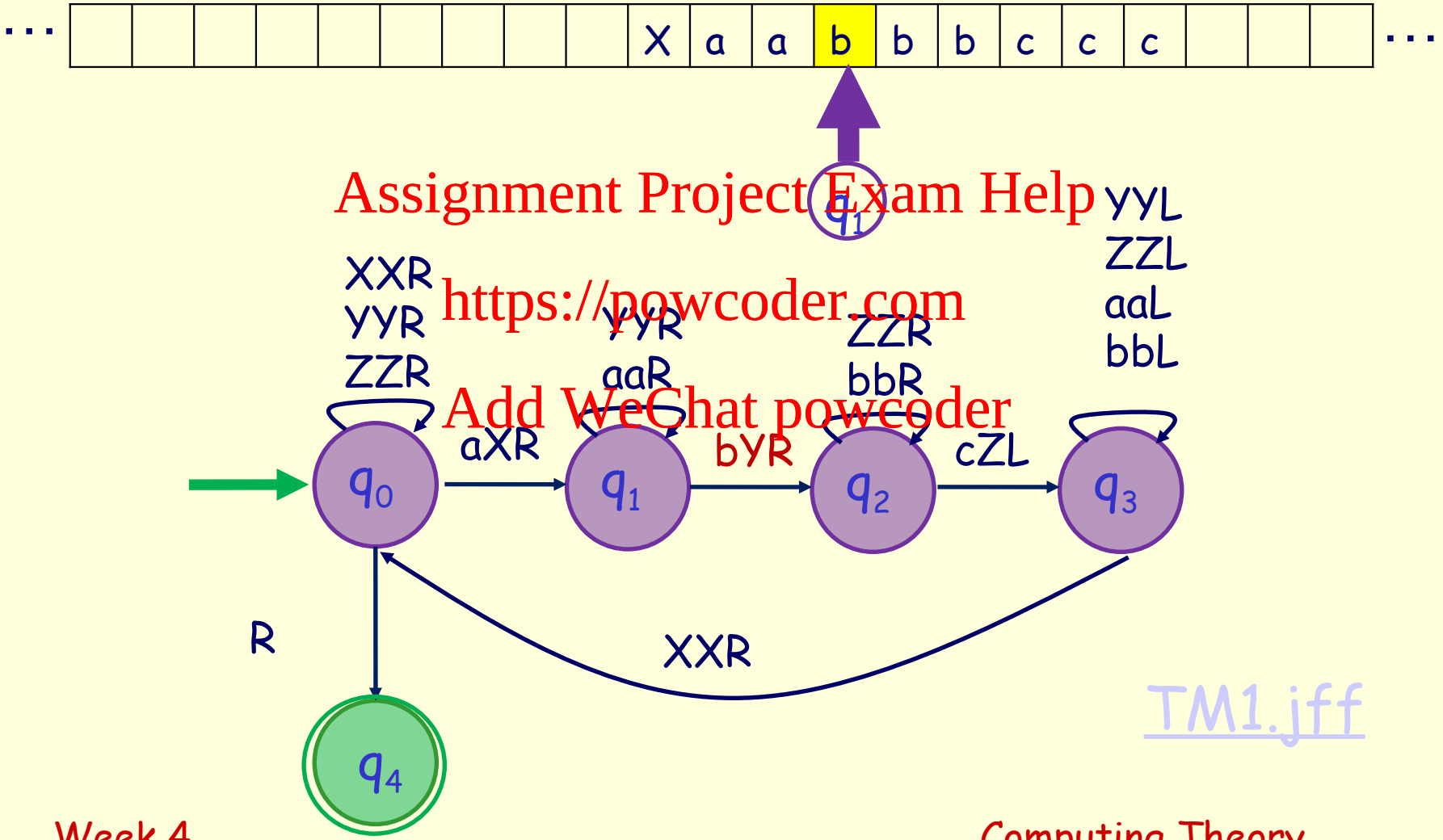

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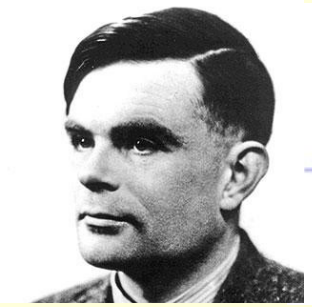
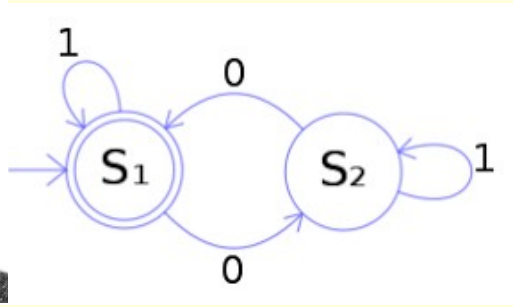
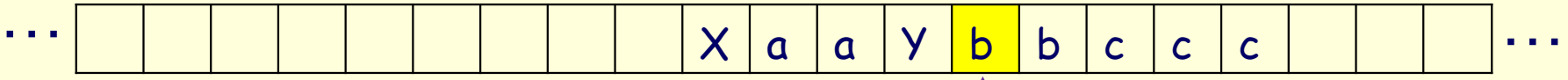
Turing machines







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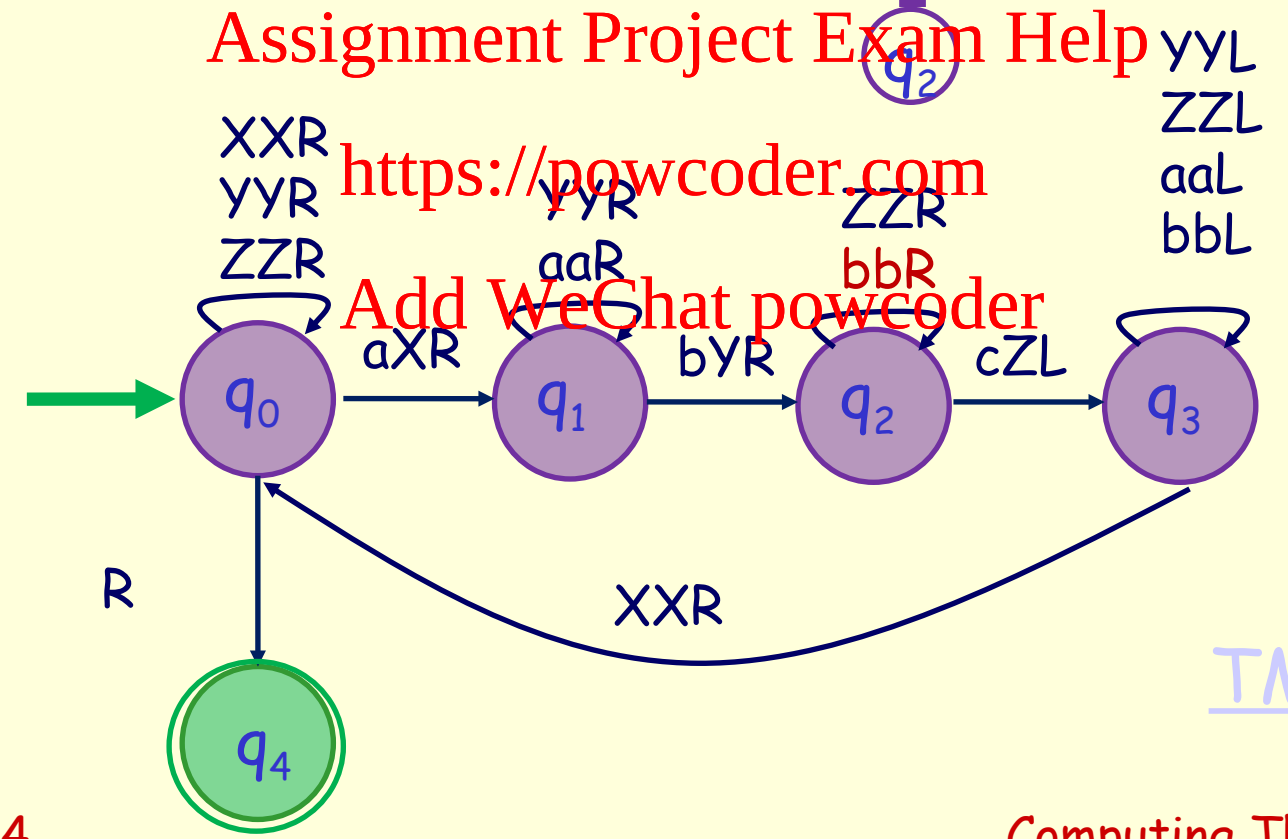

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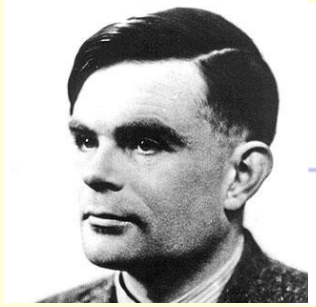
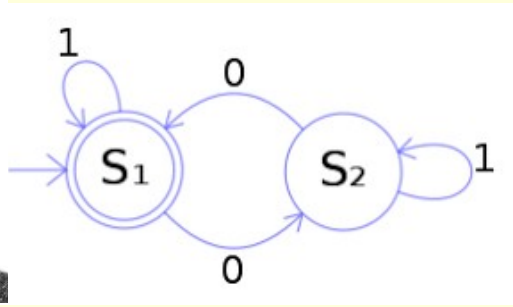
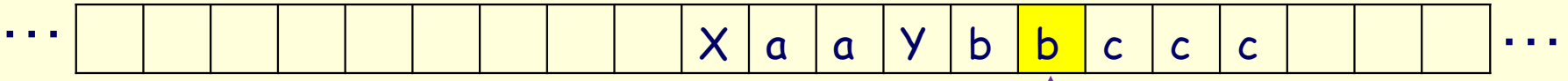
Turing machines







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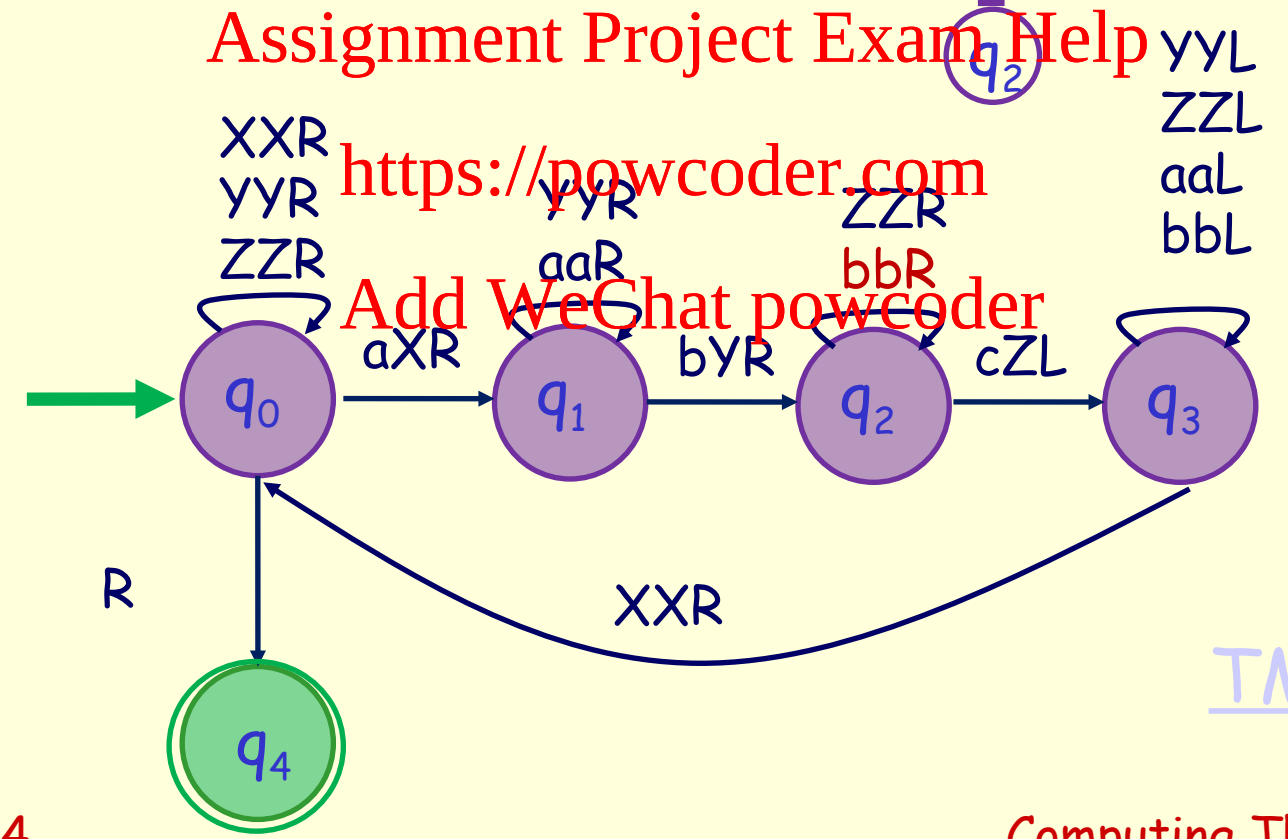

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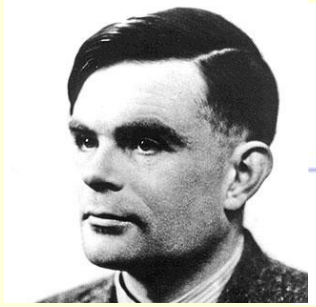

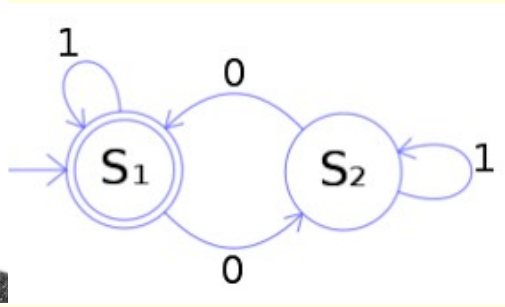

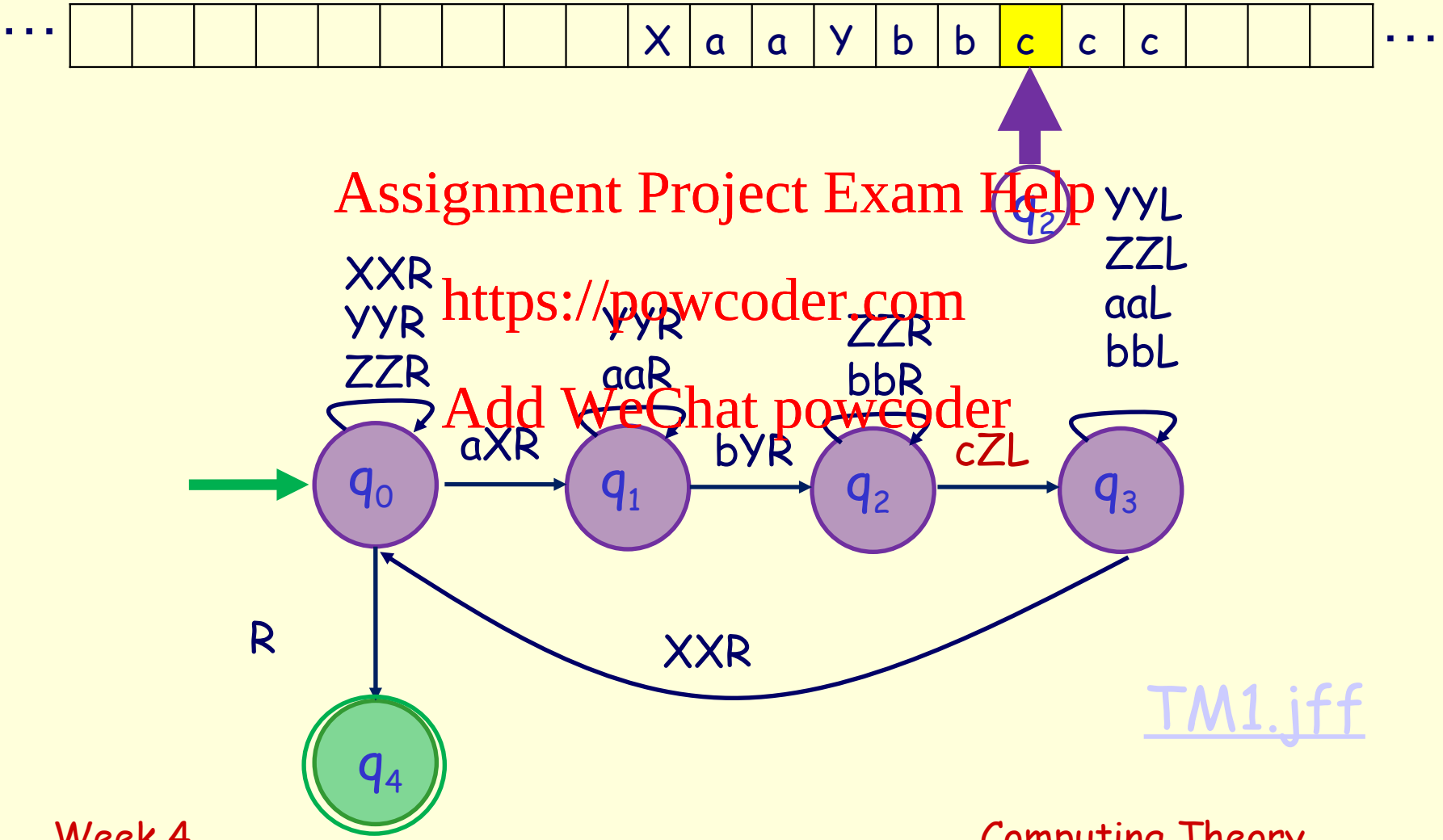

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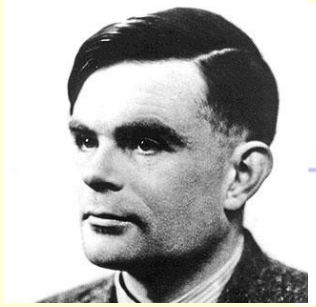

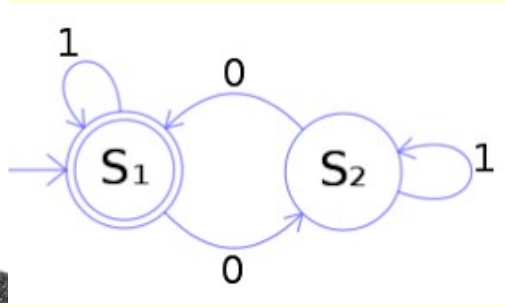

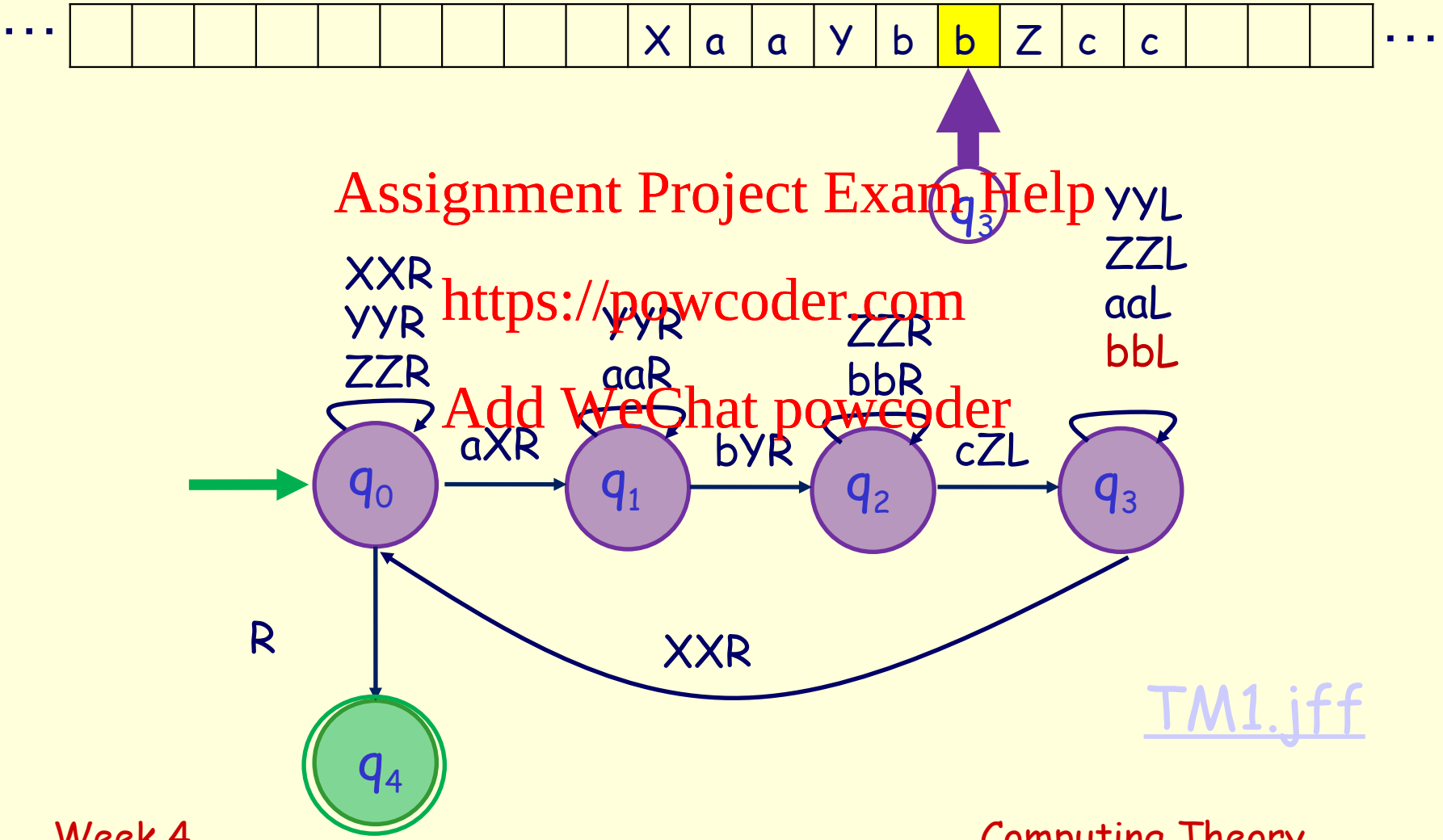

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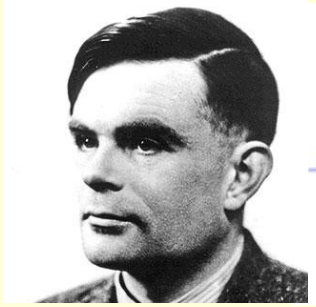

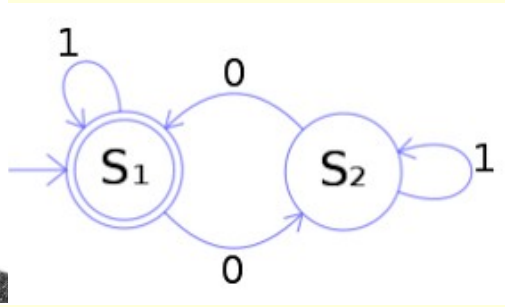

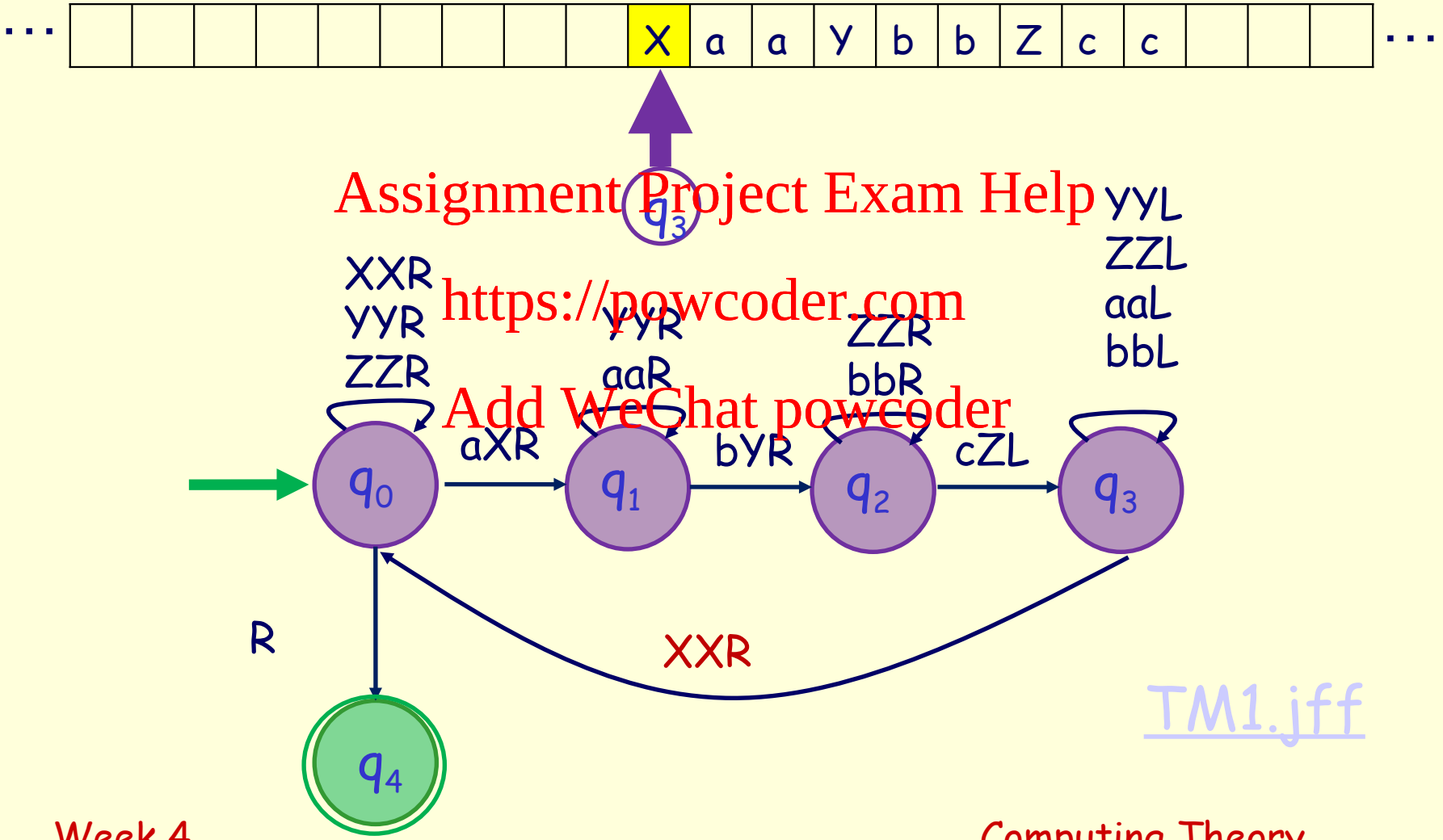

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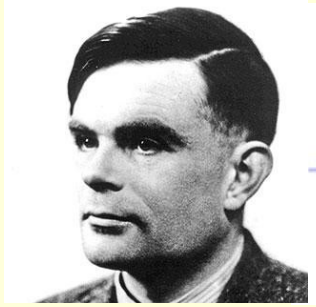

