

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.)

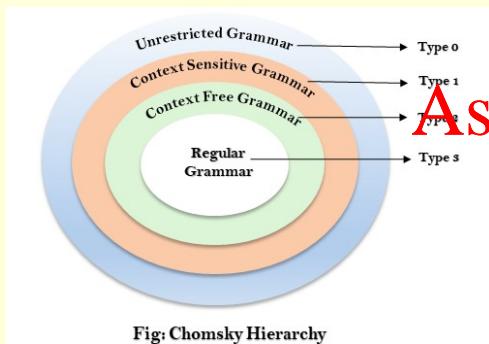
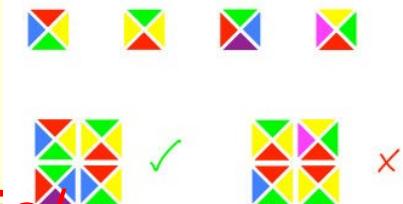


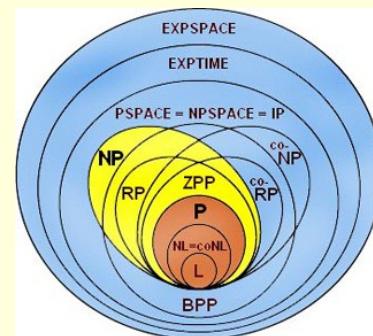
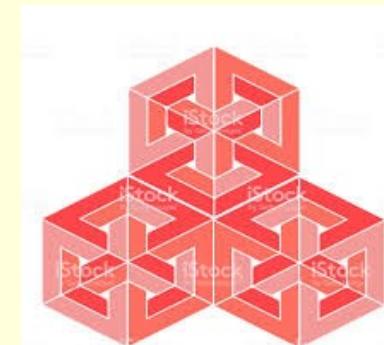
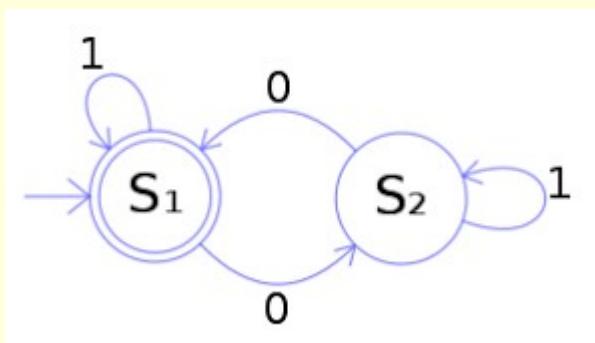
Fig: Chomsky Hierarchy

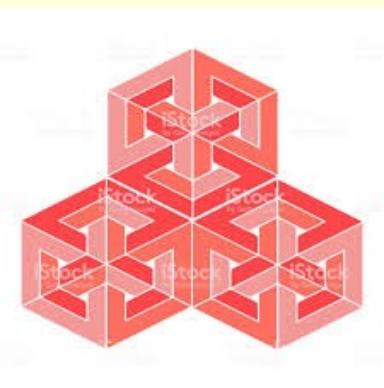
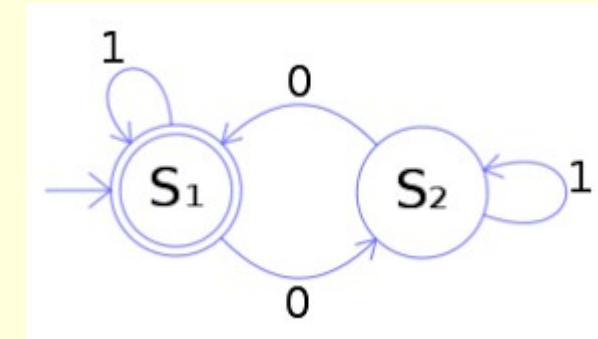
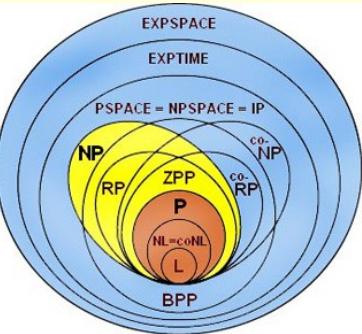
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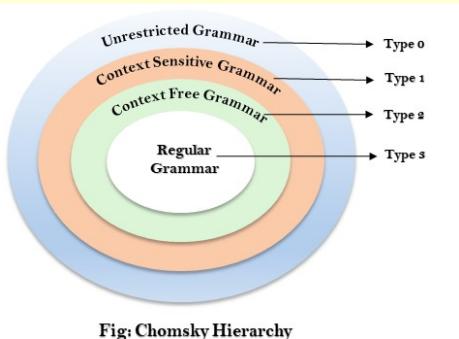
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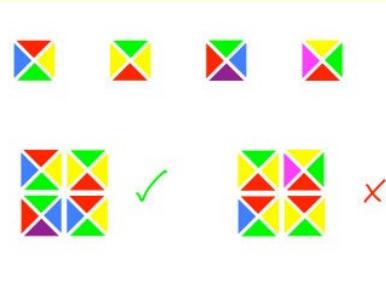