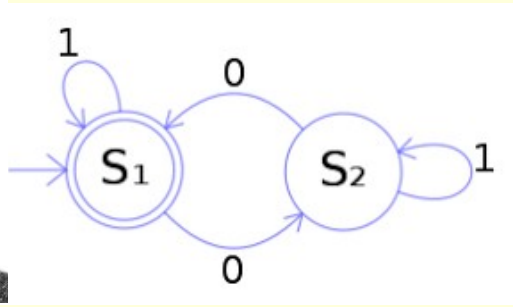

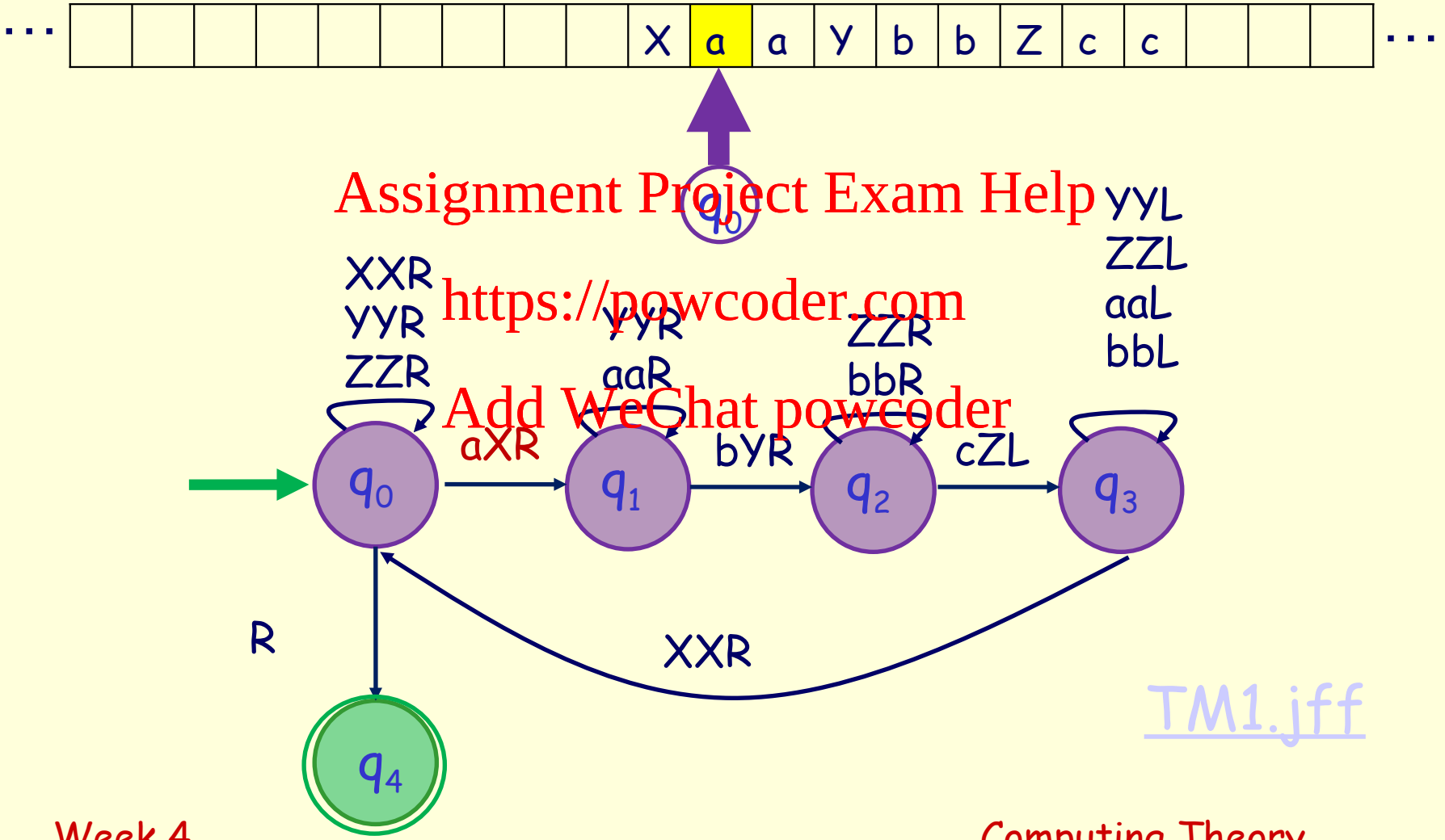

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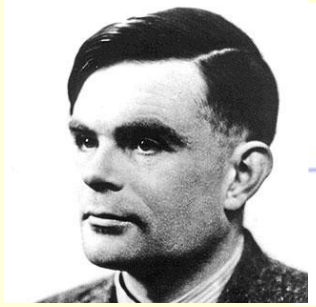

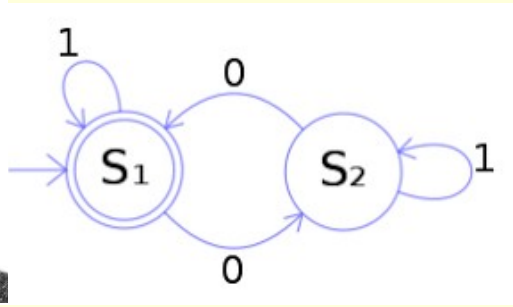

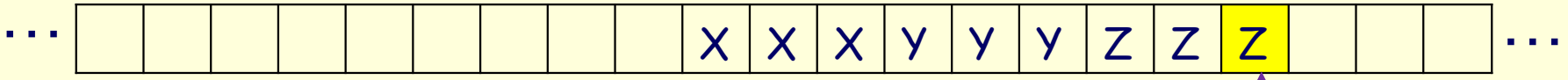

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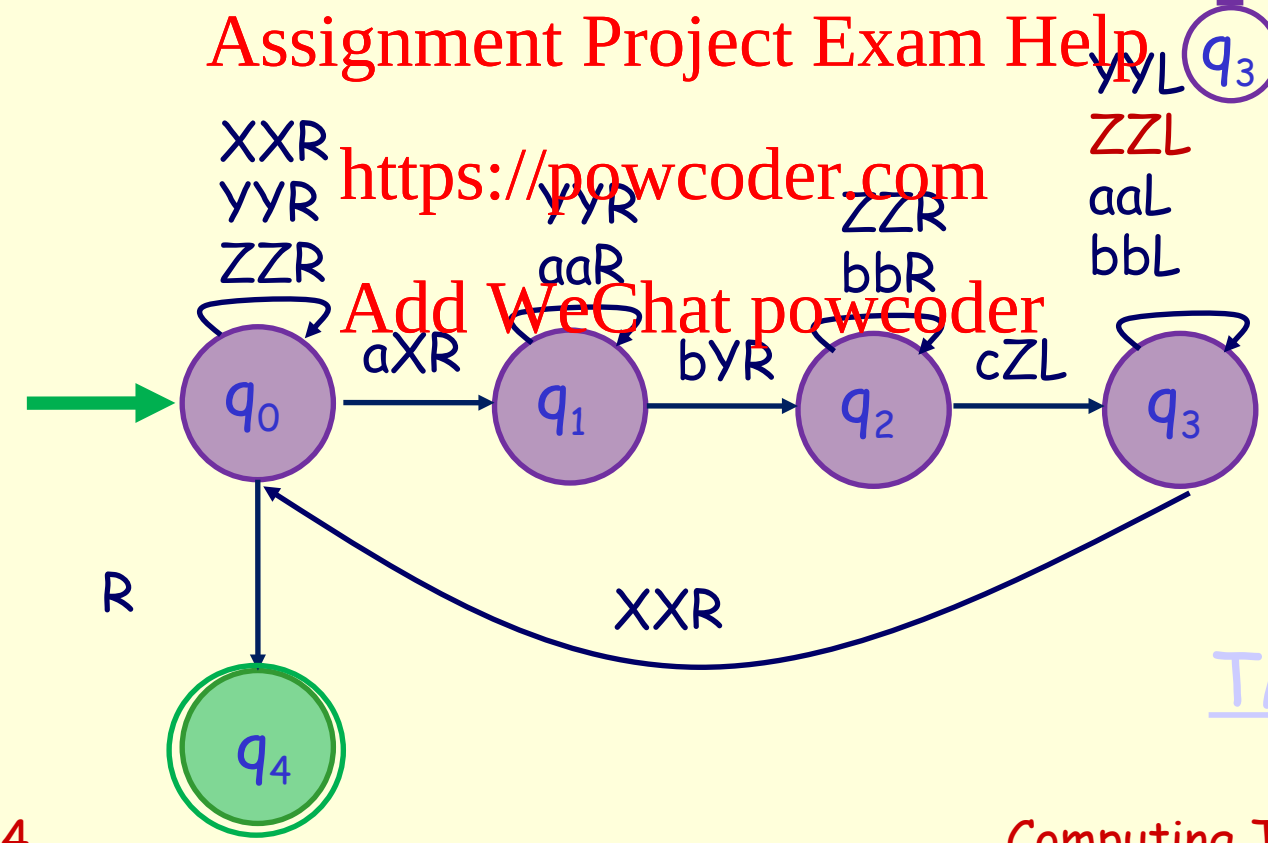

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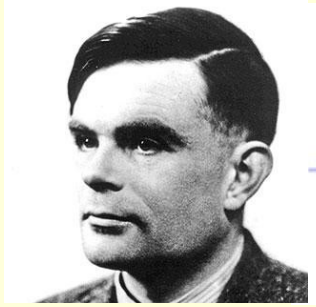

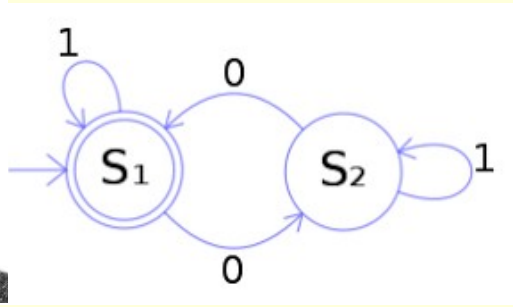

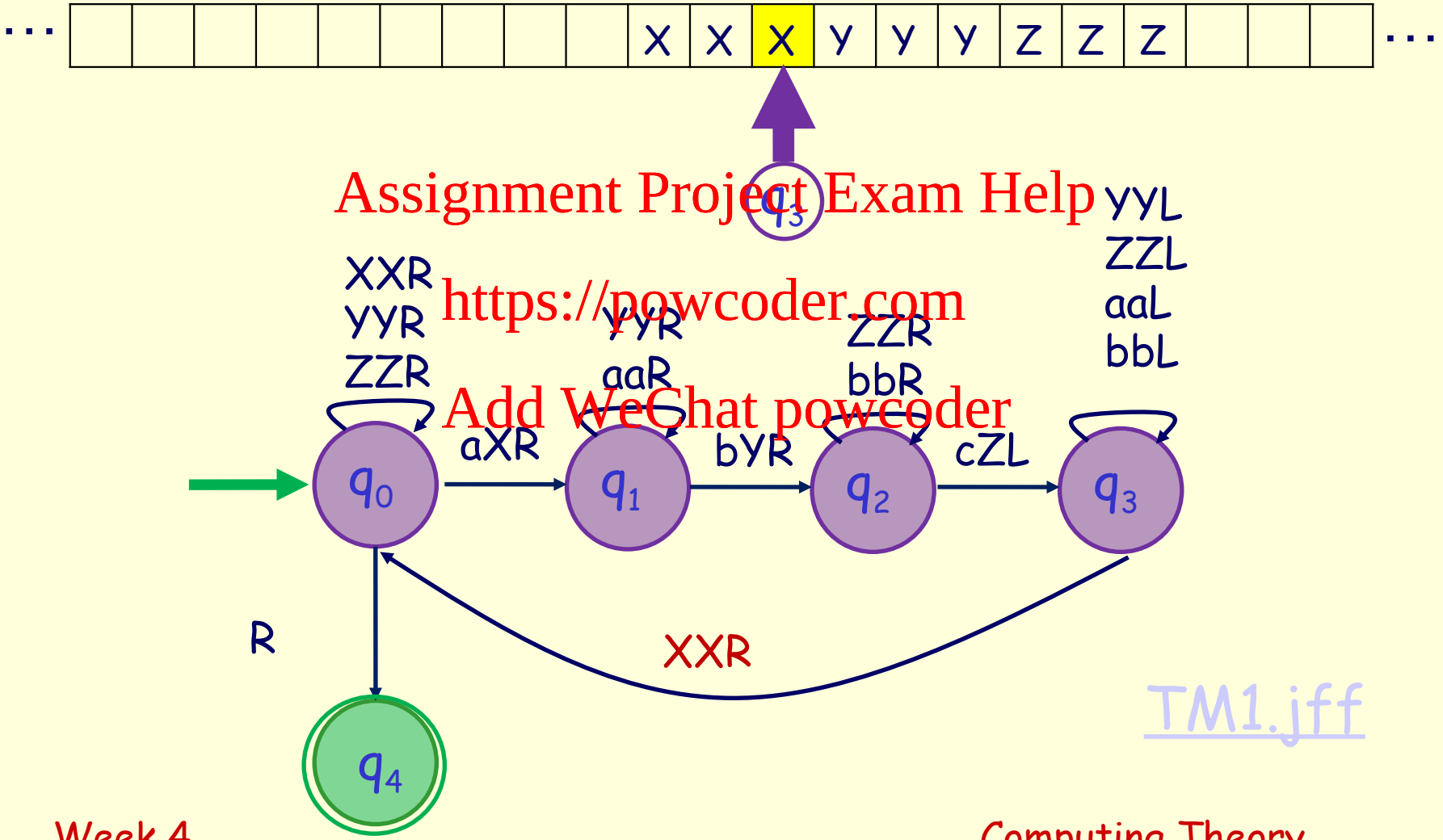

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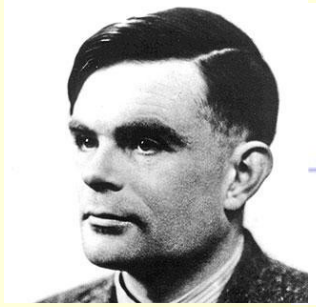

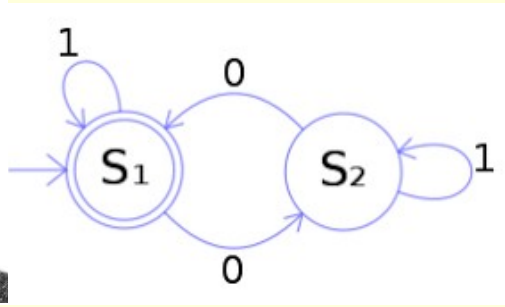

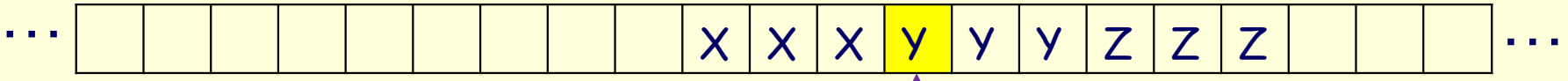

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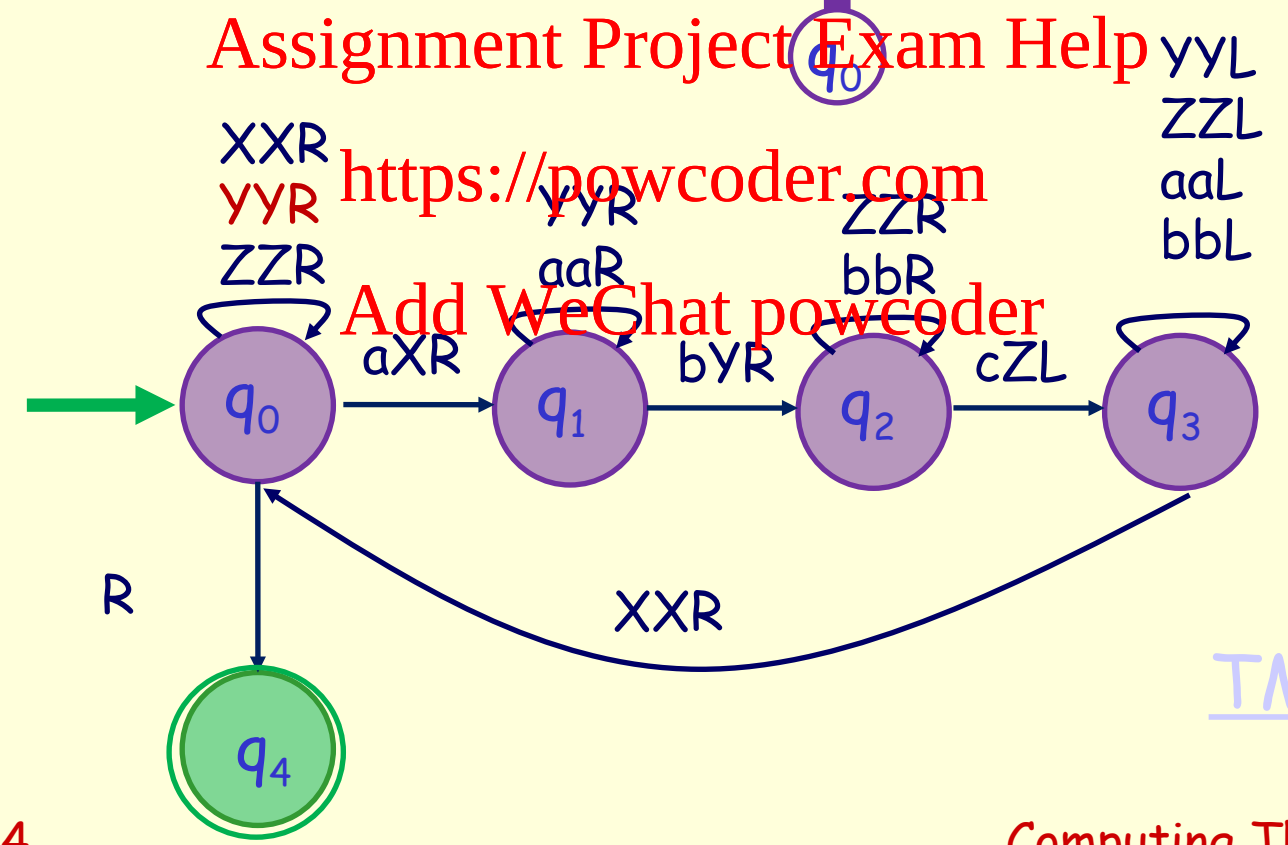

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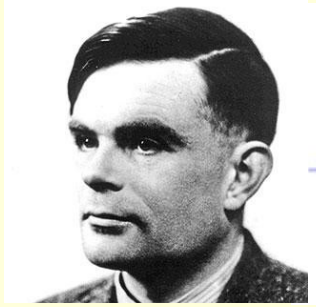

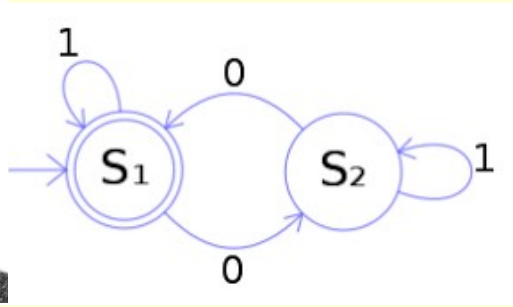

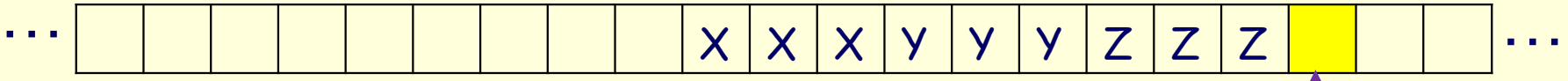

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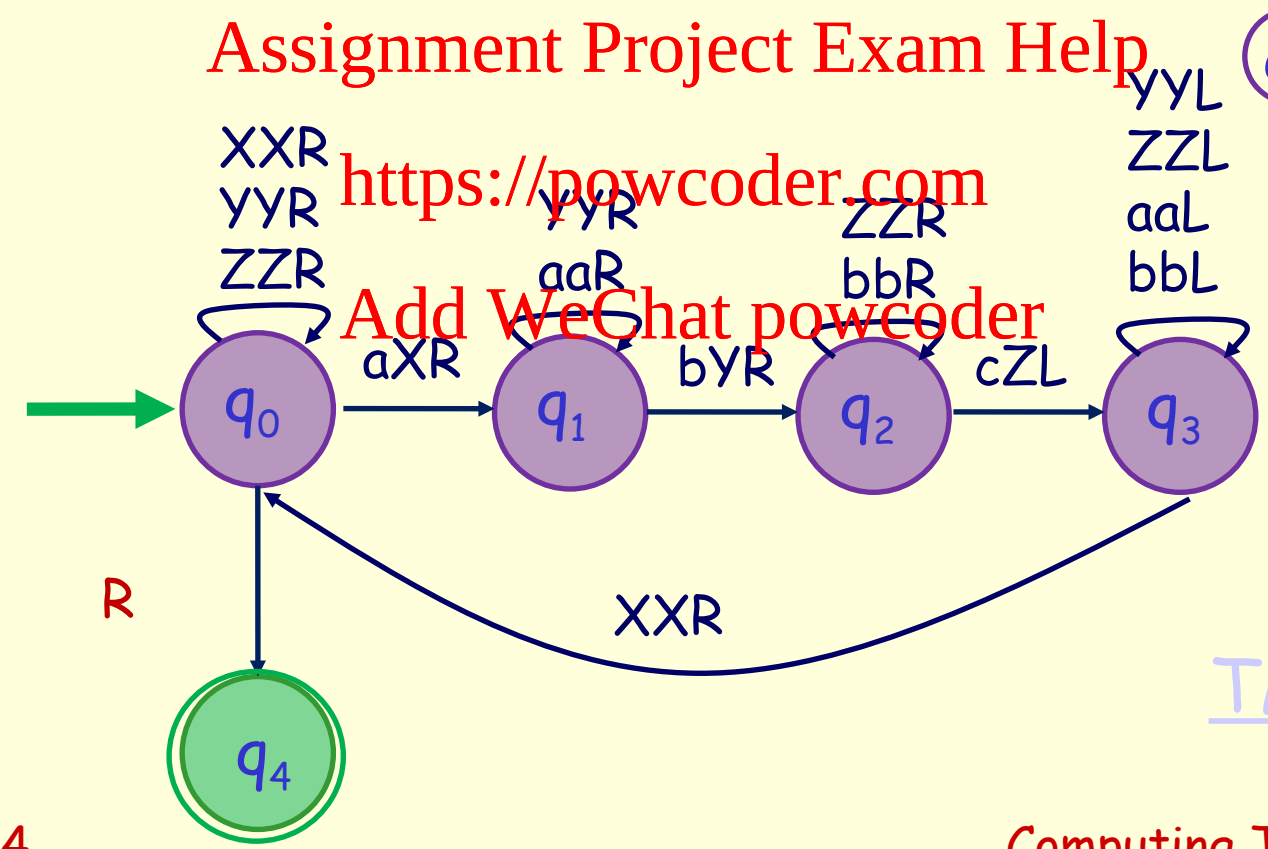

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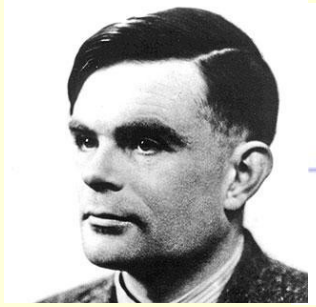

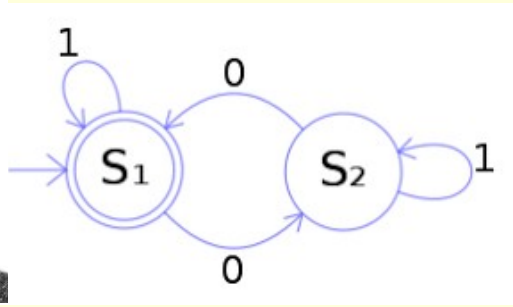

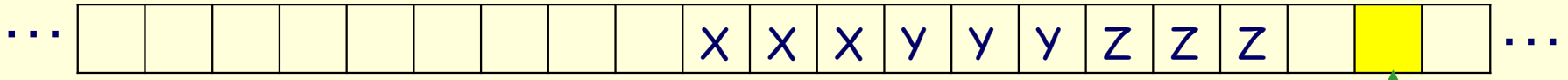

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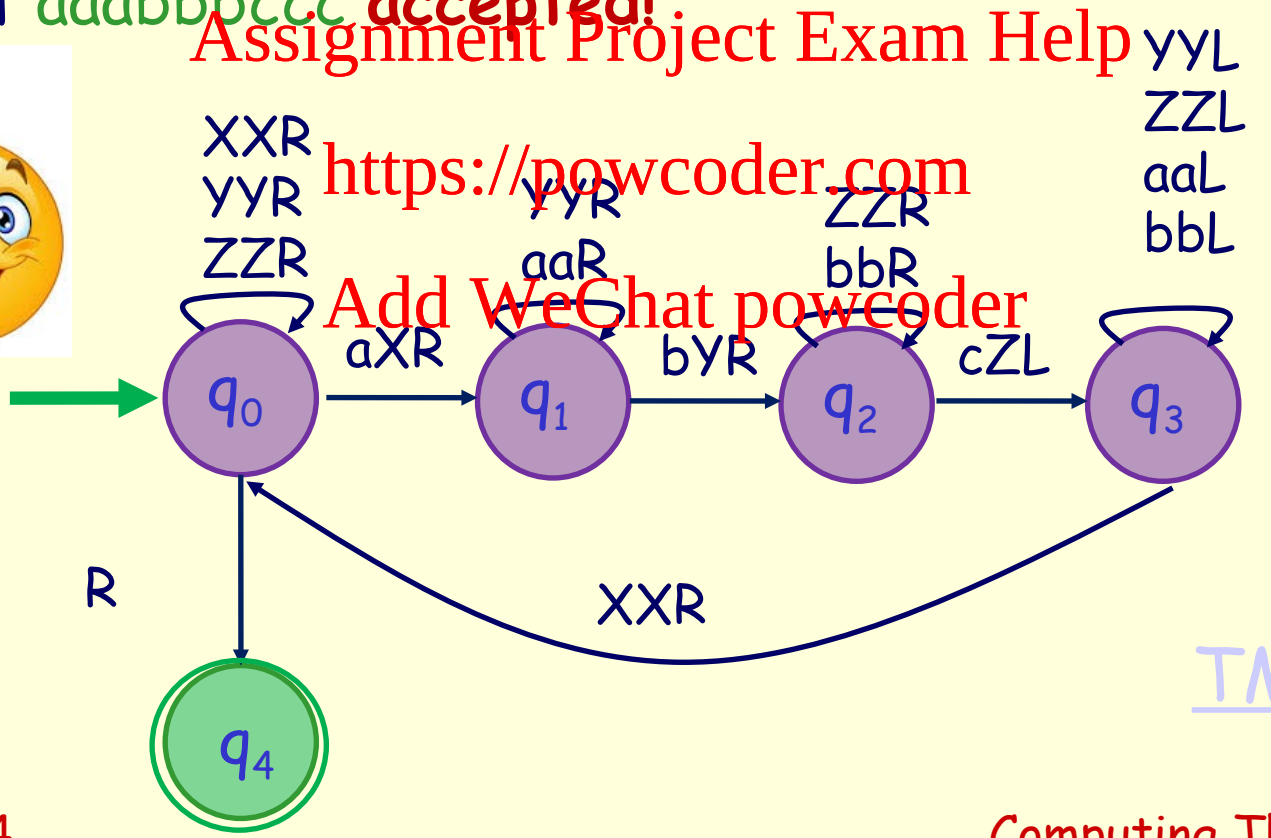

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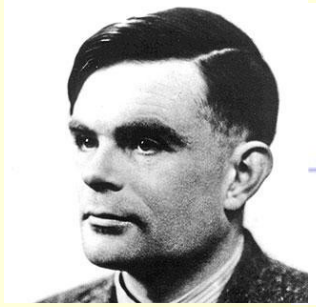

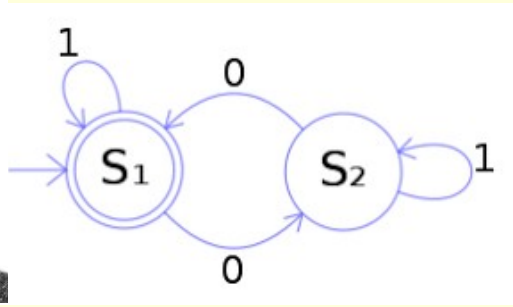

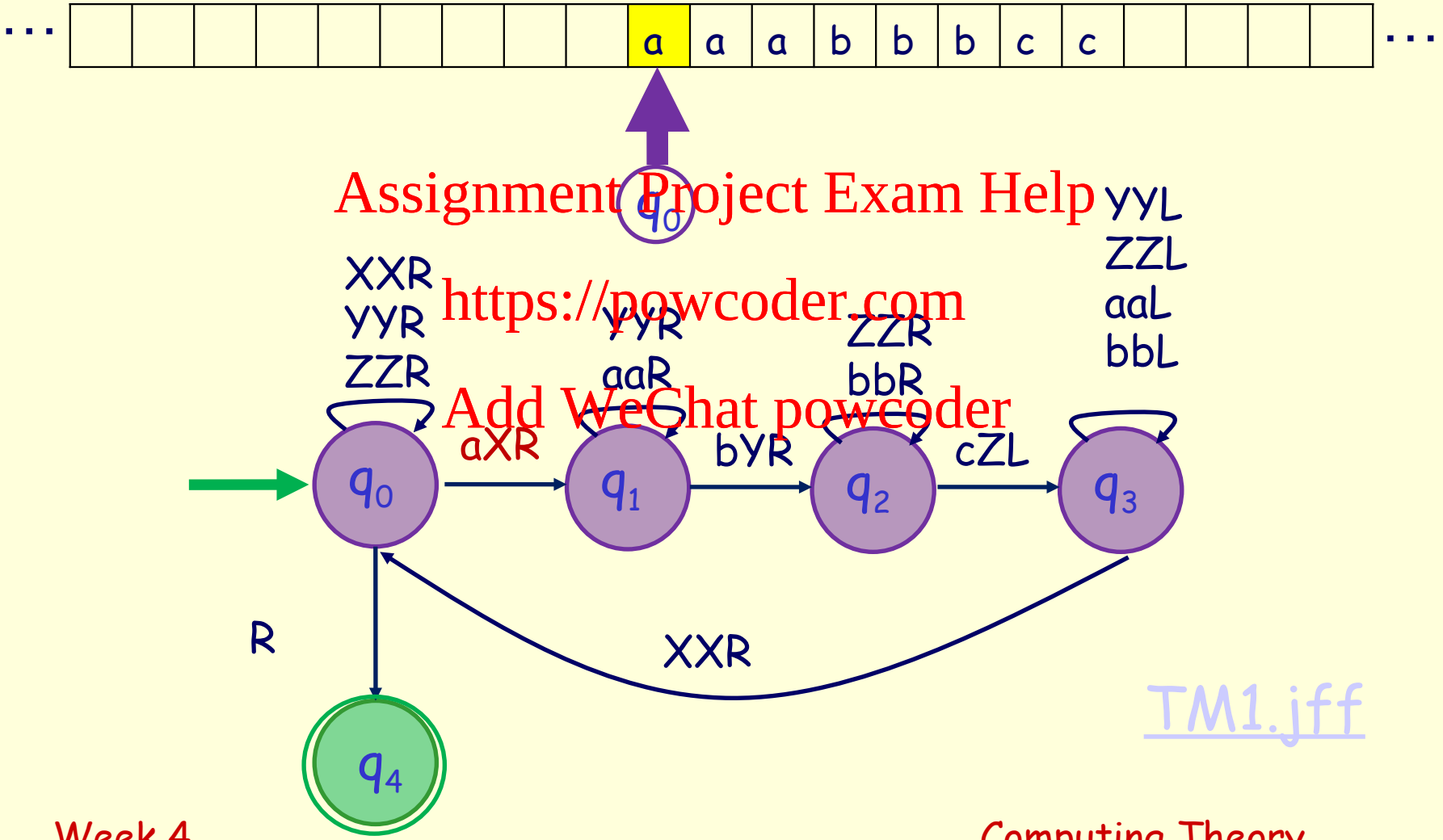

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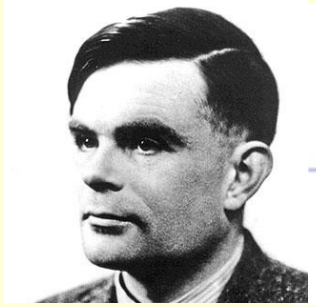

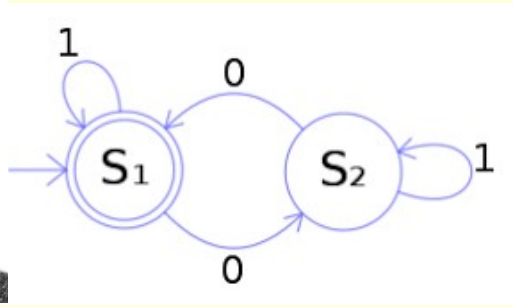

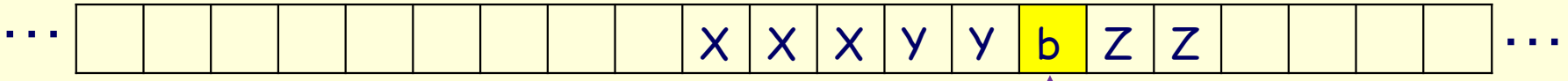

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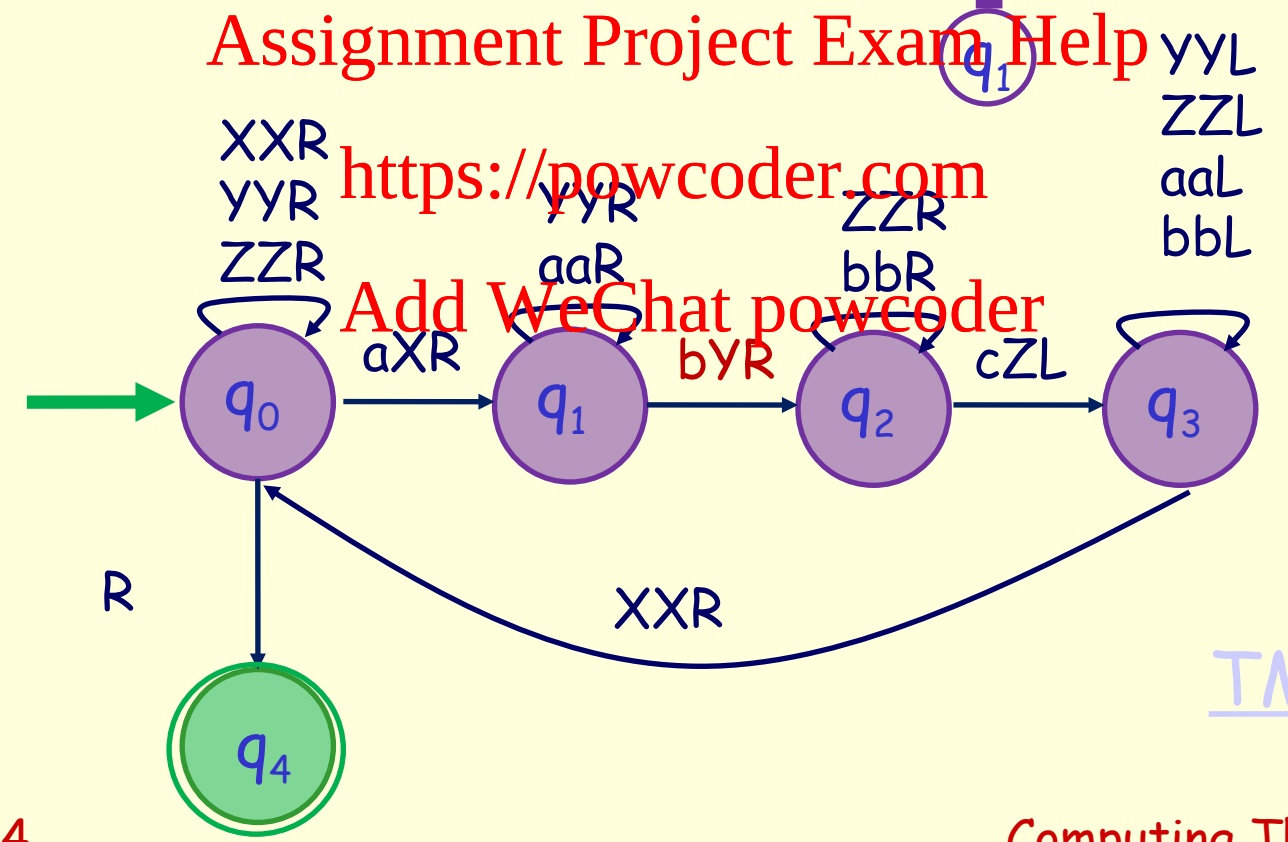

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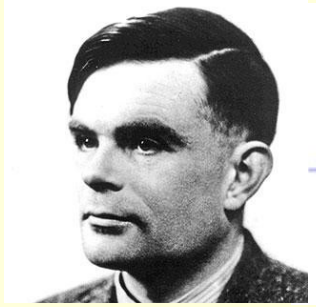

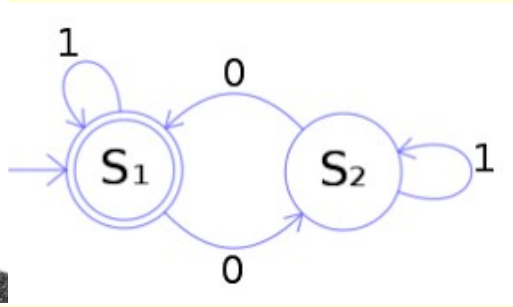

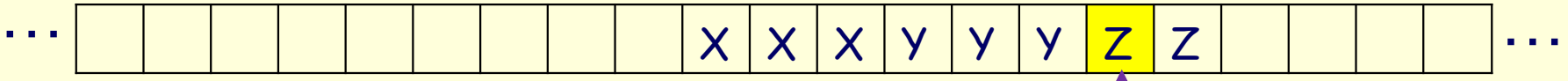

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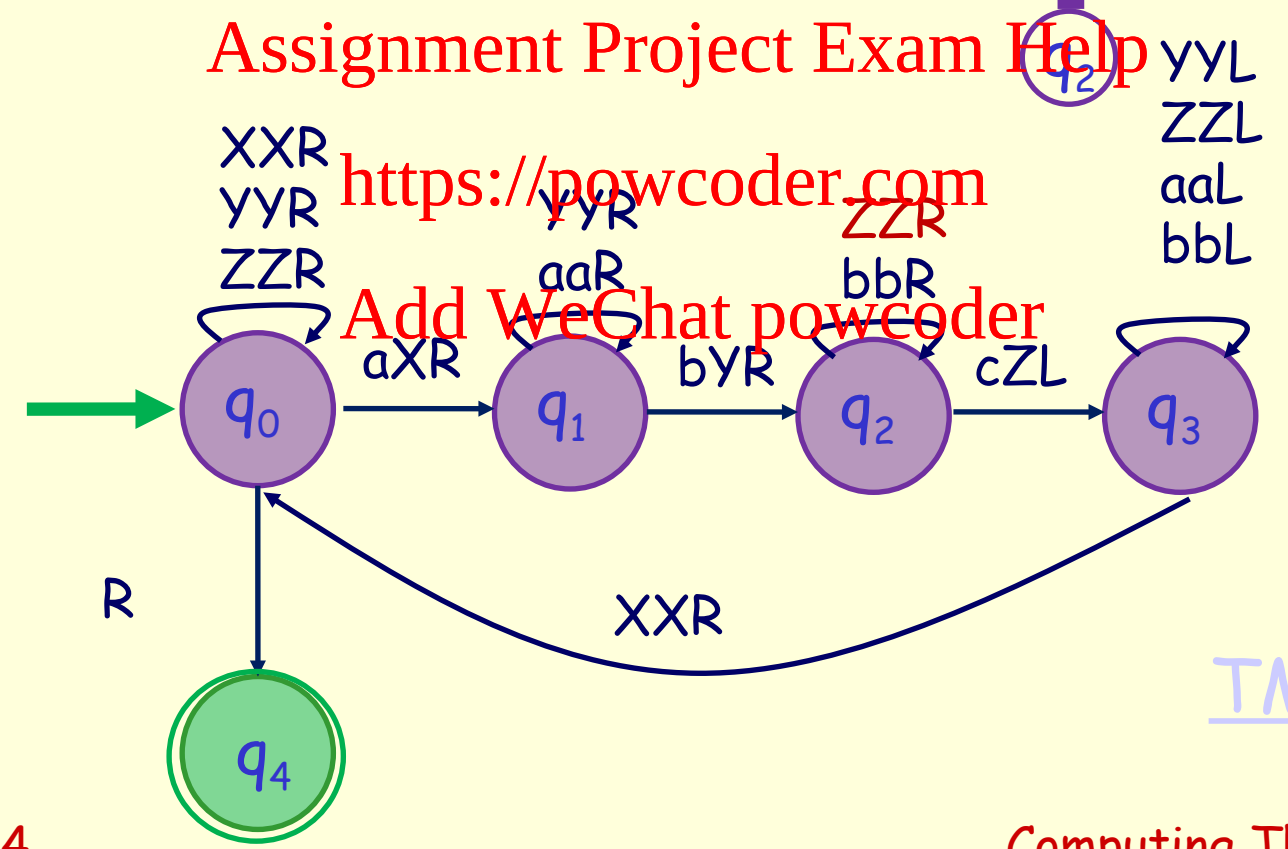

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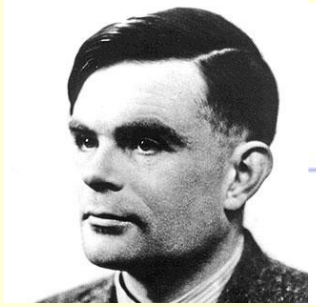

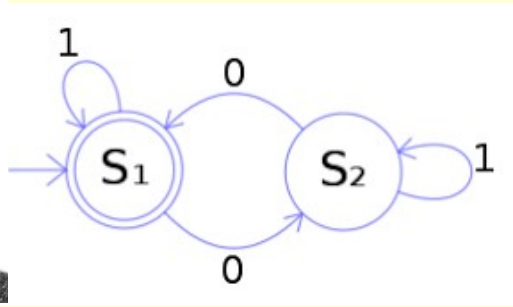

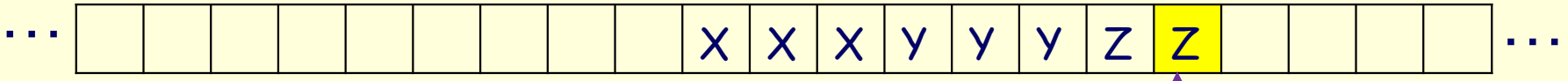

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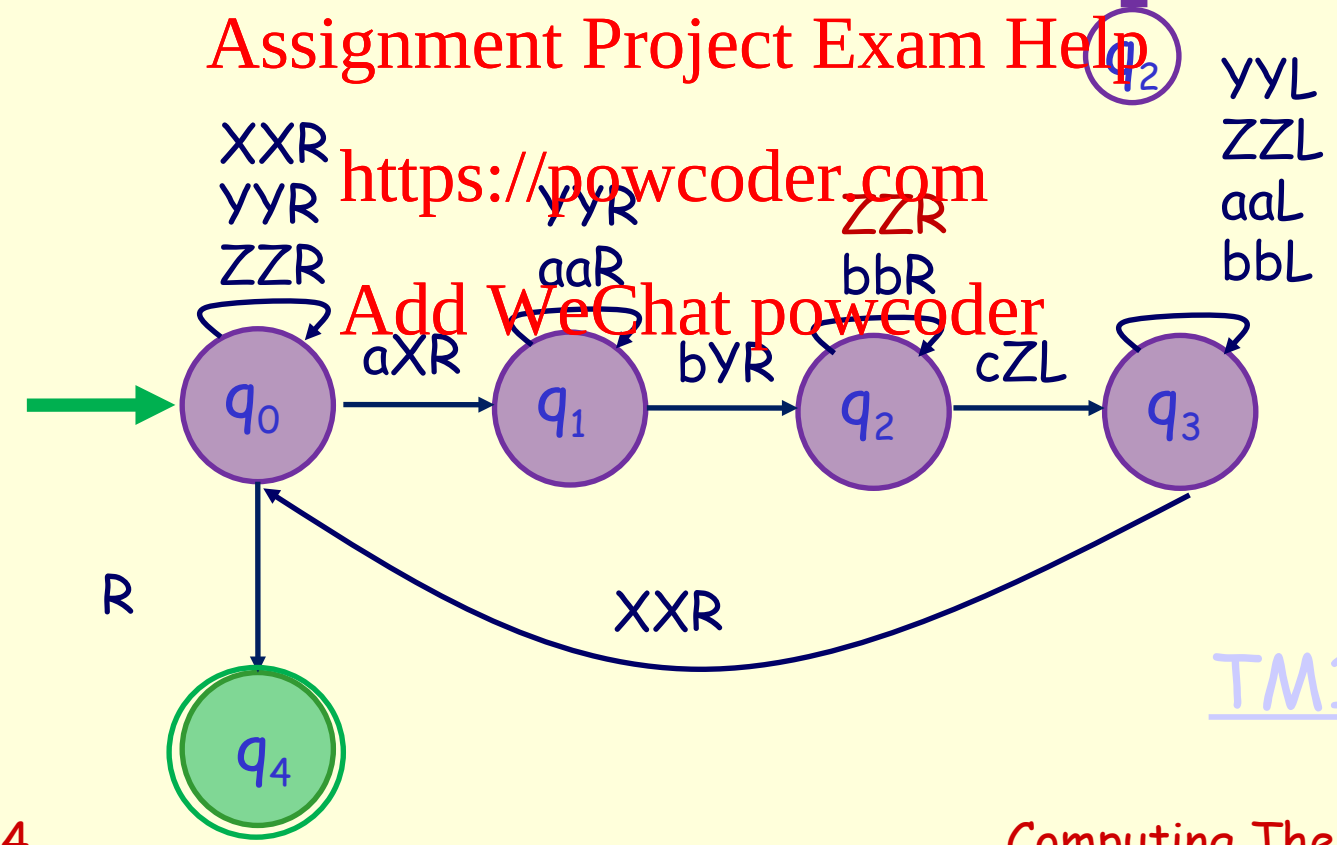

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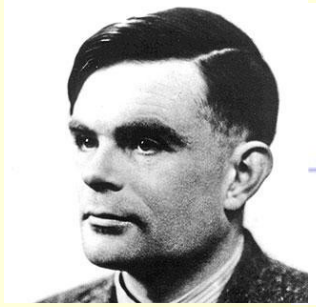

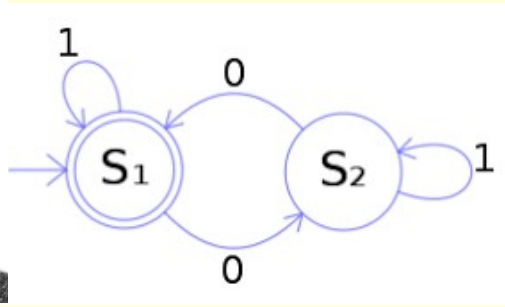

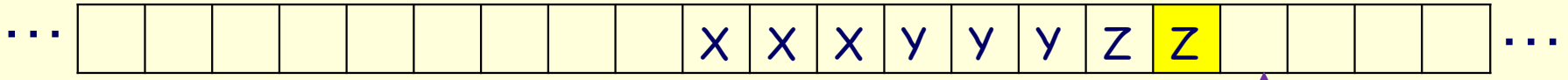

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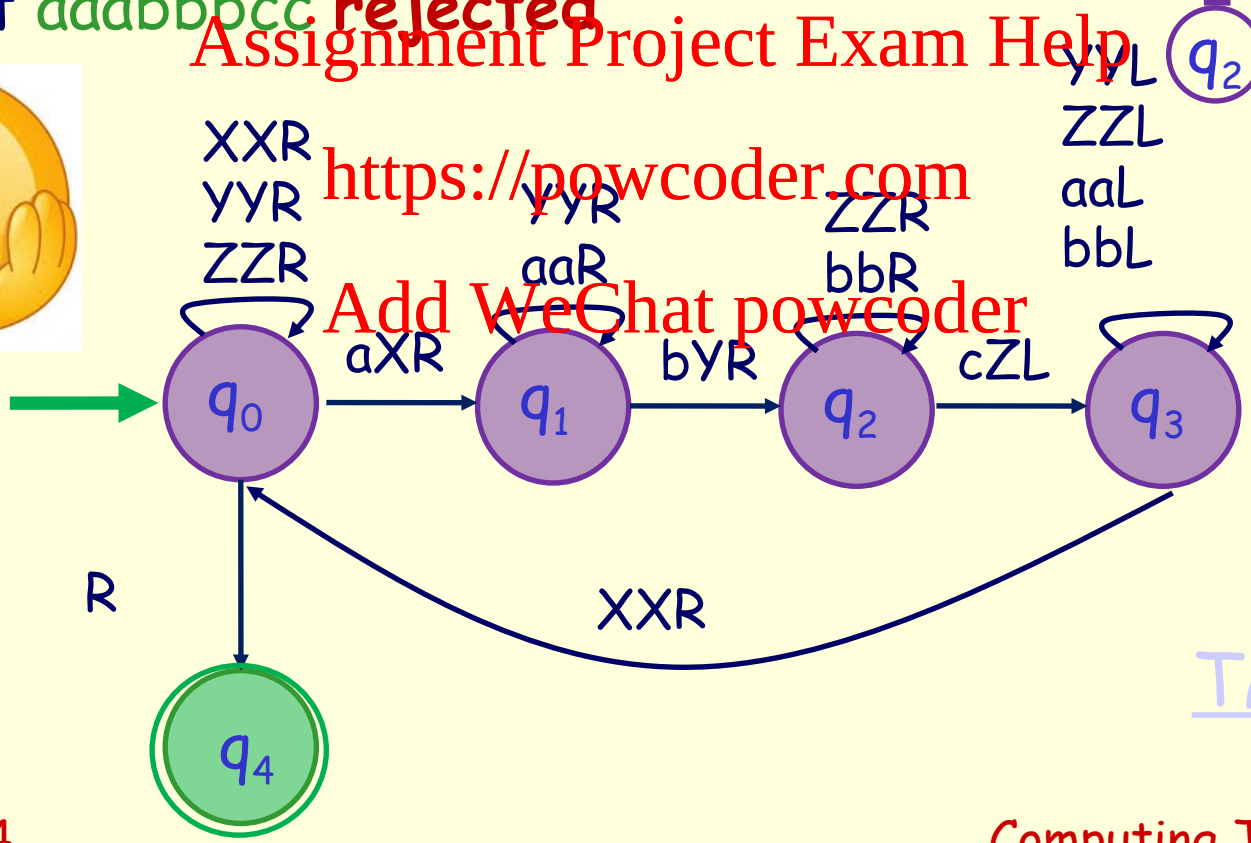

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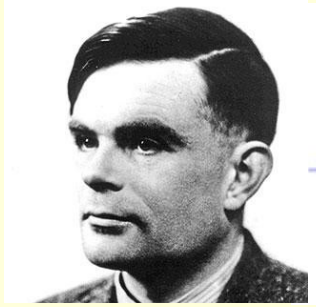