James Harland

james.harland@rmit.edu.au

* With thanks to Sebastian Sardina

Intro music 'Far Over' playing now ...



Week 4

Computing Theory

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 [Assignment Project Exam Help](https://eduassistpro.github.io/) University respectfully acknowledging Elders, past and present. Add WeChat [edu_assist_pro](#)

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)

Week 4

Computing Theory

Overview

- Questions?
- Turing Machines
- Questions? Assignment Project Exam Help
- Platypus Game
- Questions? <https://eduassistpro.github.io/>
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Questions?



Questions?

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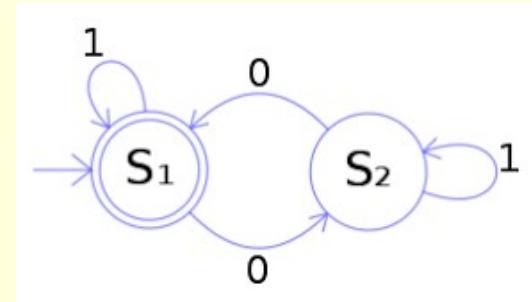
Questions?

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“Computers”

“High tech” circa 1930



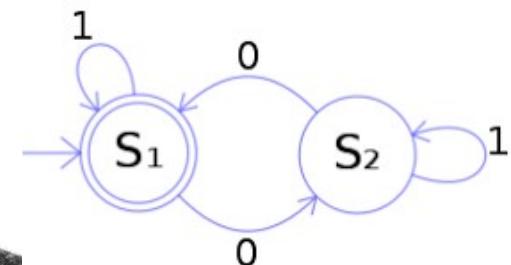
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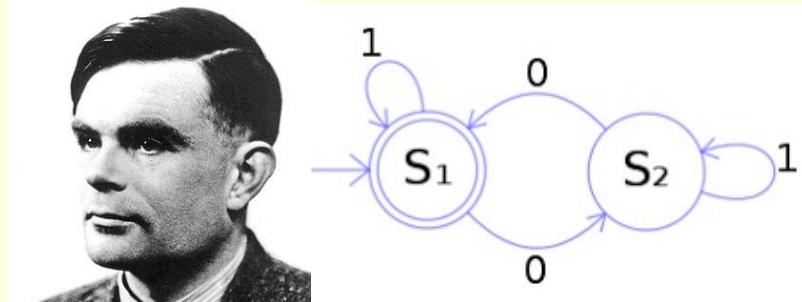


Alan Turing



- English mathematician 1912-1954
- Subject of the 2014 movie 'The Imitation Game'
- Invented Turing machines in 1936
- Involved in British codebreaking enterprise (Enigma) in World War 2 (1 <https://eduassistpro.github.io/intelligence>)
- Invented the Tu
- Computer Science Award ["WeChat Edu Assist Pro"](#) the Turing Award
- British Government formally apologised for his treatment in 2009
- 2012 Turing centenary celebrations
- Google Doodle from 23rd June 2012 is [here](#)

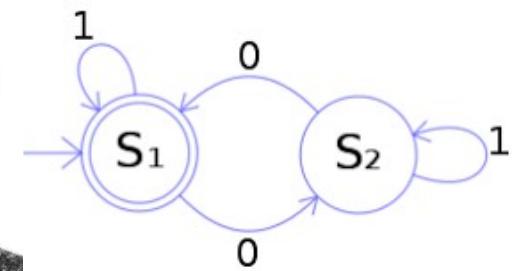
Alan Turing



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

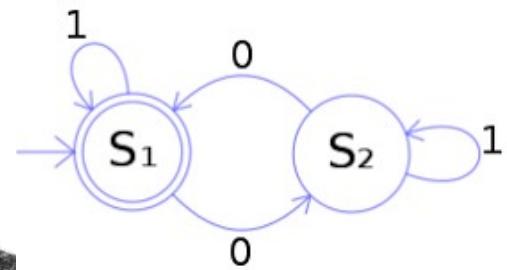
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Turing machines