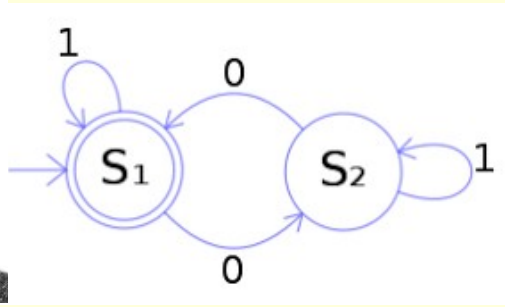

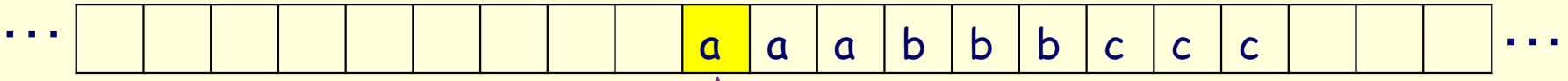

$L(M) = \{ a^n b^n c^n \mid n \geq 0 \}$

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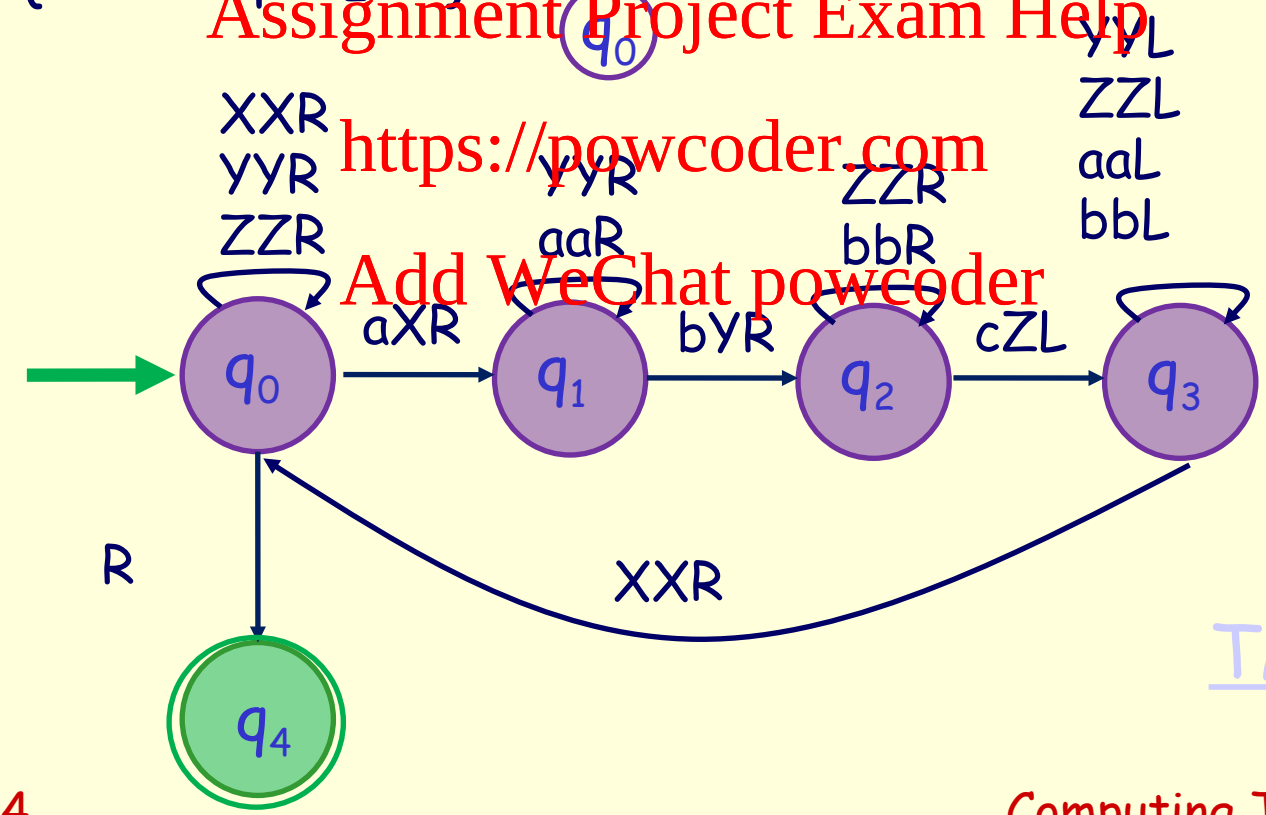
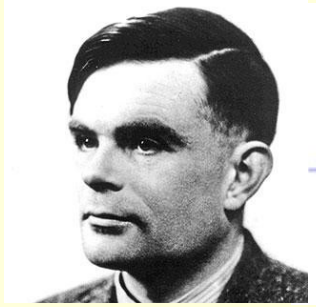
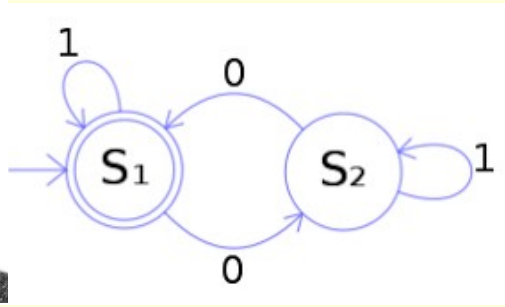
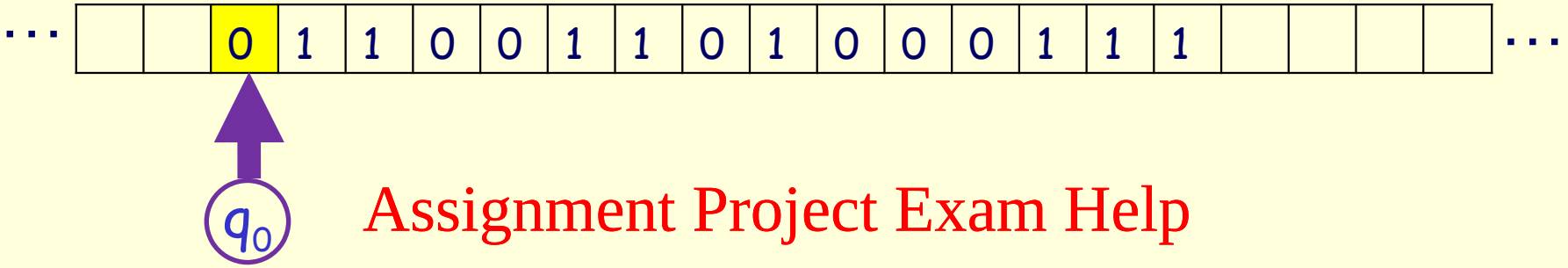


TM1.jff

Turing machines







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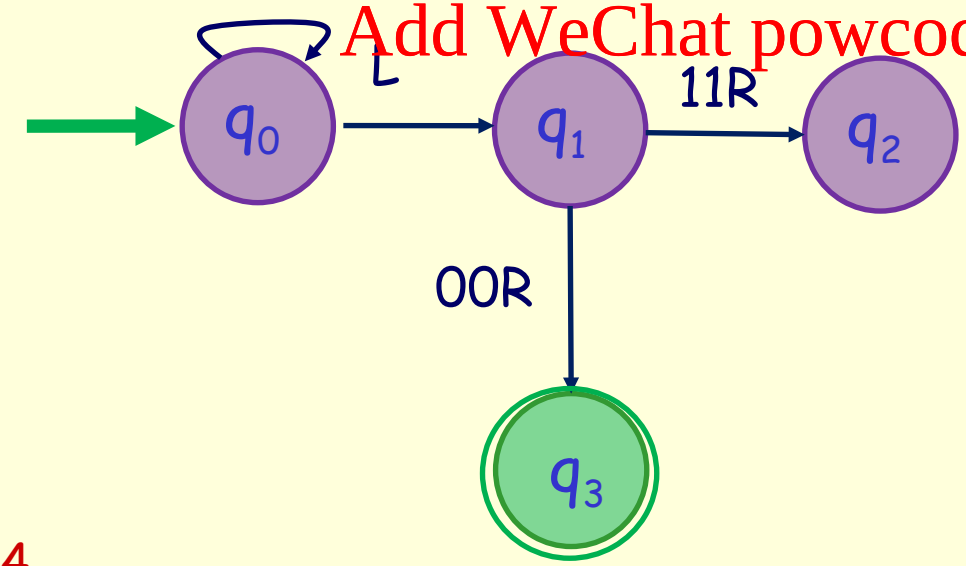
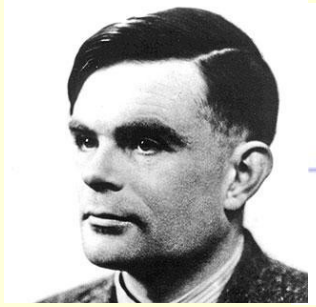
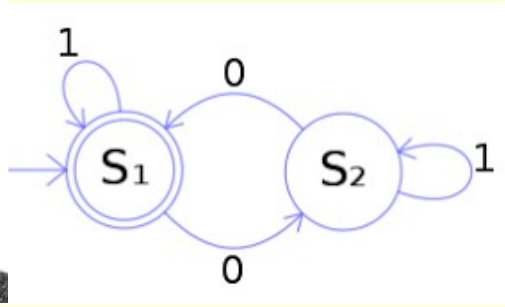
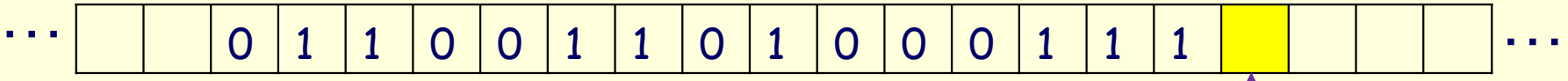


TM2.jff

Turing machines







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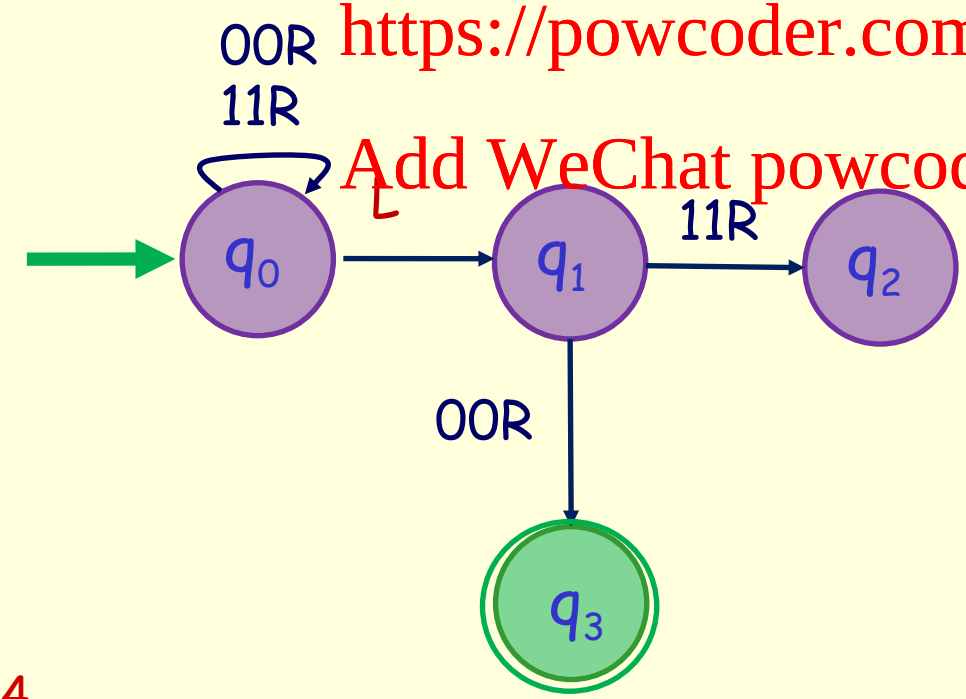

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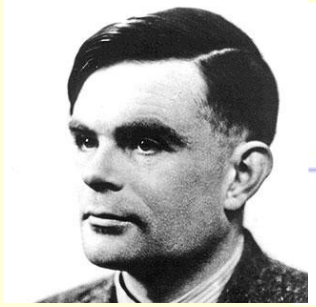
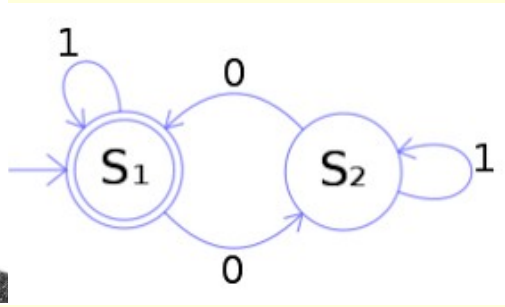
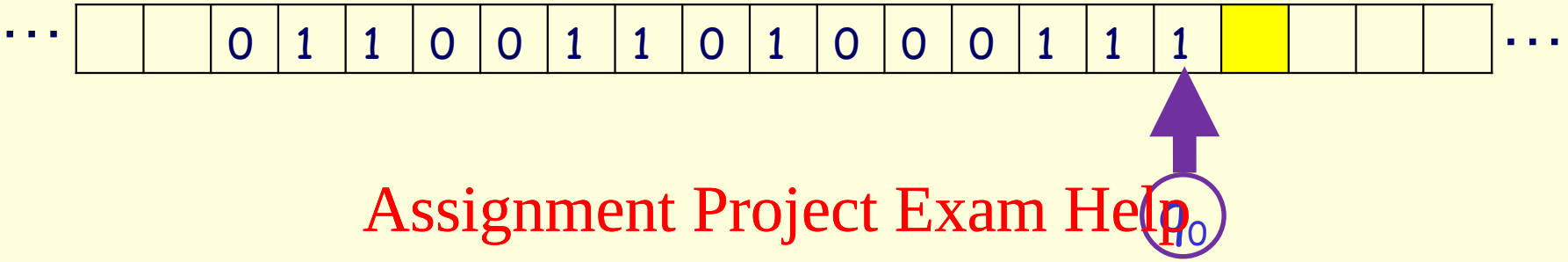
TM2.jff

Turing machines







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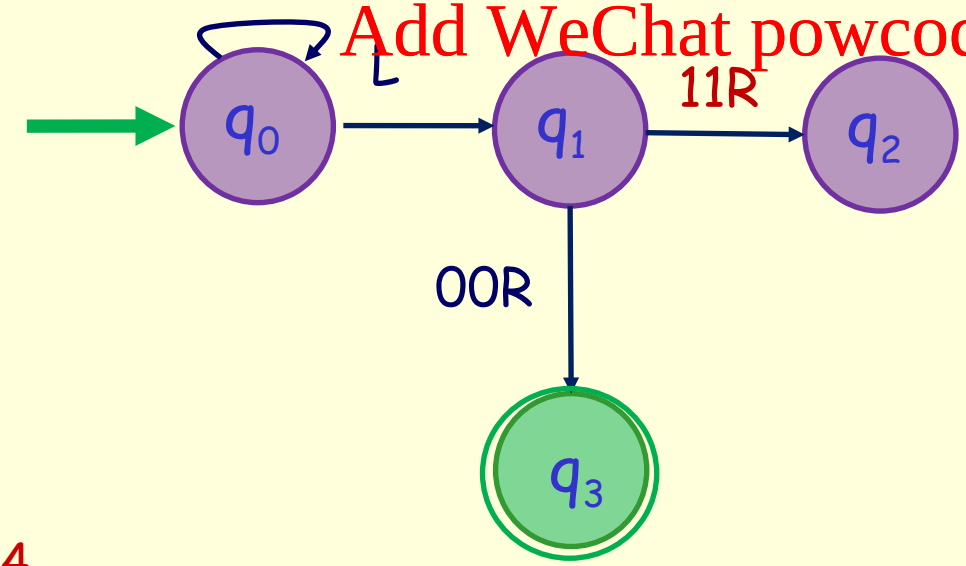
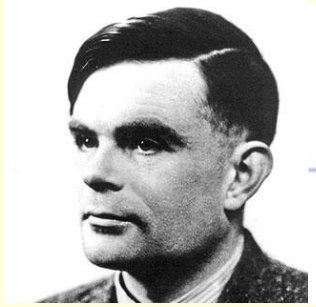
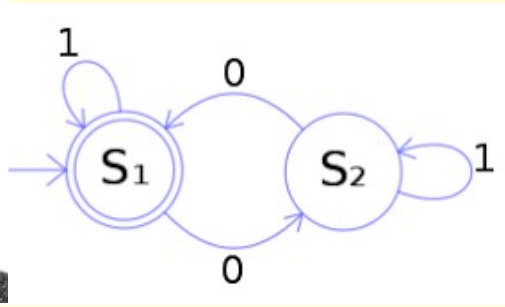
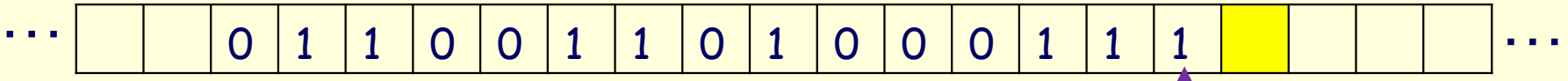


TM2.jff

Turing machines







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q_0

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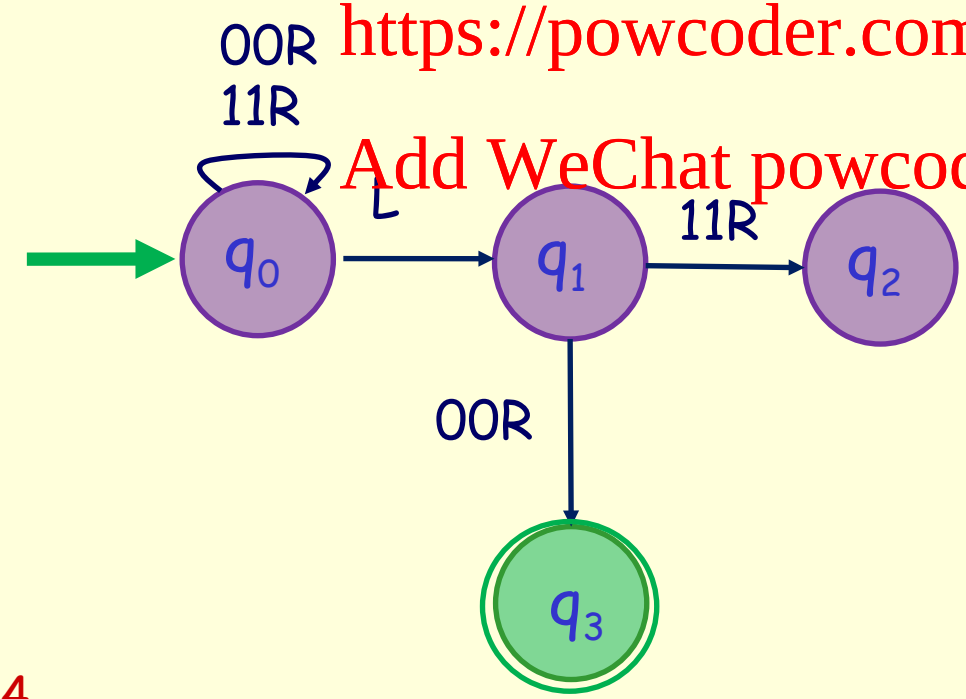

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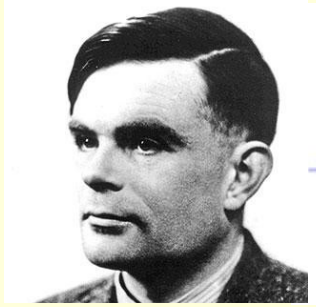
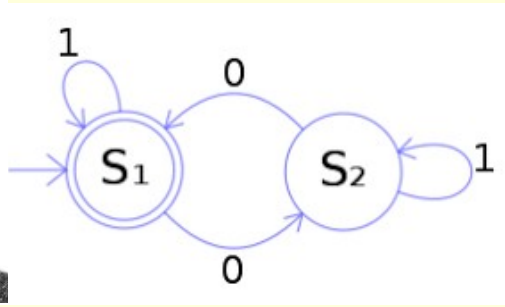
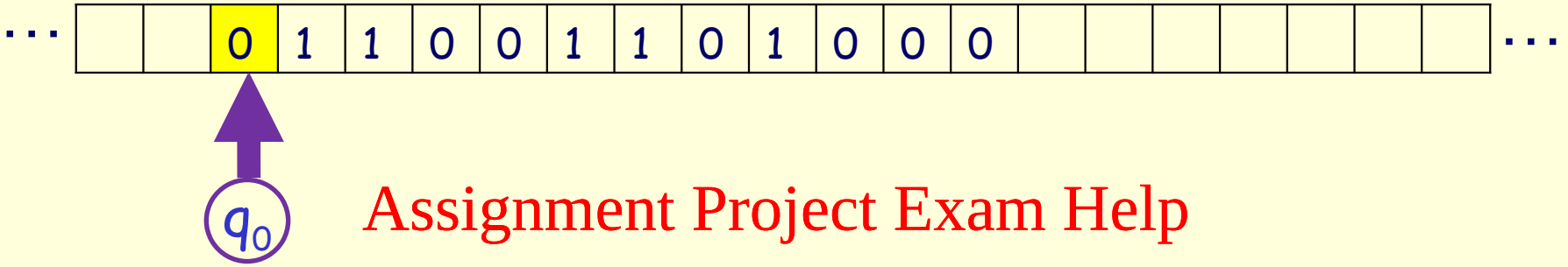
TM2.jff

Turing machines







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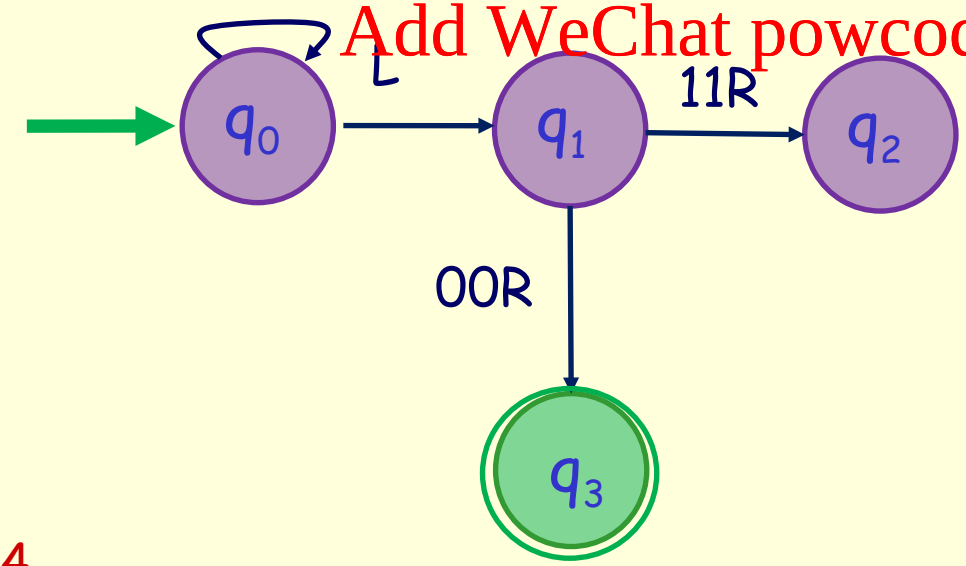
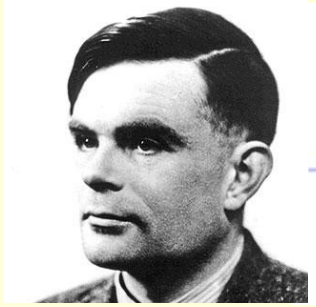
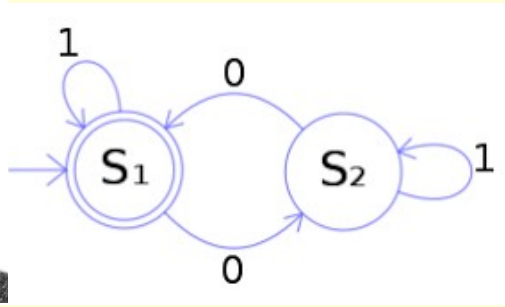
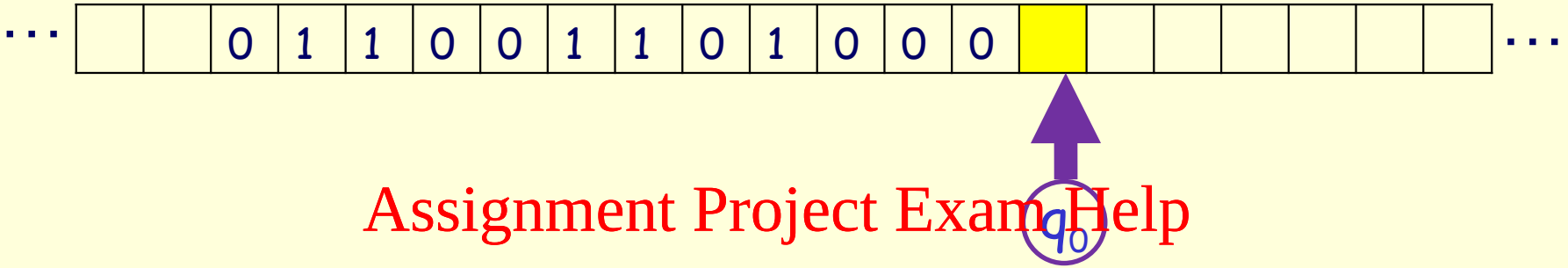


TM2.jff

Turing machines







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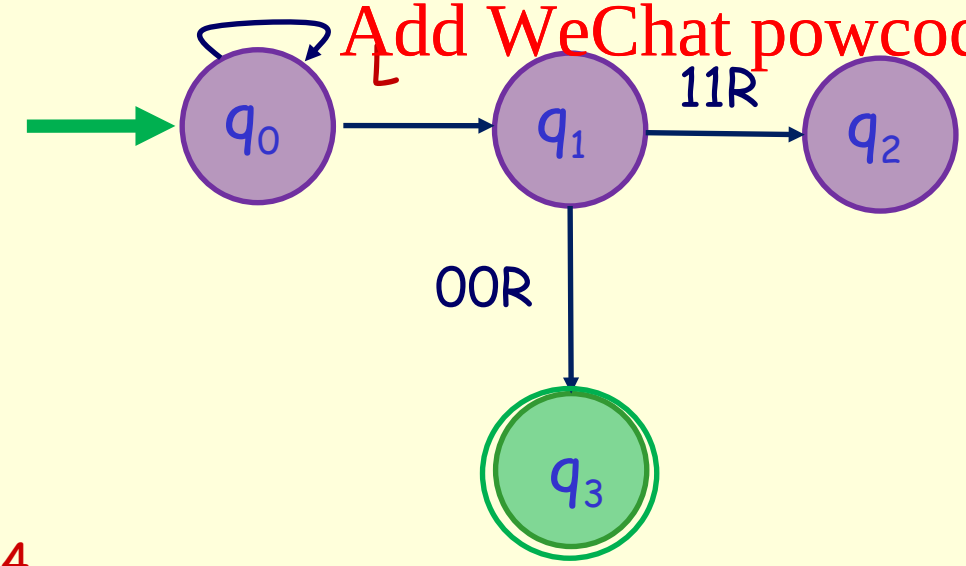
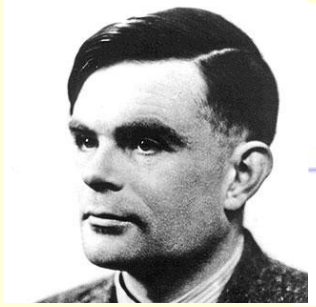
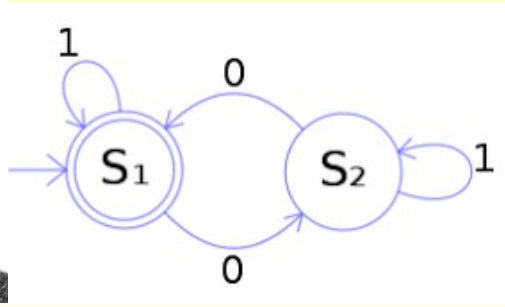
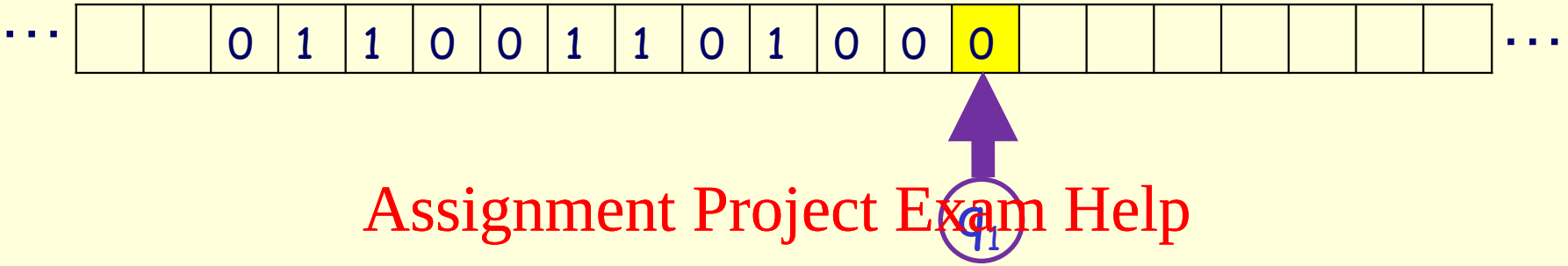


TM2.jff

Turing machines







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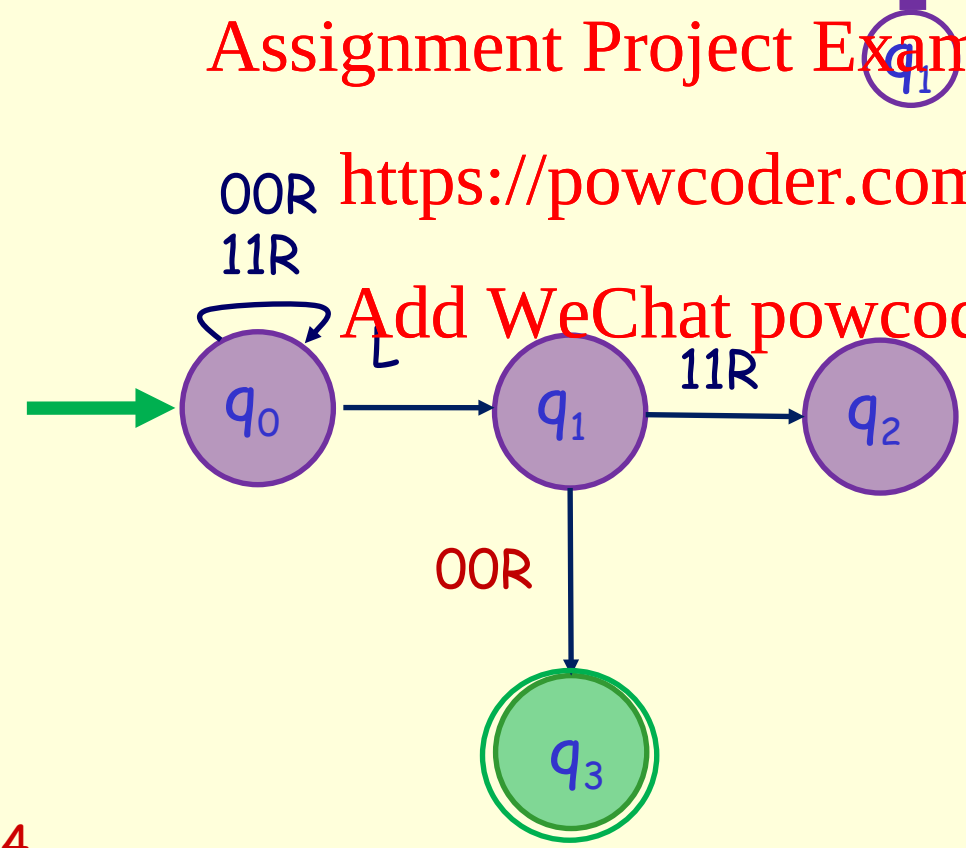
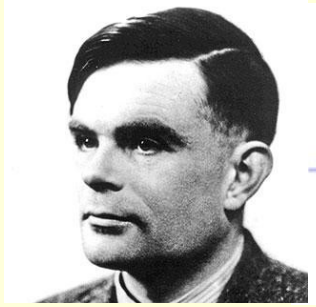
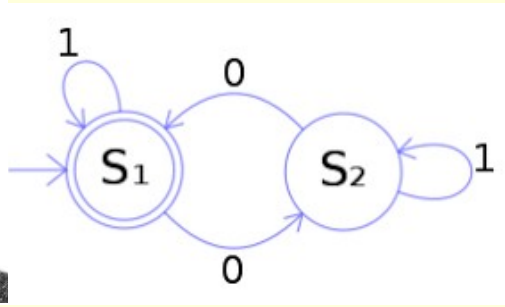
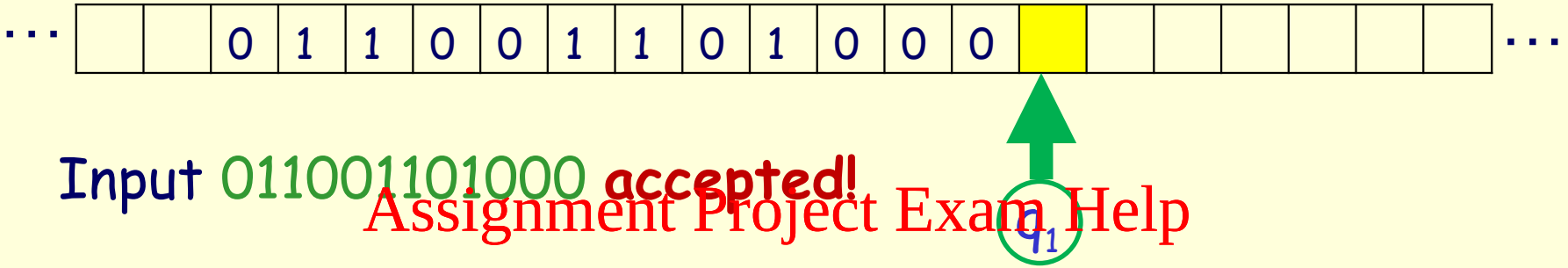


TM2.jff

Turing machines







Input 011001101000 **accepted!**

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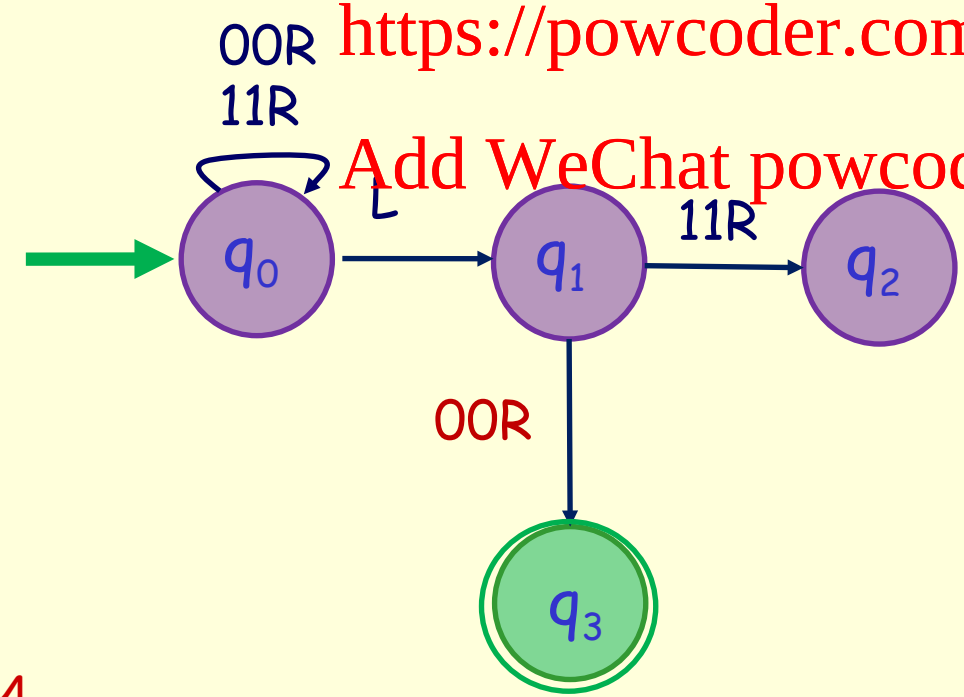

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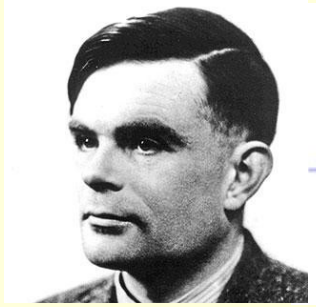
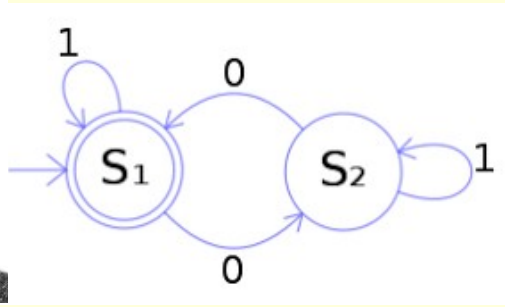
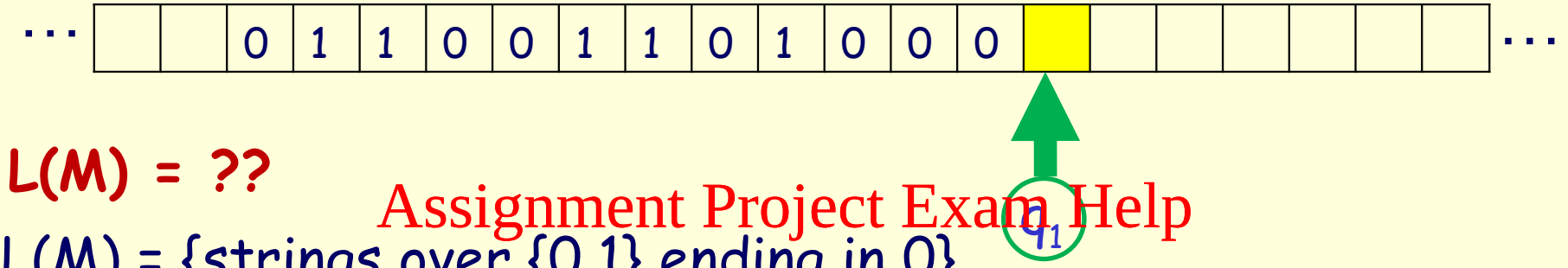
Turing machines







L(M) = ??

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L(M) = {strings over {0,1} ending in 0}

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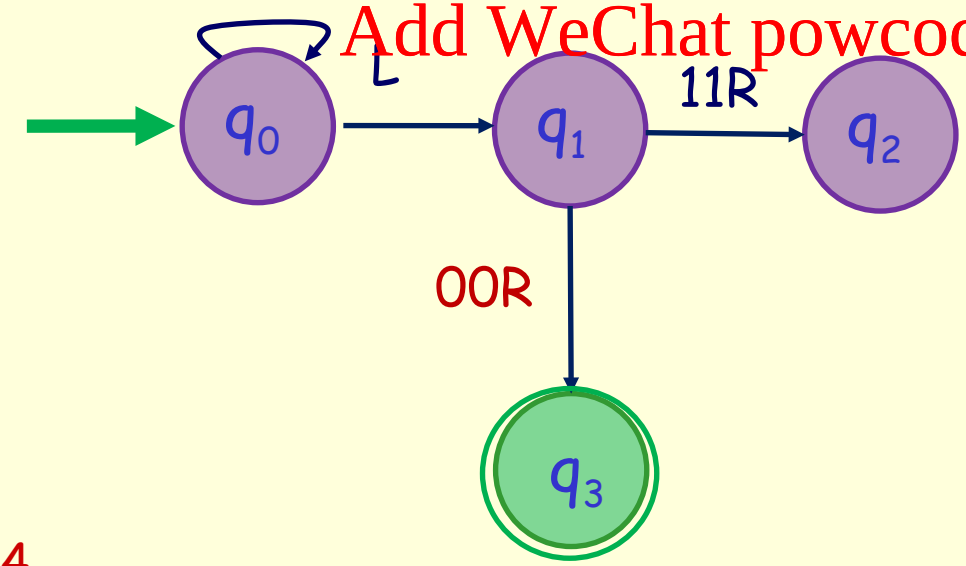

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TM2.jff

Questions?

Questions?

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Questions?

Quiz time!

Go to Canvas and find the quiz Lectorial 4 Question Set 1

- Not worth any marks
- Just for practice
- Time limit will be two minutes (which should be more than enough!)

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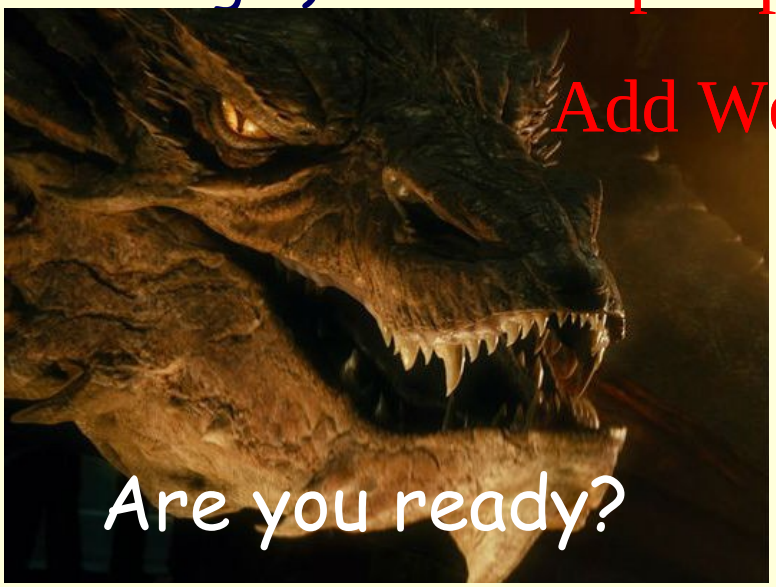

Go!

The pictures will take 2 minutes to disappear!

Thomas music means 30 seconds left!

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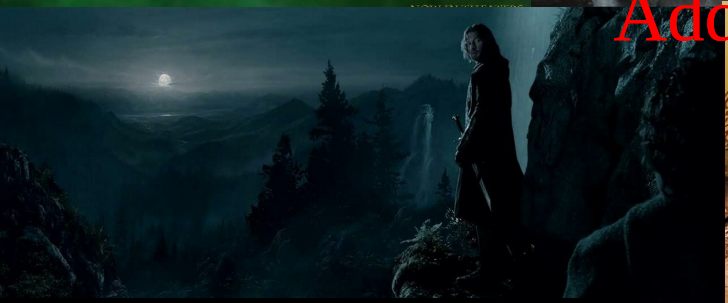

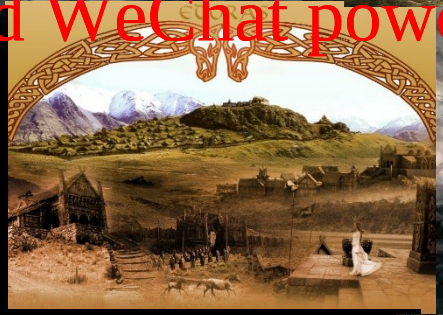

How did you go?

Question 1: Which of the following statements are correct?

- Turing was an English mathematician. **True**
- The highest award for Computer Science is named after him. **True**
- Turing invented what is now known as the Turing test for artificial intelligence. **True**
- Turing was a key member of the team at Bletchley Park that cracked the German Enigma cryptographic system. **True**
- Turing was a keen long-distance runner. **True**
- Turing wrote a paper titled "The Chemical Basis of Morphogenesis" which lead to what are now known as Turing patterns. **True**

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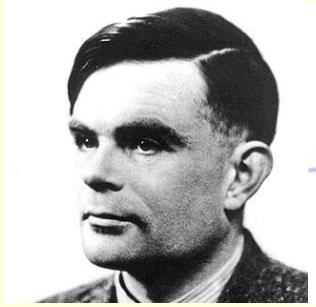
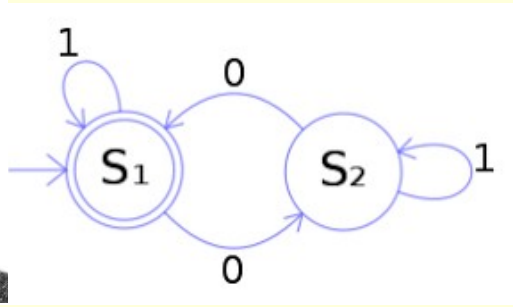
Formal Definition





A Turing machine **M** is a 6-tuple (Q, , q_0, F)

- Q is a finite set of **states**
- is a finite **alphabet**
- is the **blank symbol**
- Q x (subsets of) Q x x {L, R}
  is the **partial transition function**
- q_0 is the **start state** of the machine
- F Q is the set of **accepting or final states**

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current state → $((q_1, x), (q_2, y, M))$

current symbol

new state

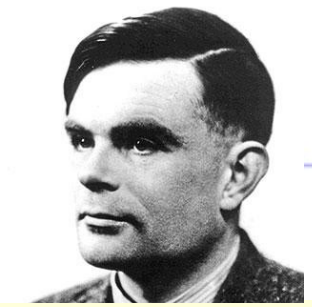
movement

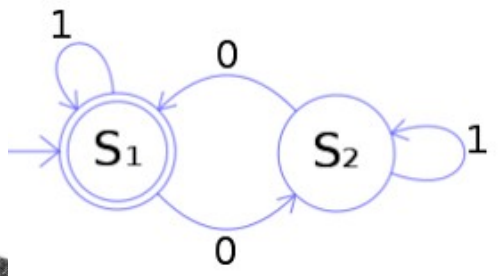
new symbol

Write

Move

FSA vs PDA vs TM





	FSA	PDA	TM
Input	String	String	String
Output	Yes or no	Yes or no	Yes or no*
Processing	One symbol at a time, left to right	One symbol at a time, left to right	One symbol at a time, moving one step in either direction
Memory	Current state	Current state + stack	Current state + tape (infinite!)
Acceptance	Final state	Final state + empty stack	Final state
Non-determinism?	Yes	Yes	Yes
Terminate?	Always	Always	Sometimes …

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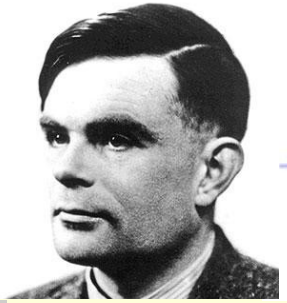
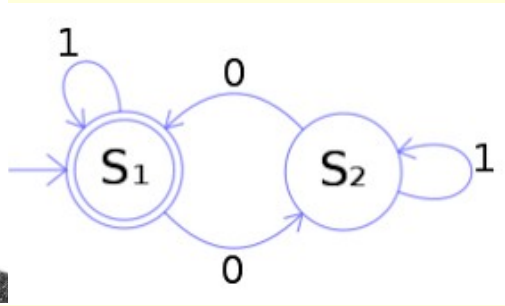
*TMs also have a different mode of output, which we will explain shortly

Turing machines





http://aturingmachine.com/

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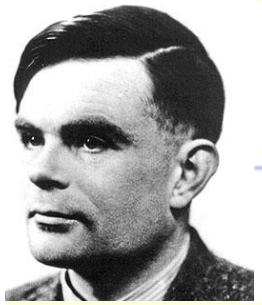
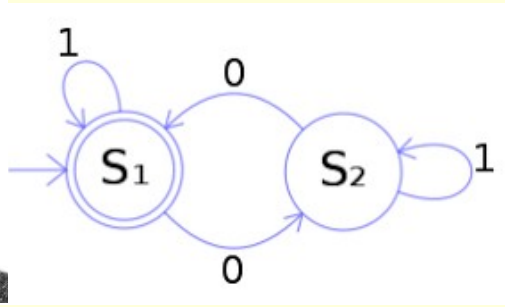
"My goal in building this project was to create a machine that embodied the classic look and feel of the machine presented in Turing's paper. I wanted to build a machine that would be immediately recognizable as a Turing machine to someone familiar with Turing's work." – Mike Davey

Turing machines





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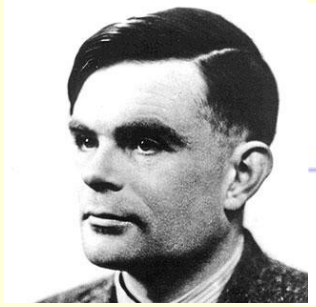
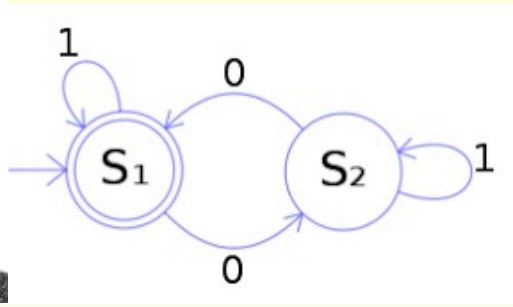
"To honor Alan Turing, we built a simple LEGO Turing Machine, to show everyone how simple a computer actually is."

https://www.youtube.com/watch?v=FTSAiF9AHN4

Turing machines





- **Finite** number of states
- **Infinite memory** (tape)
- Process **one symbol** at a time
- Can **move left or right one step** on the tape
- Halt **when there is no transition defined**
- Can be used to
  - Recognise languages (like FSA, PDA)
  - ***Compute functions (tape as output)***
- **Are as powerful as you can get (!!)**
- Extra features can be added, but do not increase power
  - Different varieties of tape (?)
  - Nondeterminism (!?!)
  - …

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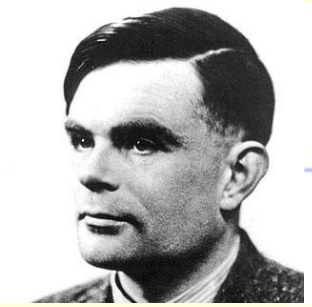
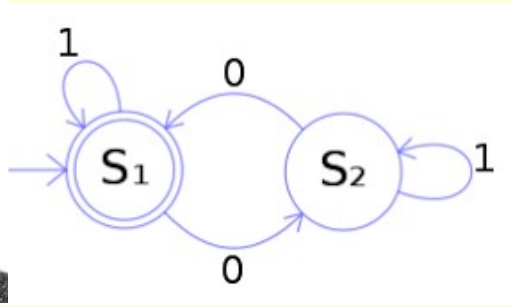
Turing machines





- Recognise the language $\{ a^n b^n \mid n \geq 0 \}$
- Recognise the language $\{ a^n b^n c^n \mid n \geq 0 \}$
- Recognise the language $\{ a^n b^n c^n d^n \mid n \geq 0 \}$
- Reverse, copy, concatenate, erase, ... input string
- Solve the travelling salesman problem (TSP)
- Encrypt/decrypt via RSA
- Check if a number is prime
- Add, multiply, divide, find square root, etc
- Search through a video to find scenes with Gandalf
- Check if a 3-SAT instance is satisfiable
- ...
- *"If it is computable, your friendly neighbourhood Turing machine can do it!"*

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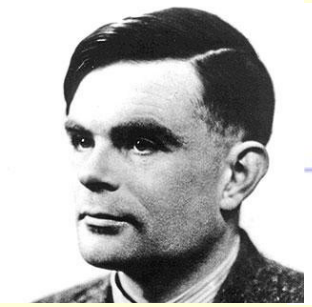
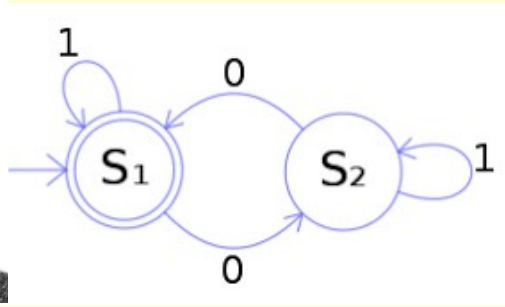
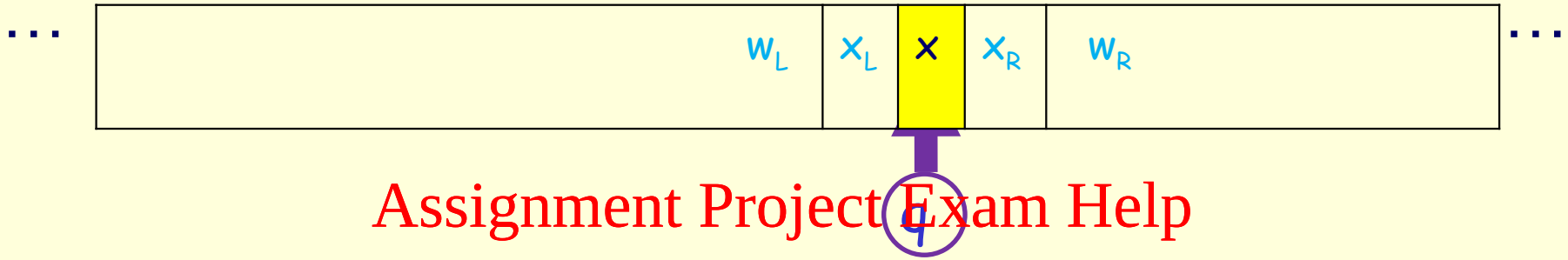
Turing machines







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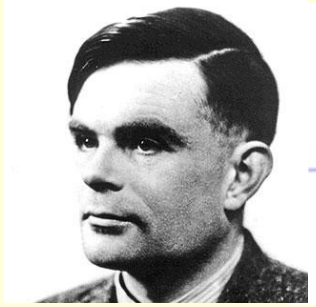
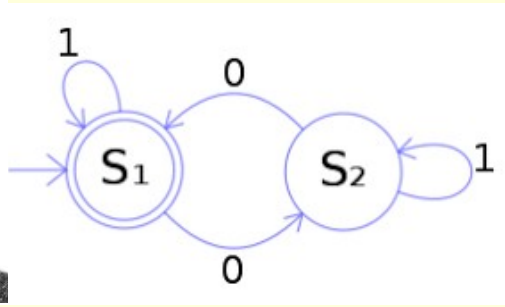
A **configuration** of **M** = (Q, Σ, δ, q_0, F) is a tuple $(q, w_L x_L, x, x_R w_R)$ where

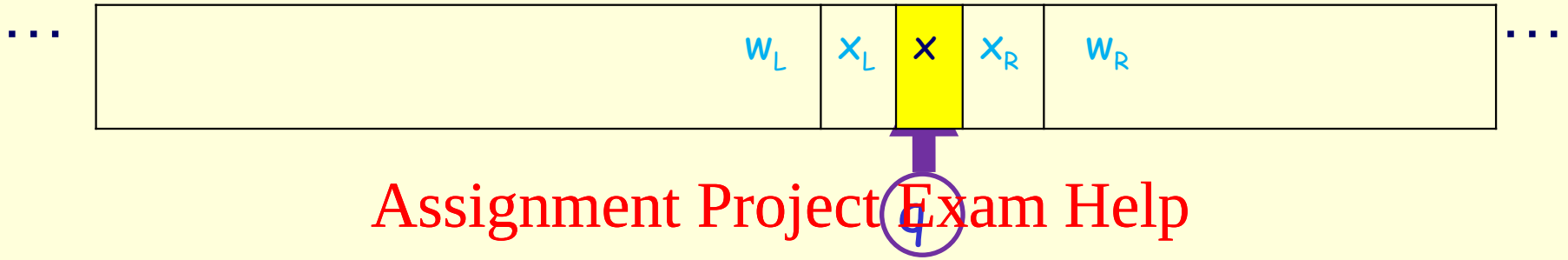
- **q** Q is the current state of **M**
- $w_L x_L$ * is the string on the tape to the **left** of the tape head
- $x_R w_R$ * is the string on the tape to the **right** of the tape head
- **x** is the symbol currently **at** the tape head

(compare FSA (current symbol, current state), PDA (current symbol, current state, stack)

Turing machines







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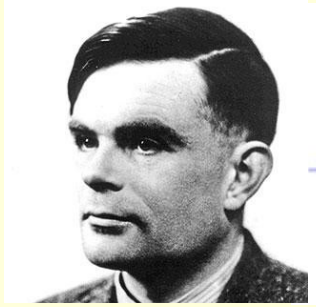
M evolves from $(q, w_L x_L, x, x_R w_R)$ to (r, v_1, y, v_2) written as

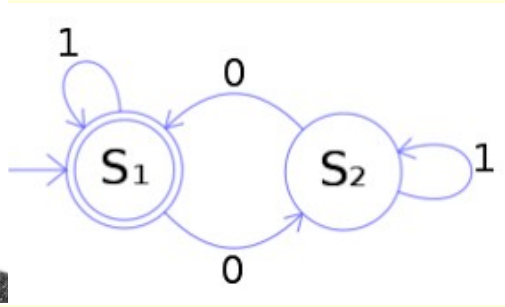
$(q, w_L x_L, x, x_R w_R) \rightarrow (r, v_1, y, v_2)$

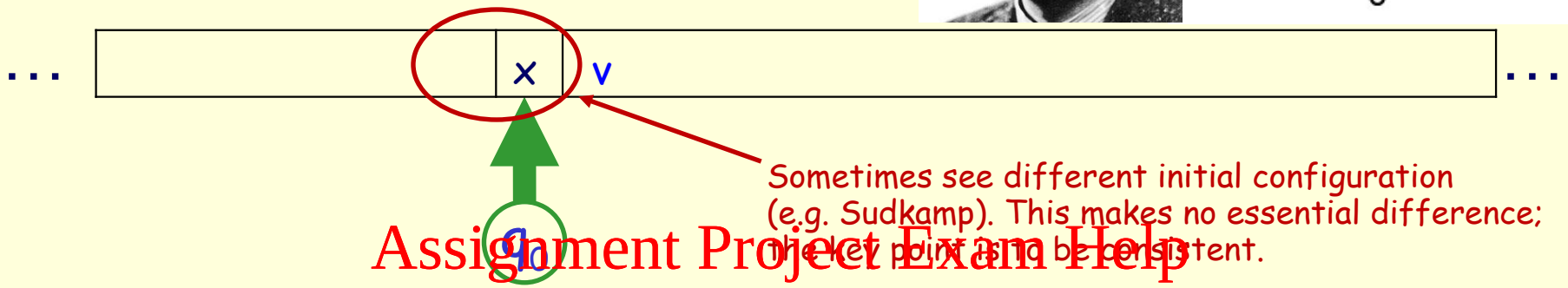
where there is a transition (q, x, r, y, D) in **M** where

- $D = L$, $v_1 = w_L$, $v_2 = y x_R w_R$, $z = x_L$
- $D = R$, $v_1 = w_L x_L y$, $v_2 = w_R$, $z = x_R$

Turing machines







Sometimes see different initial configuration (e.g. Sudkamp). This makes no essential difference; the key point is to be consistent.