- Formal model of computation, but intuitive and simple to understand
- Powerful enough to do **any** computation (!!)
- Encode both data *and programs* as strings
- **Church-Turing thesis:** Anything that can be done by an algorithmic process (so "computable" machine) <https://eduassistpro.github.io/> (ring machine)
- **There are problems which are not 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
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- Intended as a natural **aper**
<https://eduassistpro.github.io/>
- Seem to capture the
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- Stripped back to what is absolutely necessary
- **Surprise is that something so simple is so powerful ...**



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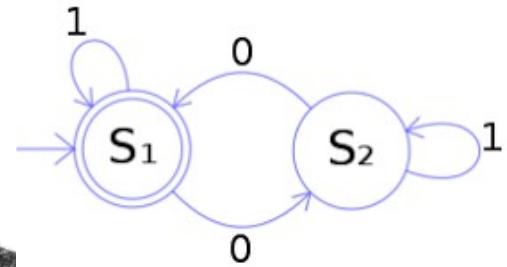


Week 4



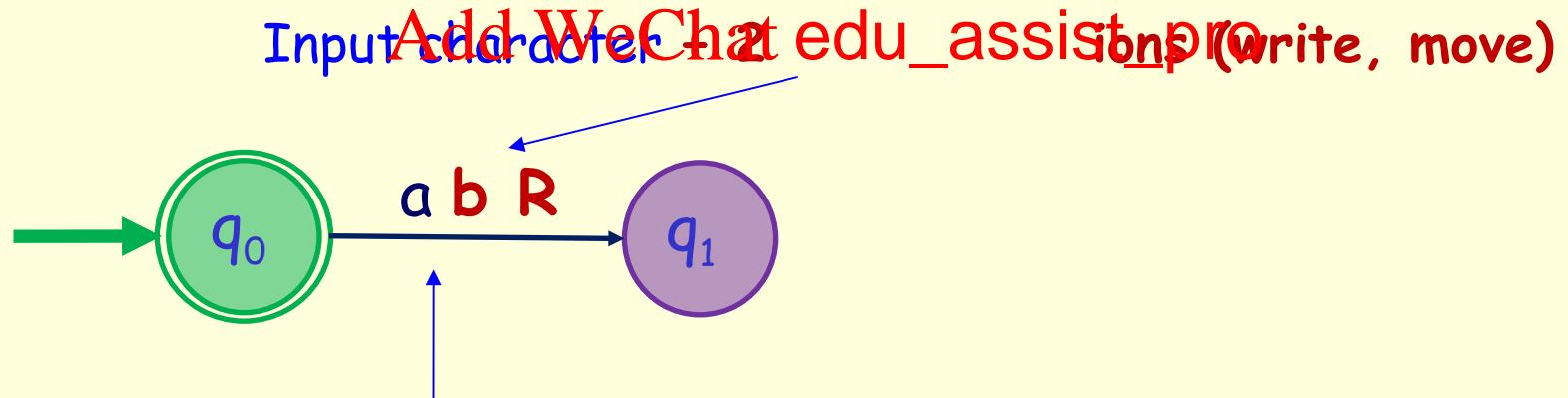
Computing Theory

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 curr
- Output is based on https://eduassistpro.github.io/ (infinitely long)



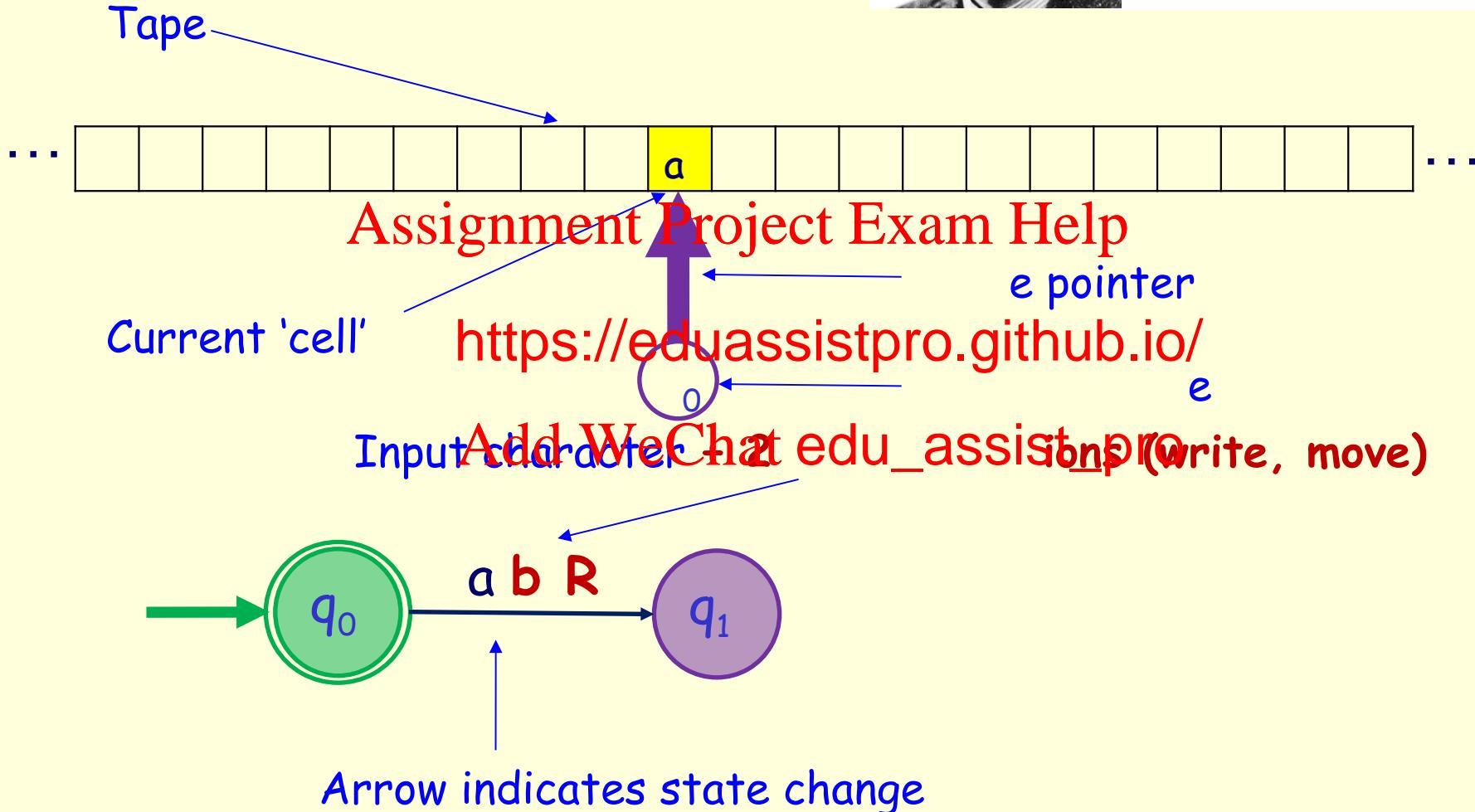
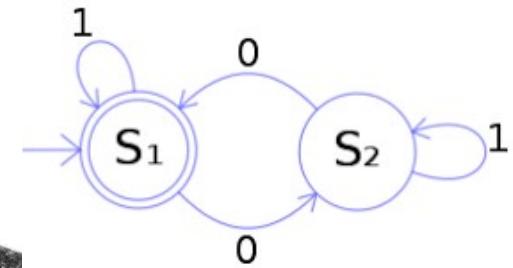
Arrow indicates state change

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

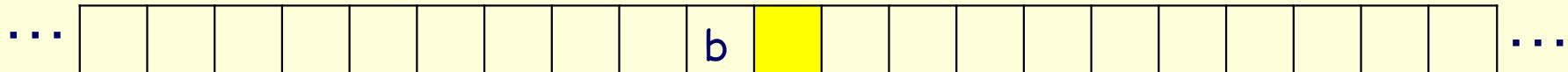
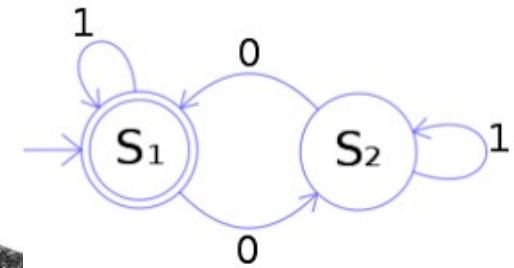
Week 4