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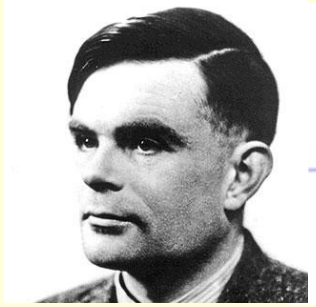
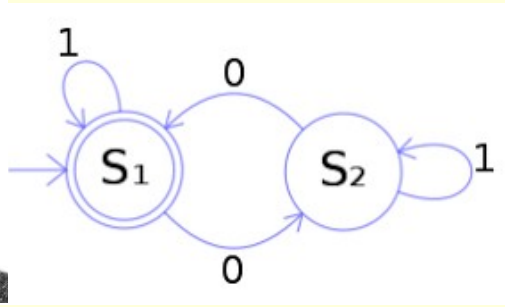
A string w is accepted by M if there is a configuration (q, w_L, x, w_R) such that

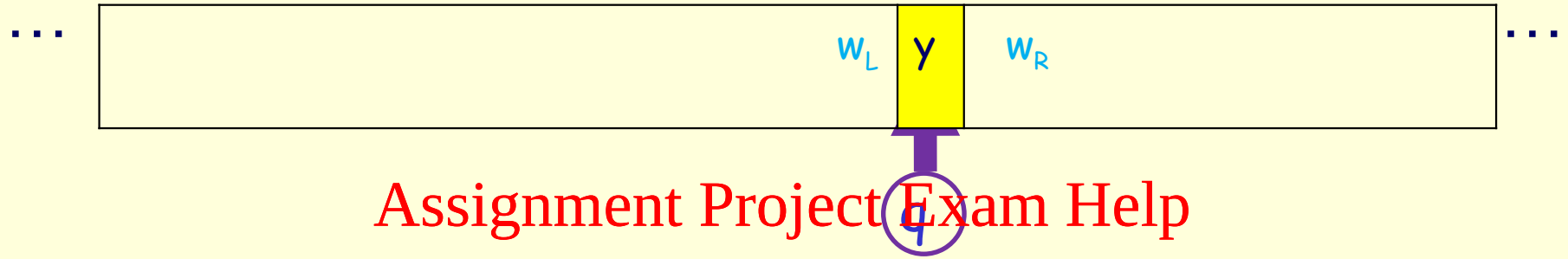
$$(q_0, , x, v) \; * \; (q, w_L, y, w_R)$$

where $w = xv$, q F and **M** halts in (q, w_L, y, w_R)

Turing machines







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A string w is **accepted** by **M** iff there is a configuration (q, w_L, y, w_R) such that

$(q_0, x, v) \vdash^* (q, w_L, y, w_R)$

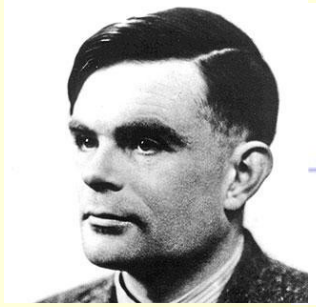
where $w = xv$, $q \in F$ and **M** halts in (q, w_L, y, w_R)

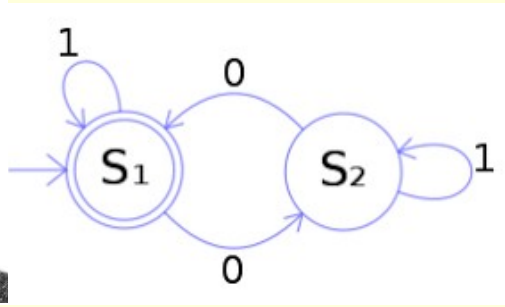
0 or more steps

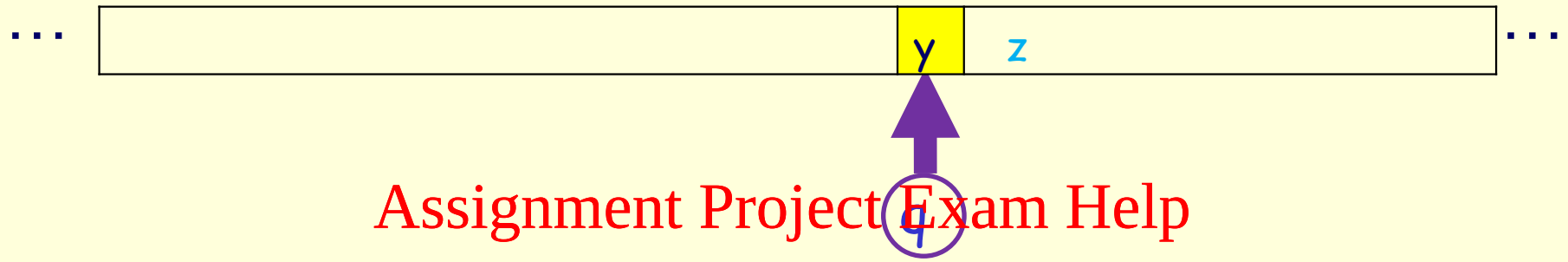
No transition for (q,y)

$L(\mathbf{M}) = \{ w \mid w \text{ is accepted by } \mathbf{M} \}$

Turing machines







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A Turing machine **M** computes the (partial) function **f**: * * iff there is a configuration (q, w_L, y, w_R) such that whenever $f(w) = v$

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$(q_0, , x, v)$ * $(q, , y, z)$

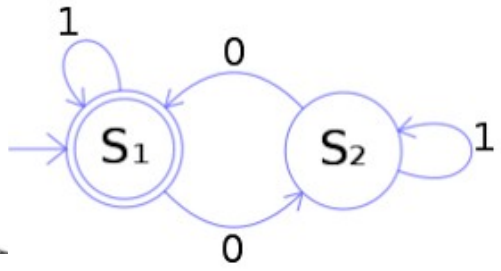
where $w = xv$, $v = yz$, q F, **M** halts in $(q, , y, z)$

O or more steps

No transition for (q,y)

*Note that if **f(u)** is undefined, **M** does not terminate …

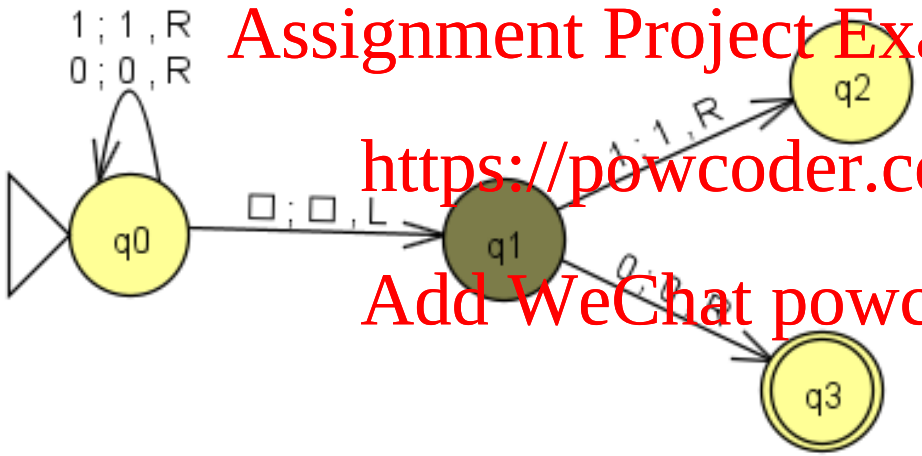
Turing machines



JFLAP : (TM2.jff)

File Input Test View Convert Help

Editor | Simulate: [011001101000]



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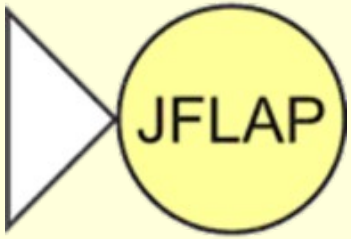
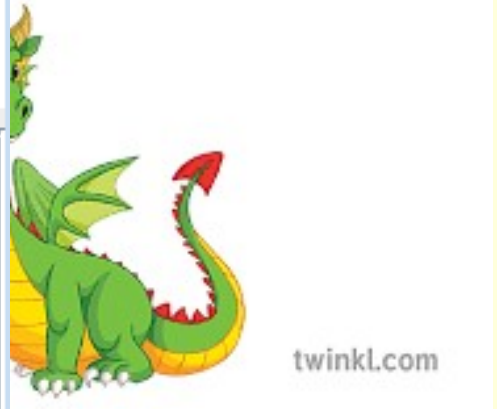


q1

001101000□□□□□□

Step | Reset | Focus | Defocus | Freeze | Thaw | Trace | Remove



ting Theory

Questions?

Questions?

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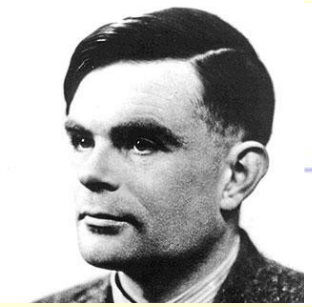
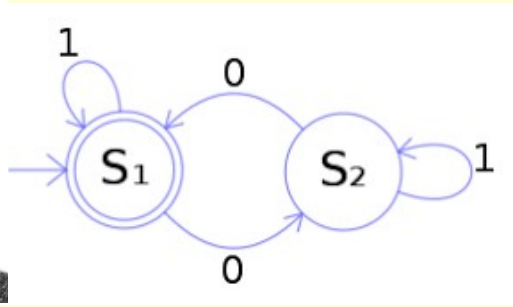
Questions?

Varieties





What if we altered Turing machines?

- Added a second tape (with its own head)
- Added ***n*** tapes (each with its own head)
- More heads on the same tape?
- Two-dimensional tape?
- Semi-infinite tape?
- More symbols?
- Less symbols?
- Nondeterminism?
- …

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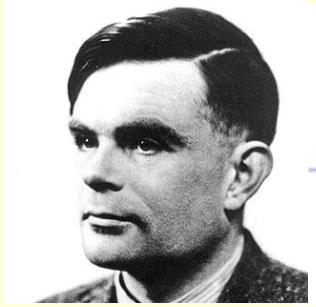
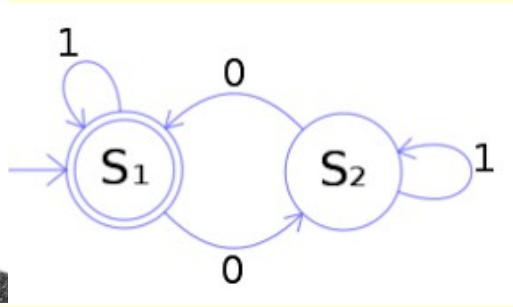
Hilbert's Hotel

Can we "improve" on Turing machines?

"Infinite" space …





What is this old lamp?

Master, I grant you three wishes.
What is your first wish?

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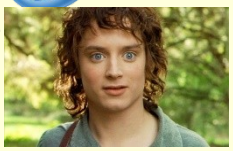
A box of chocolate frogs that never runs out!

Master, what about your other two wishes?

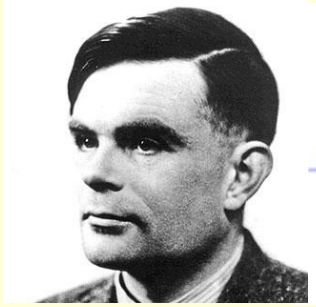


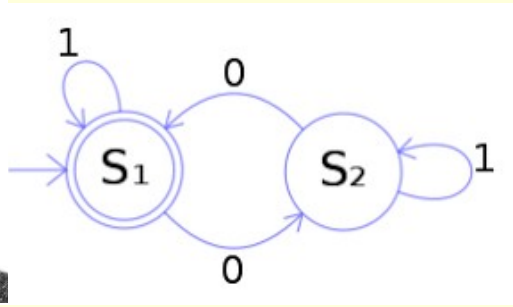
Two more of the same please!

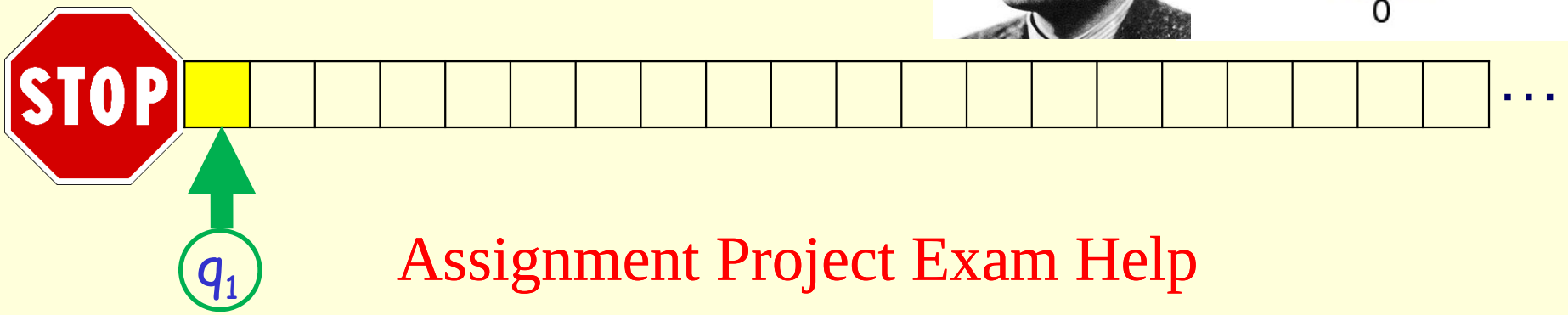
What is the joke?

Any infinite space is enough!

Semi-infinite tape







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- Tape has a **lefthand end** but extends infinitely to the right
- Machine halts abnormally if it tries to move past the lefthand end
- Common in textbooks

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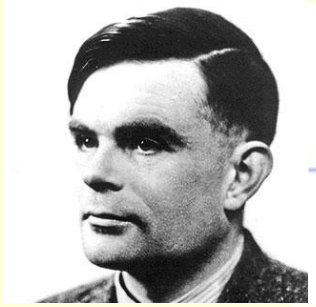
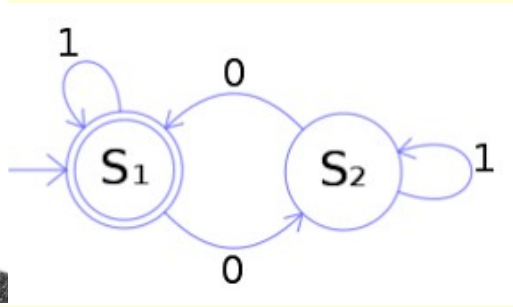
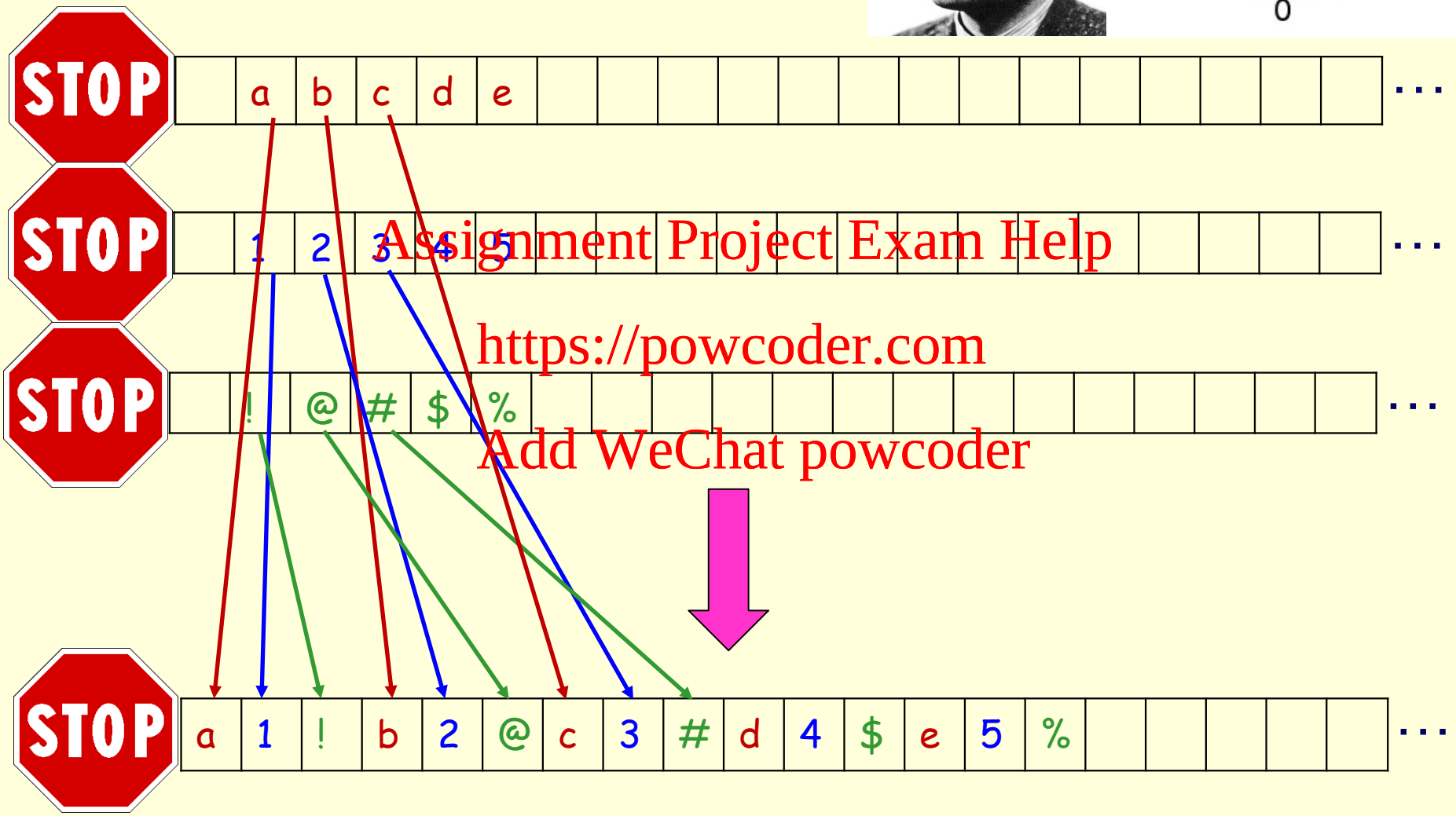
- "simplest" form of Turing machines
- No less powerful than any other kind of Turing machine!

Multi-track tape







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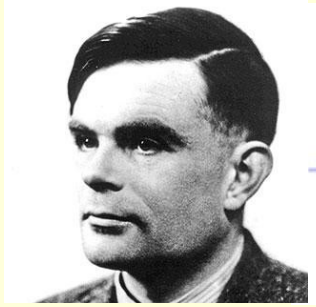
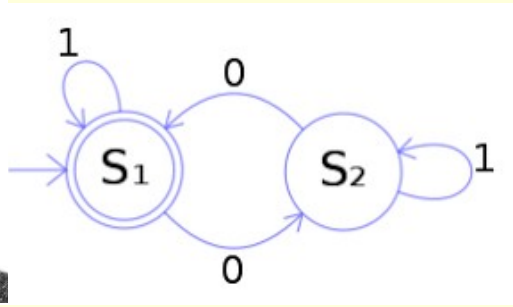
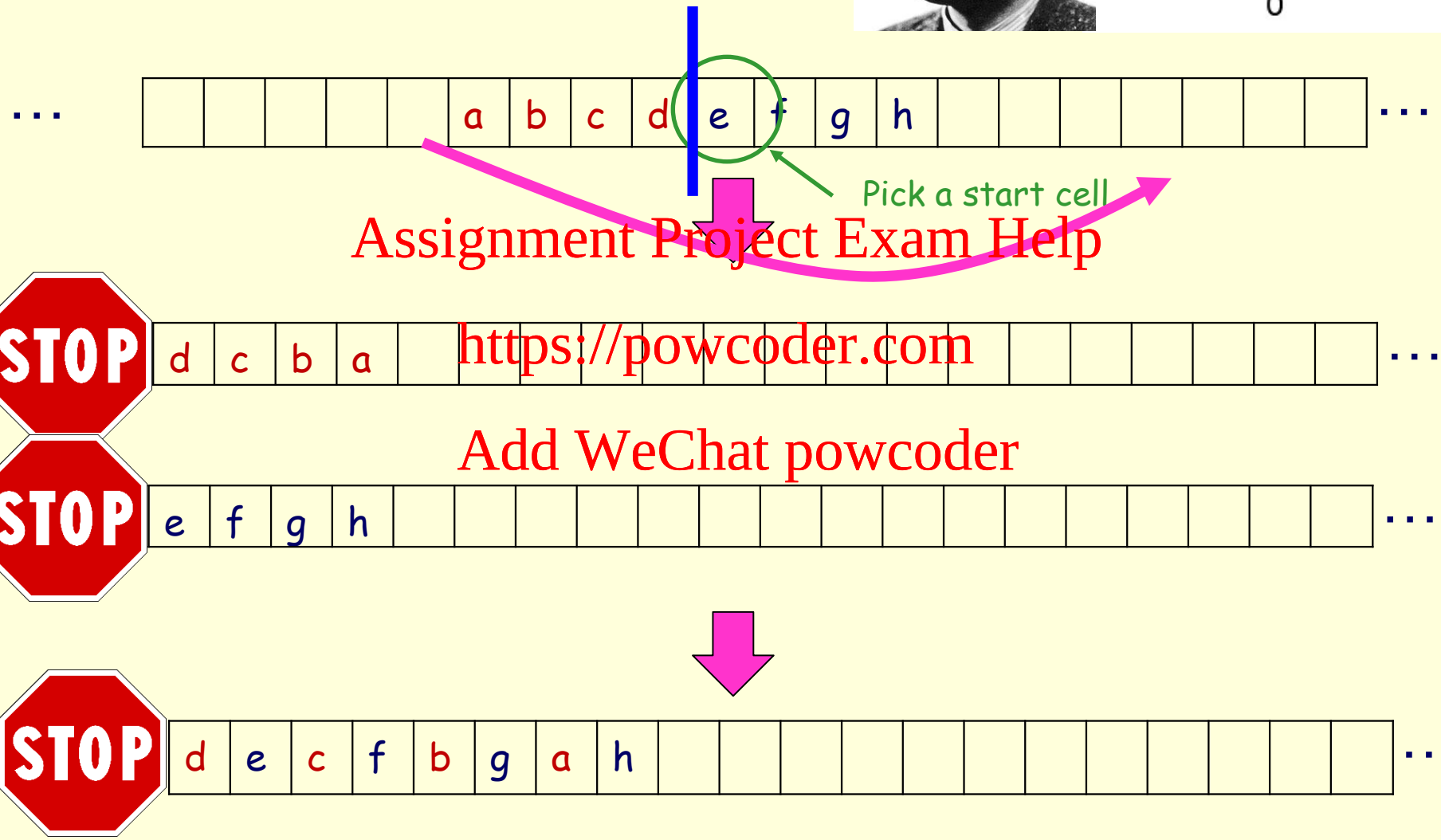
Multi-track tape







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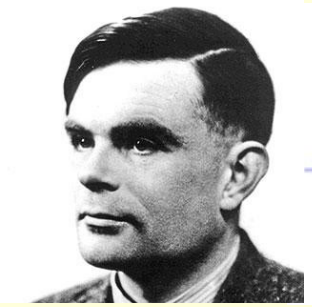
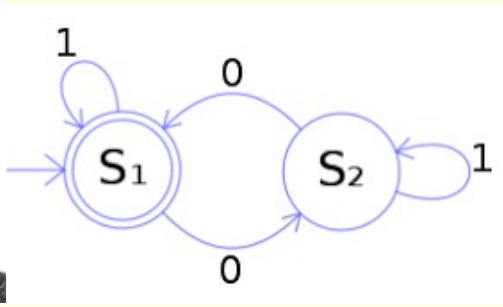
2-dimensional tape





a	b	c	d	e	f				
1	2	3	4	5	6				
!	@	$	%	^	&				
A	B	C	D	E	F				
Q	W	E	R	T	Y				
Z	Y	X	W	V	U				

...