Computing Theory

Turing machines



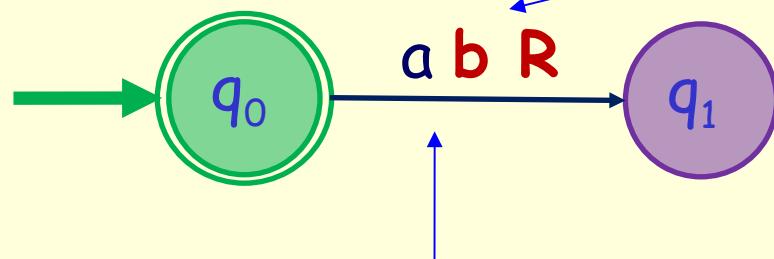
Turing machines



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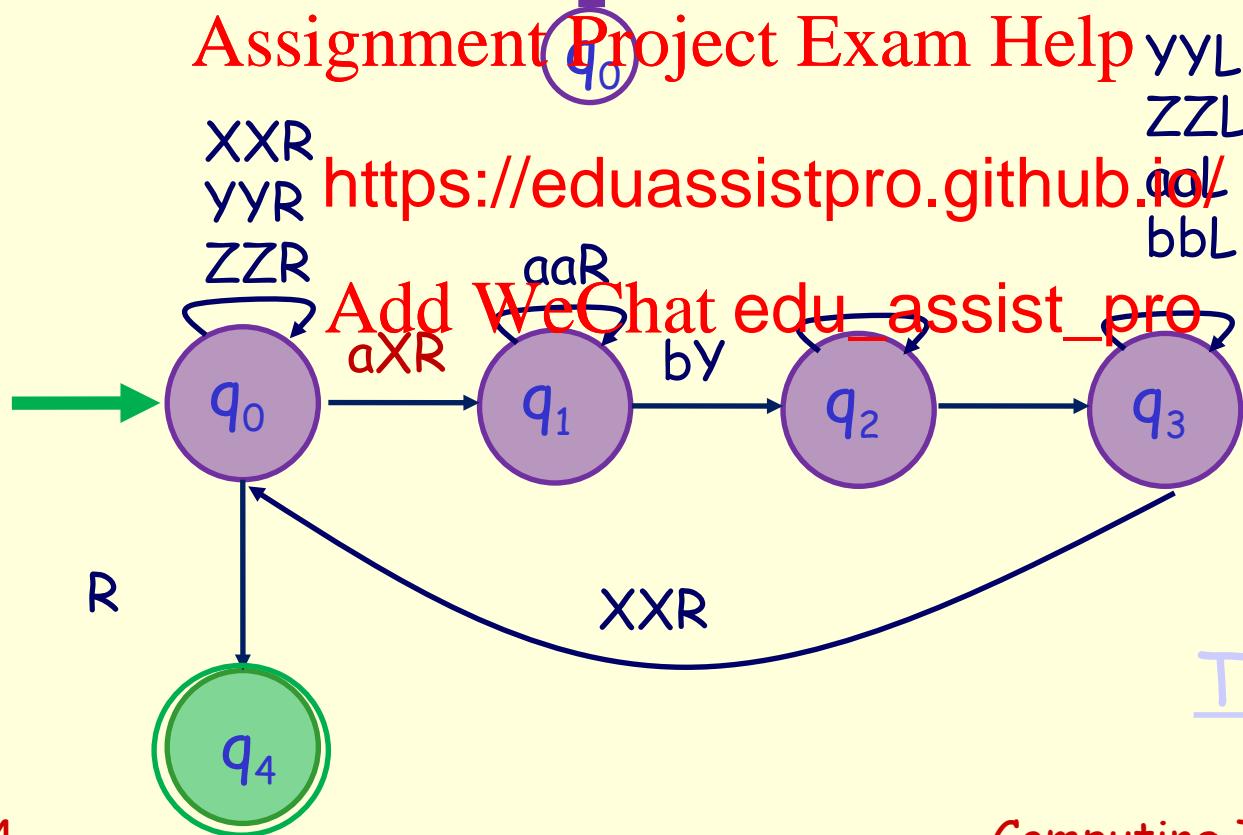
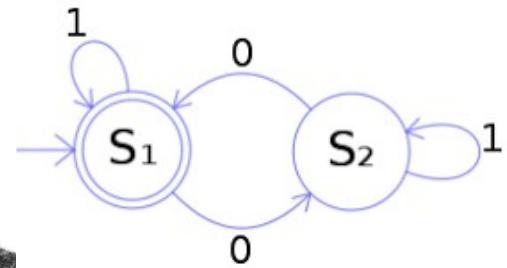