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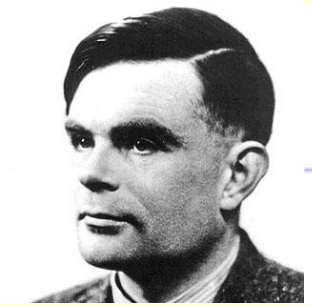
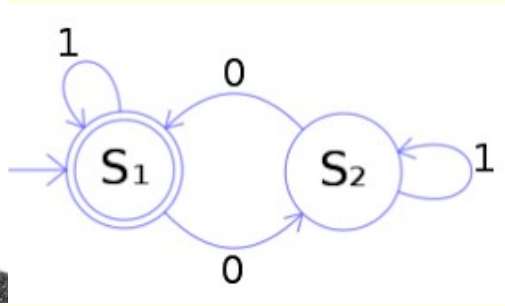
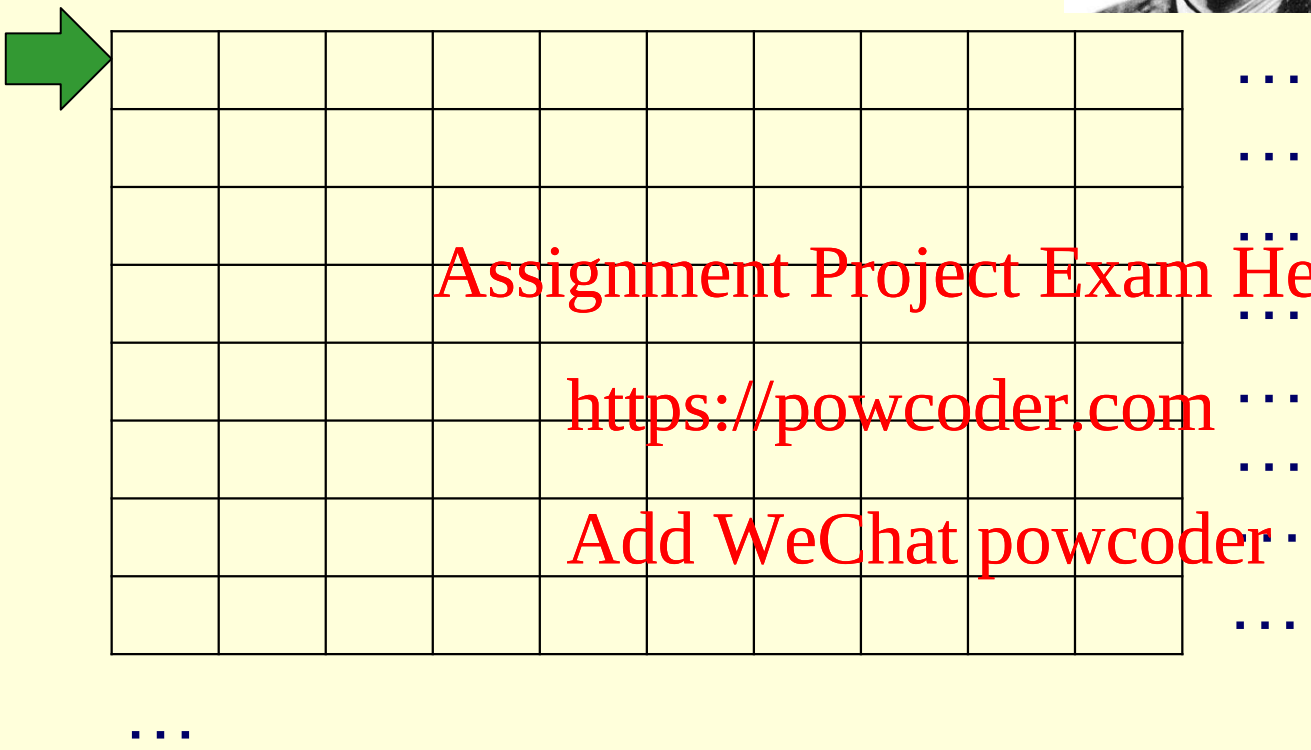
a	b	1	!	2	c	d	3	@	A	Q	B	$	4	e	f	5	%	C	W	...

2-dimensional tape







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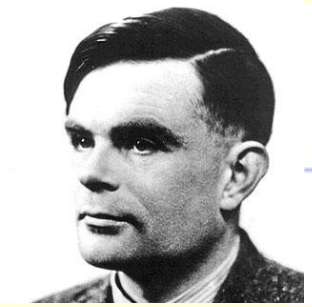
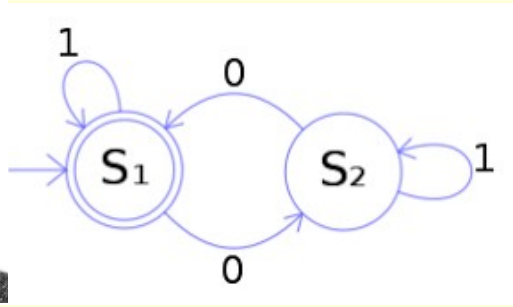
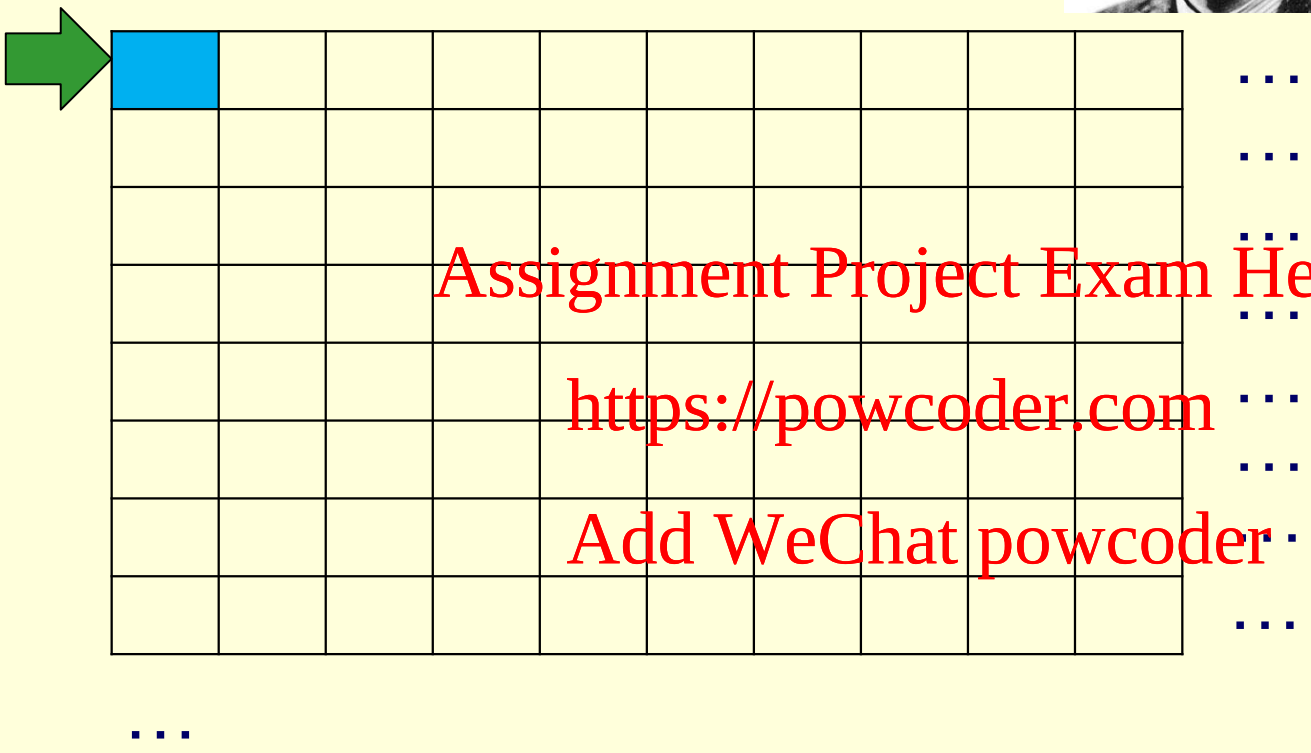
2-dimensional tape







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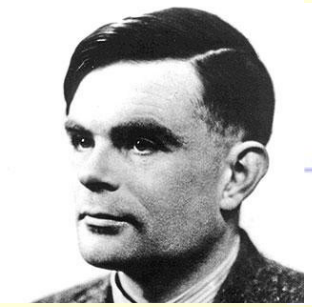
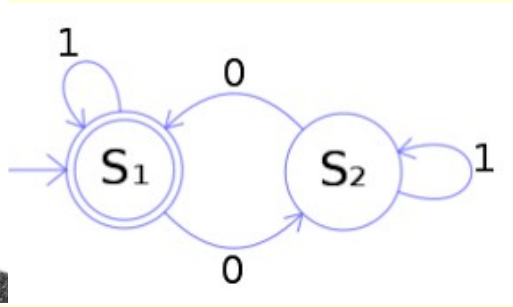
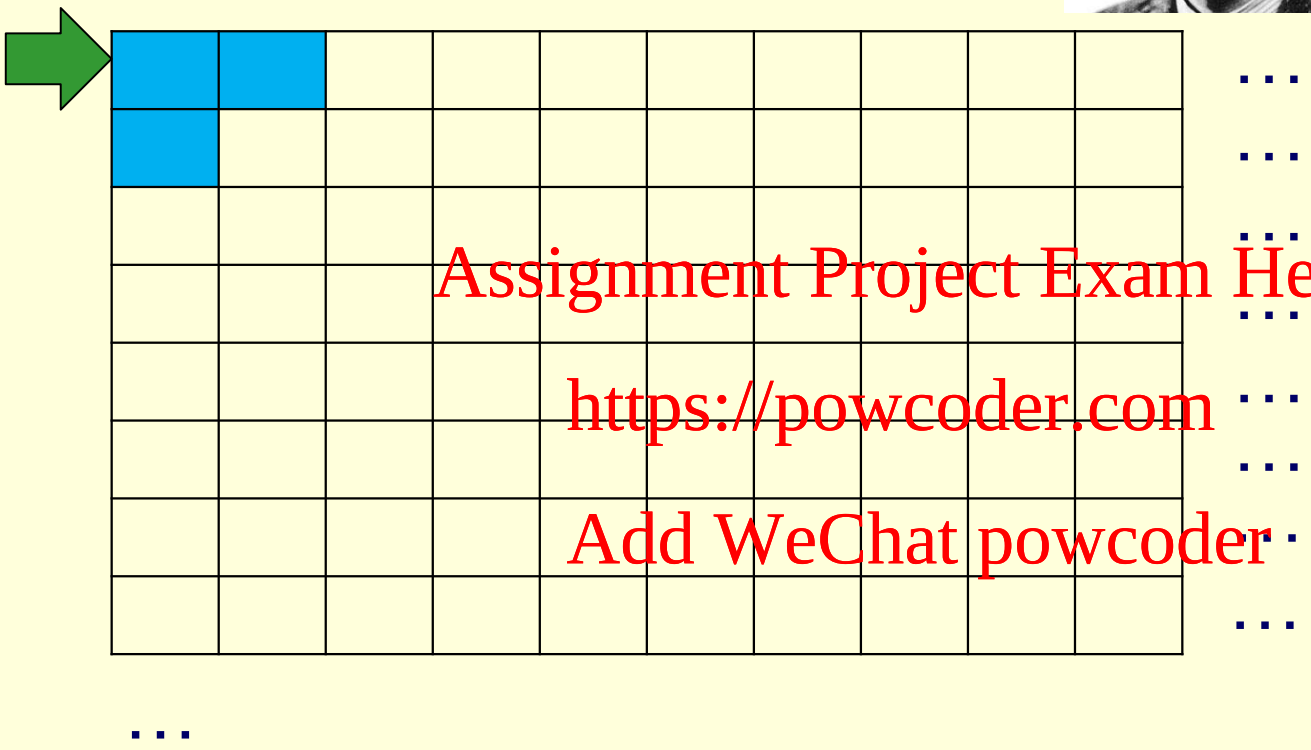
2-dimensional tape







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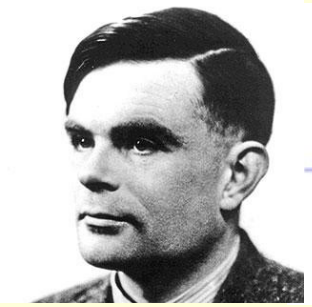

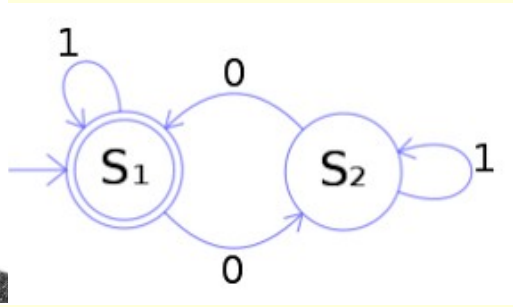

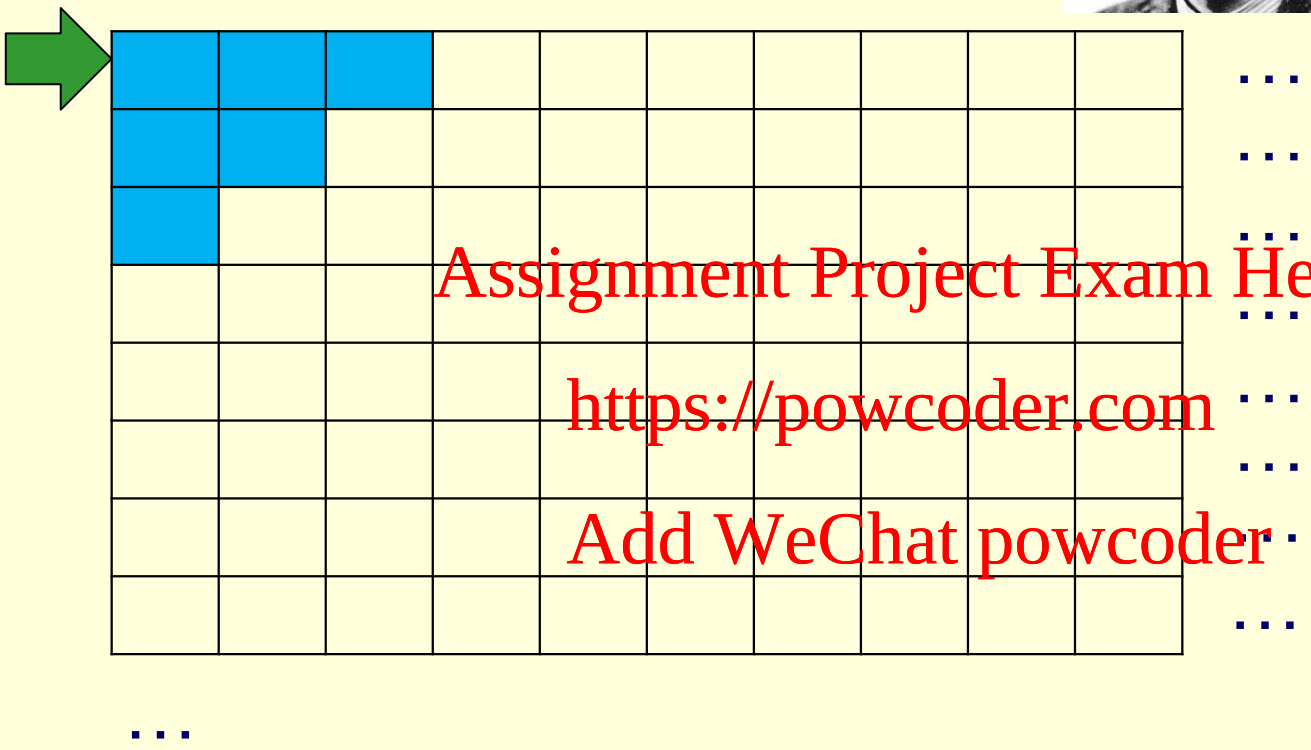

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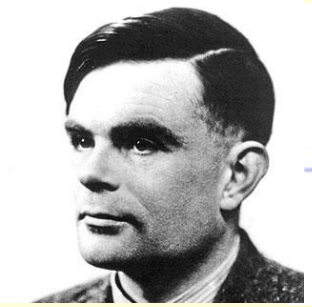
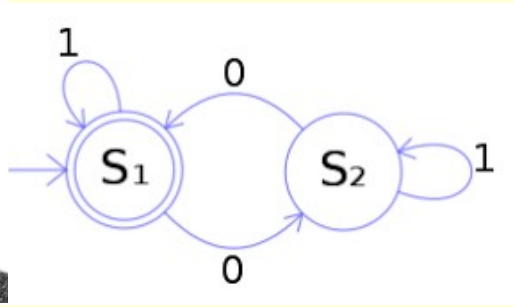
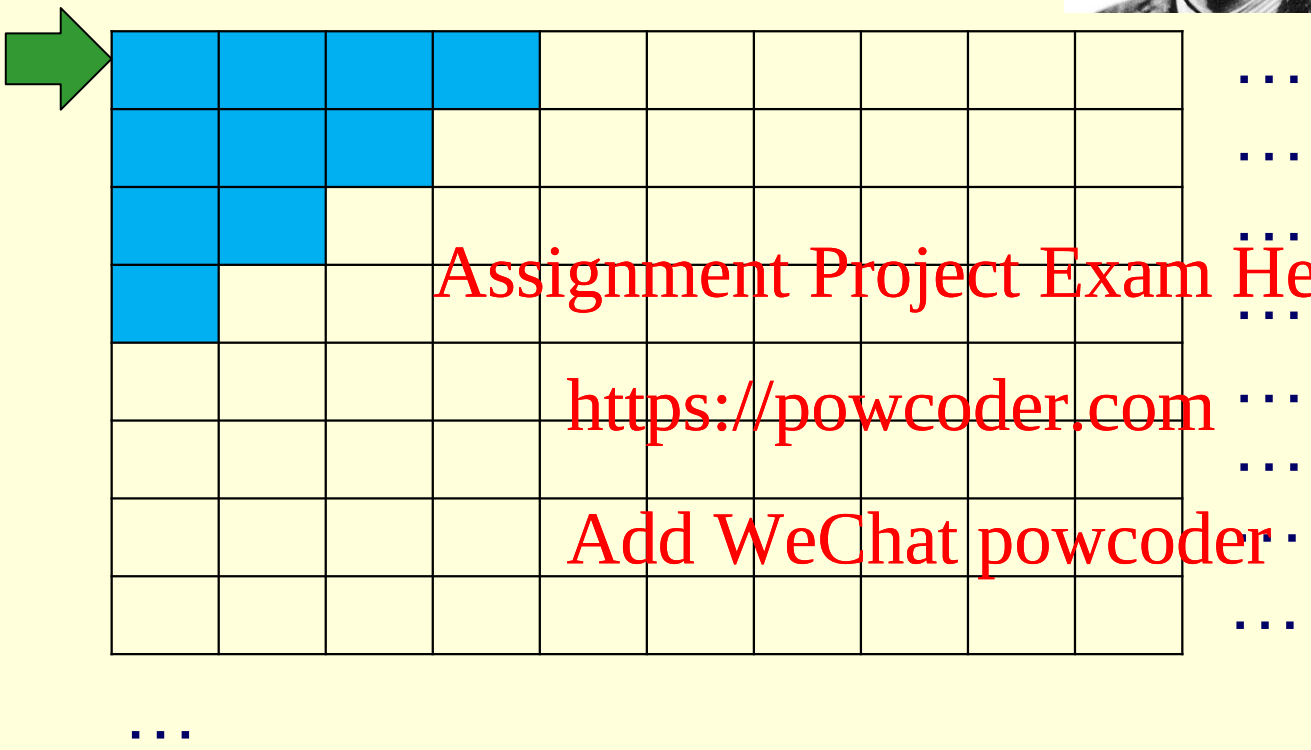
2-dimensional tape







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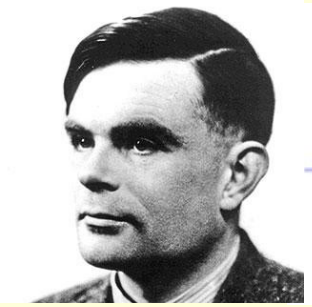
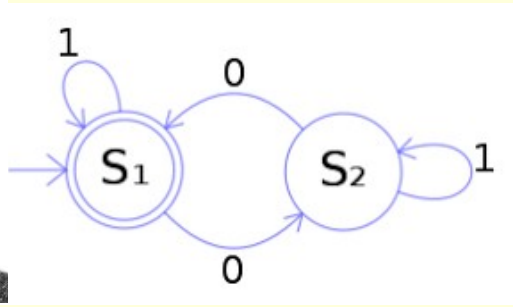
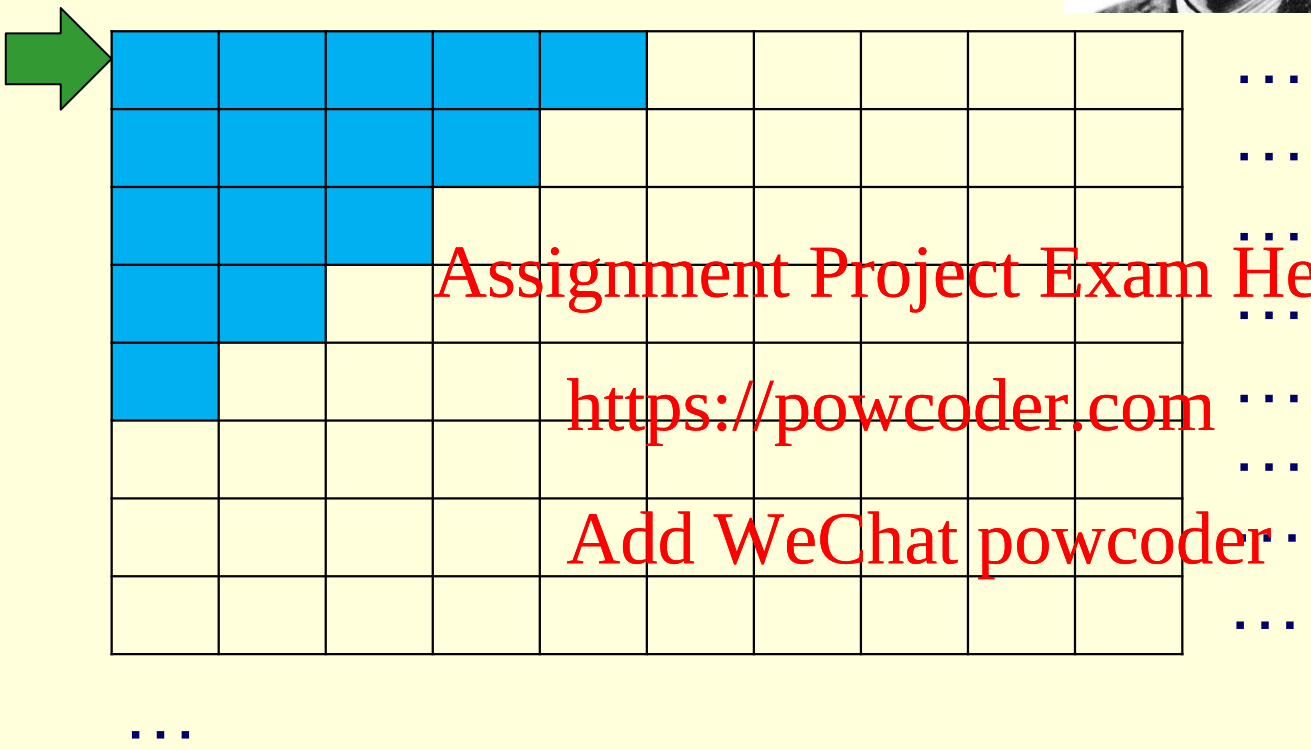
2-dimensional tape







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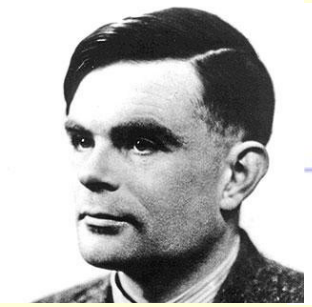
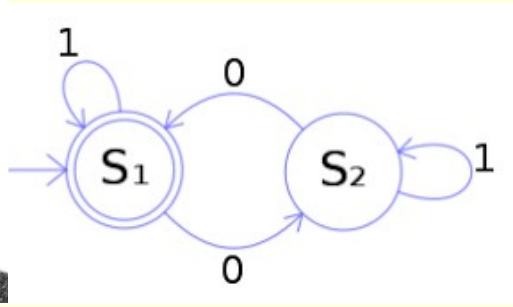
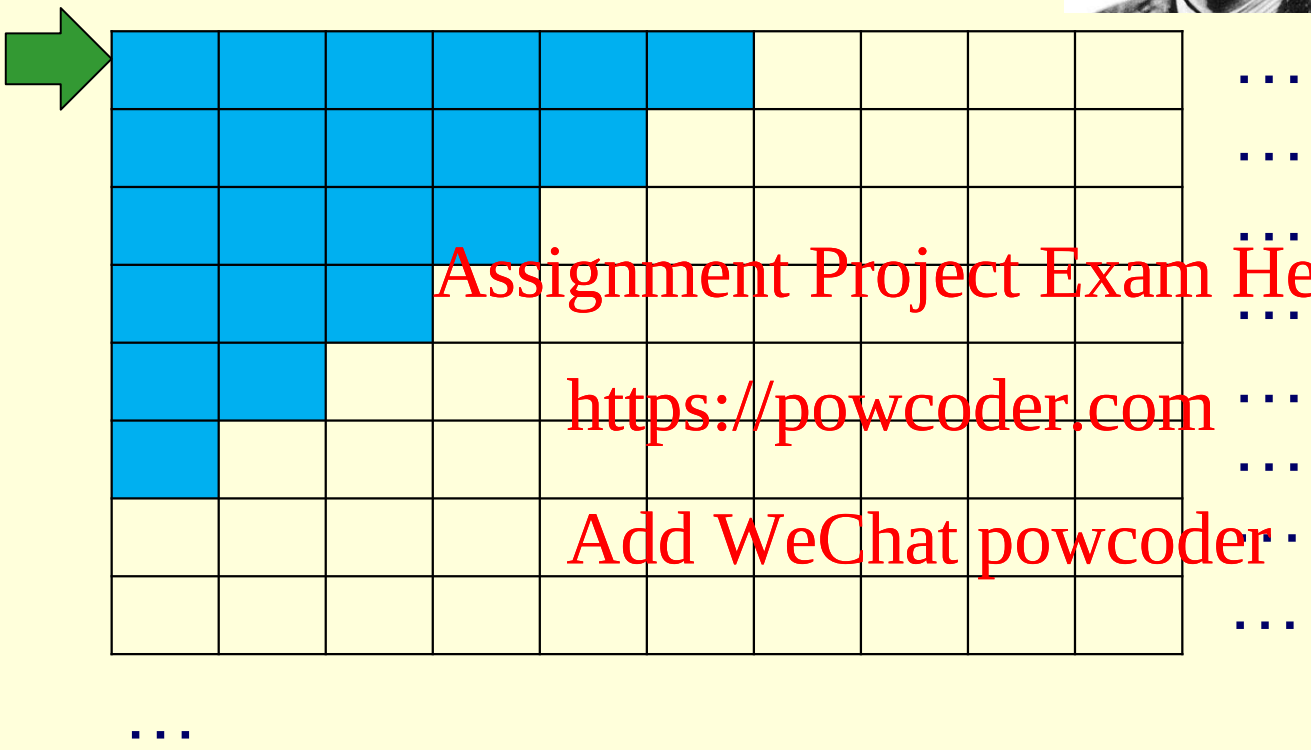
2-dimensional tape







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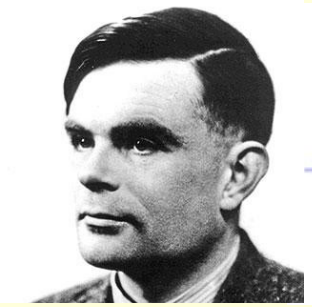
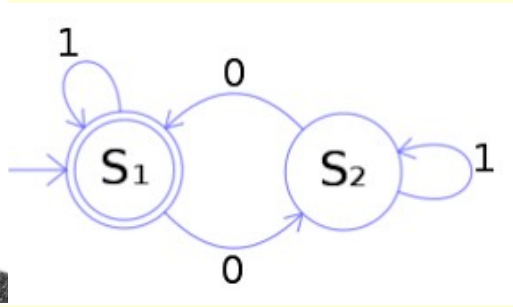
Varieties





There are **bijections** between all of the following

	1 semi-infinite tape
x	2 semi-infinite tapes
x x	3 semi-infinite tapes
x x x	4 semi-infinite tapes
	1 doubly infinite tape
x	2 doubly infinite tapes
x x	3 doubly infinite tapes
	2-dimensional tape

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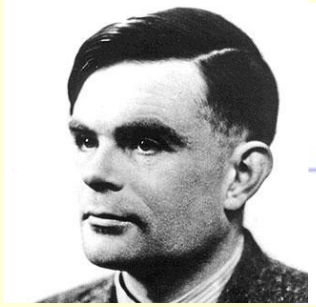
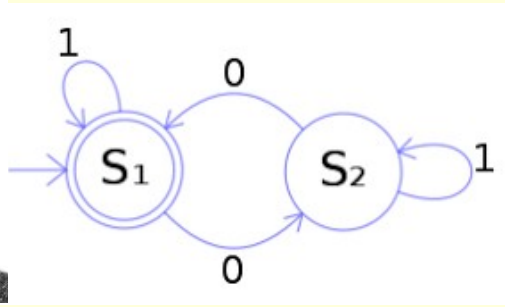
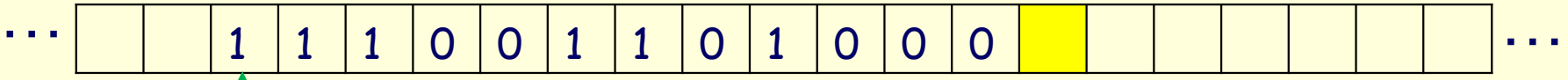
Any set bijective with works as an "index" set for a Turing machine

Varieties







Nondeterminism

For a given state and symbol, there can be more than one transition!

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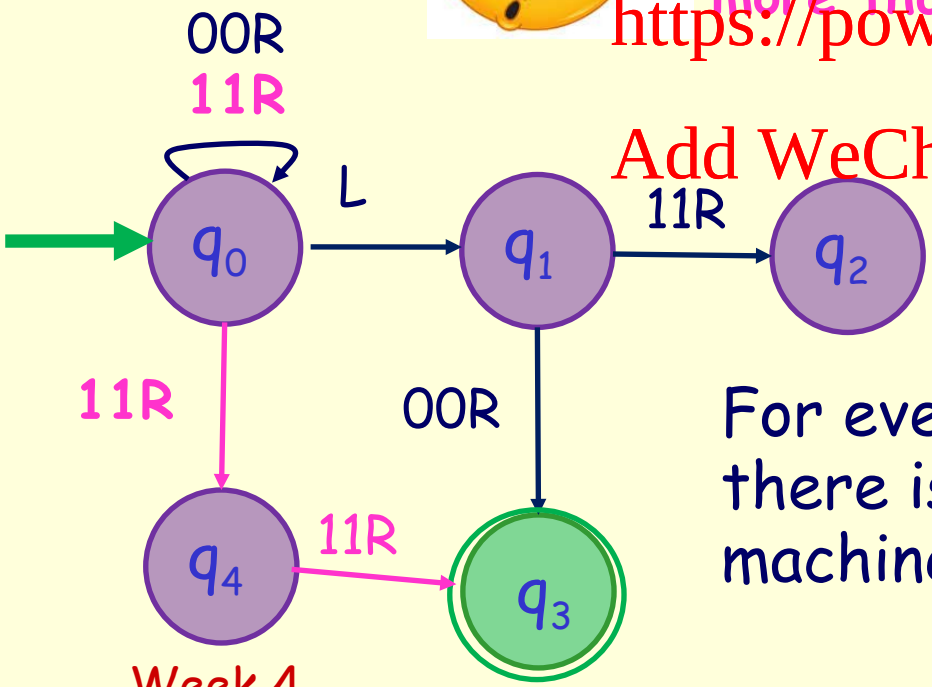
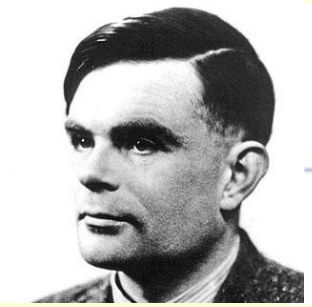
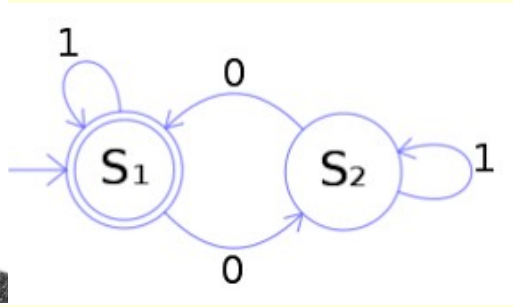


L(M) = { strings which end with 0 or contain 11}

For every nondeterministic machine, there is an equivalent deterministic machine (!!)

Varieties





For any Turing machine **M**, there is an equivalent Turing machine which uses at most two symbols (plus the blank)

- Encode strings of **M** into say {0,1} as binary codes
- (a 00, b 01, c 10, d 11 etc)
- Will need more states than **M**

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For any Turing machine **M**, there is an equivalent Turing machine which uses at most two states (!!)

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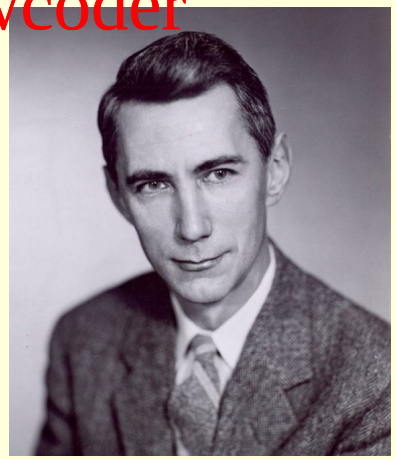
- Uses lots more symbols than **M**
- Classic results from Shannon
- Not well known or understood!



Claude Shannon

'father of Information Theory'

Questions?

Questions?

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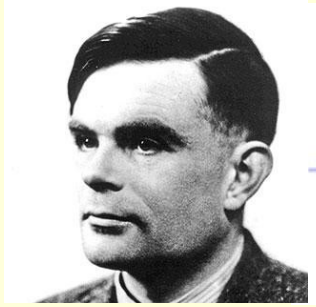
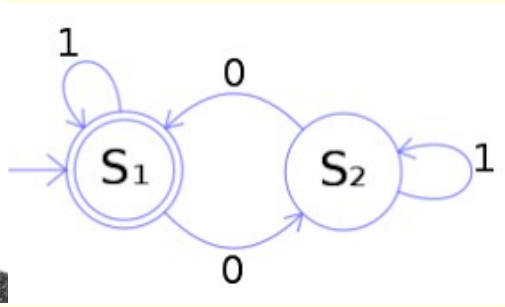
Questions?

Turing machines





- Can define Turing machines just by the **transitions**
- Graphical forms are convenient for humans
- Tables are convenient for machines

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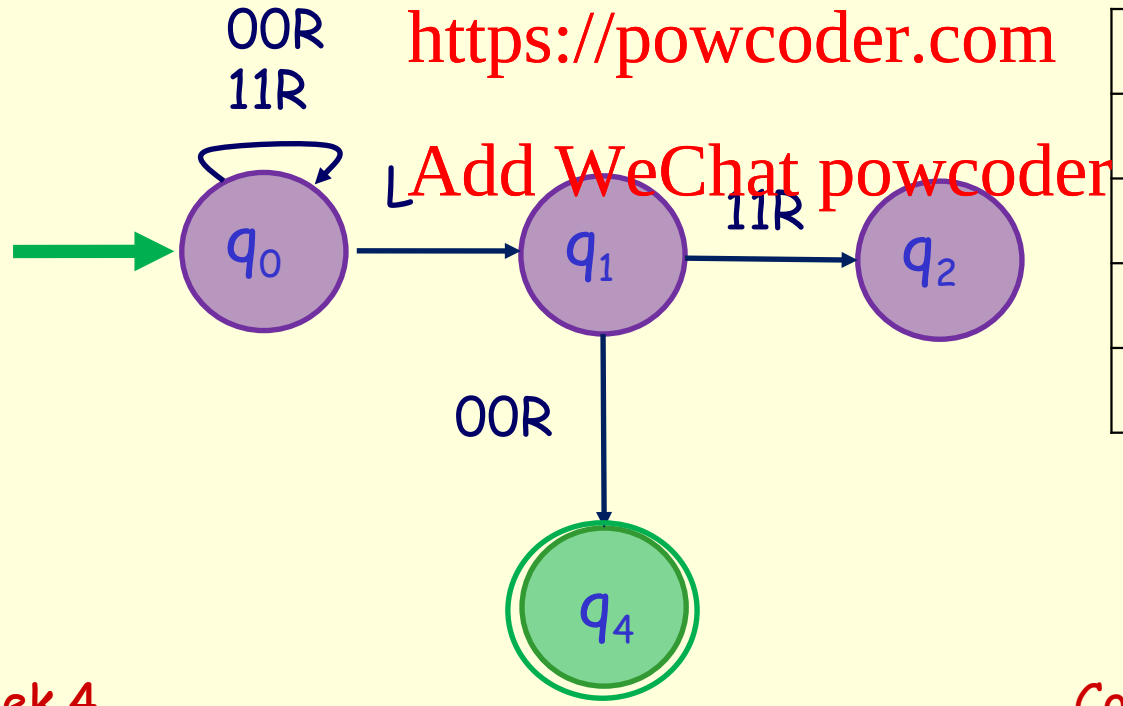
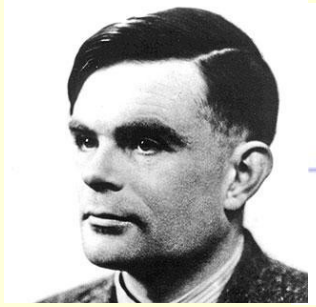
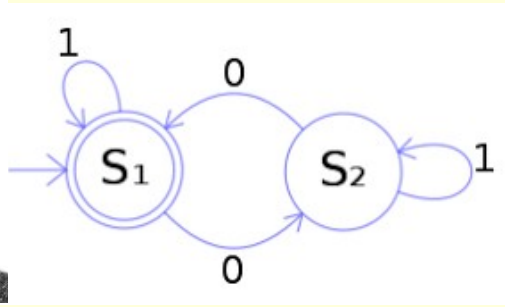


q_0	0	0	R	q_0
q_0	1	1	R	q_0
q_0			L	q_1
q_1	1	1	R	q_2
q_1	0	0	R	q_4

states alphabet

Turing machines





- Can define Turing machines just by the transitions
- Graphical forms are convenient for humans
- Tables are convenient for machines

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- A Turing machine is a table of symbols
- Each row can be represented as a string
- Rows of strings can be represented as a string

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A Turing machine can be represented as a string

q_0	0	0	R	q_0
q_0	1	1	R	q_0
q_0			L	q_1
q_1	1	1	R	q_2
q_1	0	0	R	q_4

A Turing machine can be an input to a Turing machine (!!)

Quiz time!

Go to **Canvas** and find the quiz **Week 4 Question Set 2**

- Not worth any marks
- Just for practice
- Time limit will be one minute (which should be more than enough!)

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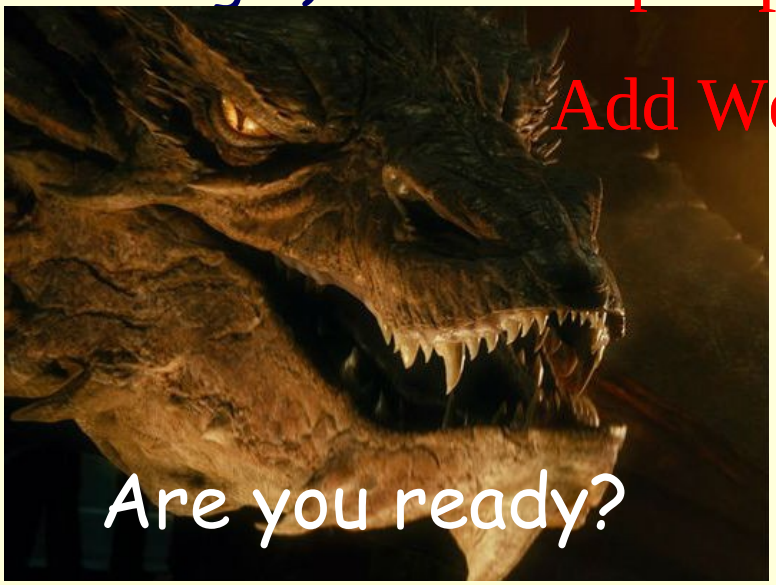

Go!

The pictures will take 1 minute to disappear!

Thomas music means 30 seconds left!

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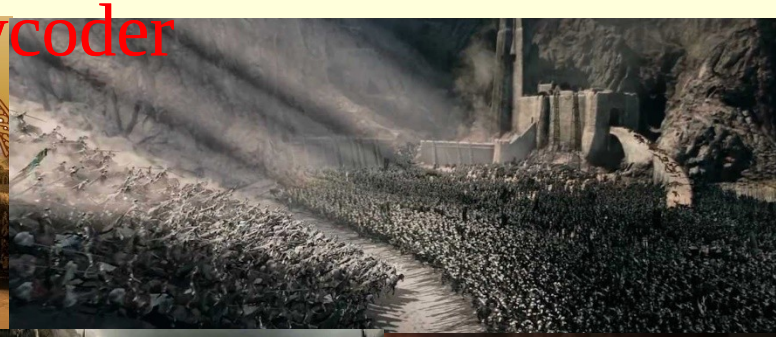



How did you go?

Question 1: Turing machines always terminate. **FALSE (!!)**

Question 2: Correct statements?

- Turing machines can recognise languages. **True**
- Turing machines can compute functions. **True**
- Turing machines are as powerful as computing formalisms can be. **True**
- Turing machines can be built out of Lego. **FALSE (infinite memory)**

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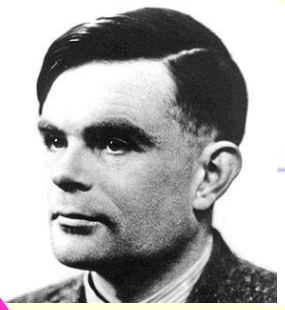
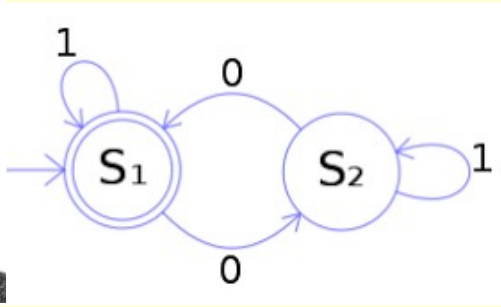
Question 3: Which of the following increase the power of a Turing machine?

- Nothing! **True**
- Replacing a semi-infinite tape with a doubly infinite one. **FALSE**
- Replacing a one-dimensional tape with a two-dimensional one. **FALSE**
- Allowing machines to be nondeterministic. **FALSE**
- Adding an extra tape. **FALSE**

Turing machines





q_0	0	0	R	q_0
q_0	1	1	R	q_0
q_0			L	q_1
q_1	1	1	R	q_2
q_1	0	0	R	q_4

0	q_0	0	q_0	R
1	q_0	1	q_0	R
	q_0		q_1	L
1	q_1	1	q_2	R
0	q_1	0	q_4	R

0	1		1	0
q_0	q_0	q_0	q_1	q_1
	1		1	0
q_0	q_0	q_1	q_2	q_4
R	R	L	R	R

input
state
input
state
move

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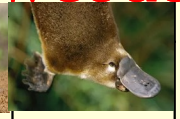
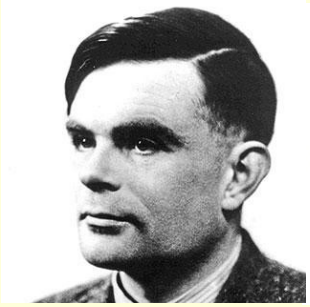
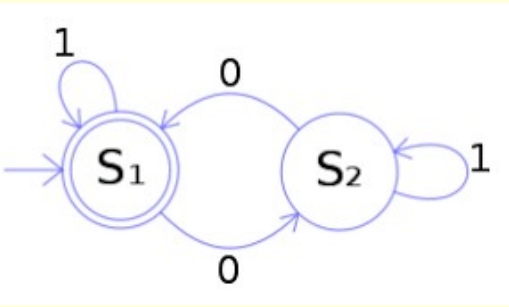
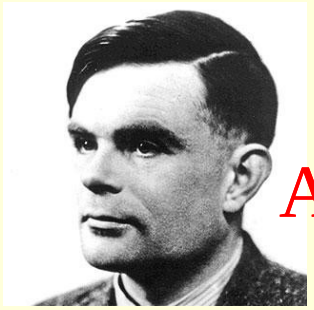
						
colour	colour	colour	colour	colour	colour	colour
animal	animal	animal	animal	animal	animal	animal
tree	tree	tree	tree	tree	tree	tree

Turing machines





	
Infinite tape	Finite tape
1 machine per tape	2 machines per tape

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Fundamental difference we will discuss next week

Not previously explored (to my knowledge)

The Platypus Game

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The Platypus Game

Survey results (so far)

Attempts: 19 out of 19

Which of the following approaches should we use to approximate a tournament of 268,435,456 machines?

"Round robin + knockout" means we divide the machines up into chunks of say 1,000, play a full tournament for each chunk, and then have a knockout round for the 268,000 or so winners.

"Champions League" means we play as many random matches as possible, and use a ranking (ie a ladder in sporting terms) to rank all teams. Once the "season" is over (ie we have no time to play any further matches), the machine that is at the top of the rankings is the winner.

Round-robin + knockout	9 respondents	47 %	✓
Champion's League	9 respondents	47 %	
Something else	1 respondent	5 %	

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The Platypus Game

Survey results (so far)

Attempts: 19 out of 19

The scoring system is a key aspect of playing a tournament. Is this current one too simple? Should it be improved? Please select all of the options that you think are appropriate.

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No change at all	9 respondents	47 %
More points for changing green to yellow (or vice-versa)	3 respondents	16 %
Bonus or penalty scores for terminating the game	5 respondents	26 %
Bonus or penalty scores for reaching a tree	3 respondents	16 %
Score multiplied by the number of platypodes in the machine	2 respondents	11 %
Tiebreaker of some sort	7 respondents	37 %
Other		0 %

The Platypus Game

Survey results (so far)

No change at all	14 respondents	74 %
Games run on more than one starting set of cells (all green, "chess like", random)	1 respondent	5 %
Shortening or lengthening the maximum number of turns before a game ends (currently 100)	1 respondent	5 %
More players (3 to 8 say)		0 %
Larger or smaller number of cells (eg 11? 31? 101?)	2 respondents	11 %
Different rules for teaching a tree?		0 %
More colours	2 respondents	11 %
More animals	3 respondents	16 %
2-dimensional board		0 %
Machines change somehow during play	2 respondents	11 %
Something else		0 %

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Theory

The Platypus Game

Survey results (so far)

Do you have any other suggestions or comments about tournaments?

I propose the "Double Elimination Tournament" style which is like a normal bracket knockout style except you have to lose 2 matches to be knocked out. There are two brackets and when an entity loses for the first time it joins the "Losers Bracket" and must be knocked out of that to be fully out of the tournament.

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Sounds interesting!

All suggestions are good I would just like more player involvement. The machine is entirely deterministic and that's boring.

Very true (ie it is deterministic). What would be 'less boring'?

Lets host the playtpus game on the cloud so it can run 24/7.

I will see what I can do ..

The Platypus Game

Survey results (so far)

Do you have any other suggestions or comments about tournaments?

Maybe instead of a champion's league with random matchups there are brackets to determine which machine you can fight against? (like an elo rating system to determine which players are suitable matches to play with)..

Sounds interesting too!

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The Platypus Game

Survey results (so far)

Are there any other suggestions or comments about scoring?

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For the tiebreaker, maybe let the match be that reaches the green cell with platypus be the winner.

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Interesting --- so we reward the 'bold platypodes'!

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I would like a change to the scoring system that allows the player to be rewarded for taking more risk.

Similar, presumably …

Simple is better, and changes to rules would not change the outcome too much.

No change is easy to do!

The Platypus Game

Survey results (so far)

Are there any other suggestions or comments about rule changes?

If we have a larger number of cells, then there might be some bonus for reaching a tree since it'll be harder to achieve..

Good thought. Presumably the number of cells and tree options should be linked like this.

Shorter games means faster progression, which I'll deal with happily.

A short game is a good game!

There is still time to complete the survey, so get your answers in now!

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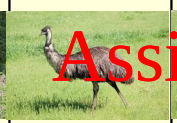
The Platypus Game

Why 268 machines?

						
2	2	2	2	2	2	2
4	4	4	4	4	4	4
2	2	2	2	2	2	2

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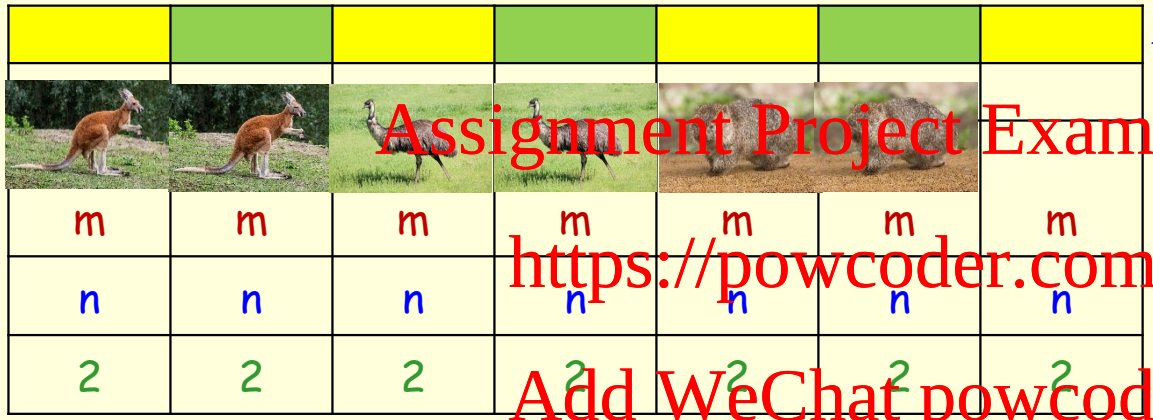
16 X 16 X 16 X 16 X 16 X 16 X 16 = 16^7

16^7 = **268,435,456**

What would be the general formula for m colours and n animals?

The Platypus Game

What would be the general formula for m colours and n animals?



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2mn 2mn 2mn 2mn 2mn 2mn 2mn ... 2mn

mn-1 times

$(2mn)^{mn-1}$

The Platypus Game

$(2mn)^{mn-1}$

n	m	$(2mn)^{mn-1}$
2	2	512
3	2	248,832
4	**2**	**268,435,456**
5	2	512,000,000,000
6	2	1,521,681,143,169,020

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n	m	$(2mn)^{mn-1}$
2	3	248,832
3	3	11,019,960,576
4	**3**	**1,521,681,143,169,020**
5	3	478,296,900,000,000,000,000
6	3	286,511,799,958,070,000,000,000,000

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Questions?

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Questions?

Break time! (We resume when all the pictures are gone! This will take 3 minutes!)

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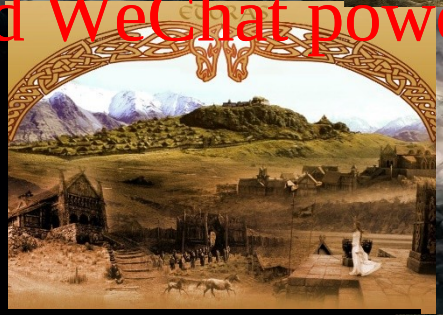


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I AM BACK!


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Alternative Scheme?

Troll	Dreadful	Poor	Acceptable	Exceeds Expectations	Outstanding

Outstanding – CONGRATULATIONS! Your exemplary powers of deduction and a formidable knowledge of the inner workings of the magical world reveal you to be a witch or wizard of genuine skill and learning.

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Exceeds Expectations – Well done – a most creditable performance!

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Acceptable – demonstrates real magical potential.

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Poor – Alas – we regret to inform you that you have narrowly failed. This may have been due to factors outside your control (eg: poltergeist intervention, examination nerves or a malfunctioning quill.) Please do not disconsolate.

Dreadful – We are sorry to inform you that you have failed.

Troll – You would appear either to have abandoned the test due to factors outside your control (eg, earthquake, poltergeist attack), or else you are a troll, in which case you are to be congratulated on being able to use a computer and have achieved the grade of O.F.T. (Outstanding for Trolls).


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