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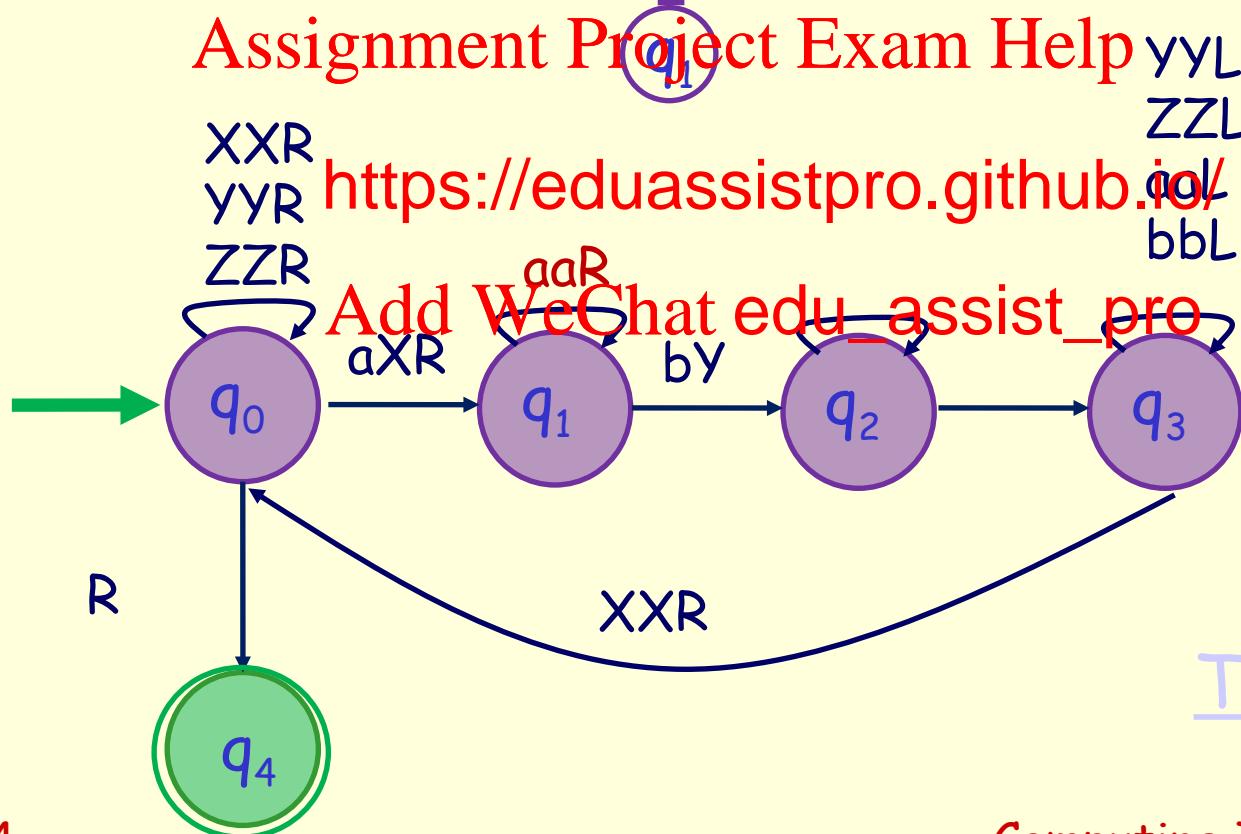
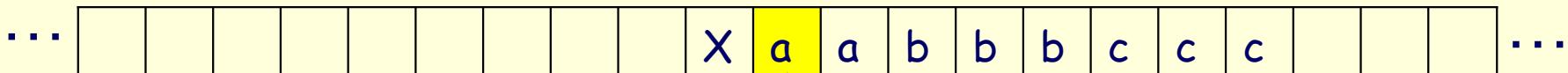
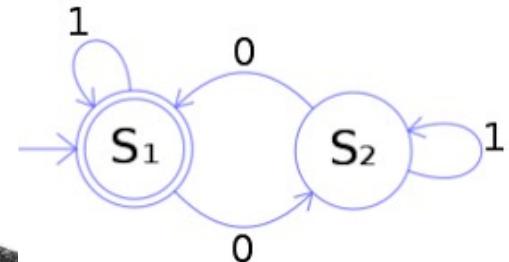


Arrow indicates state change

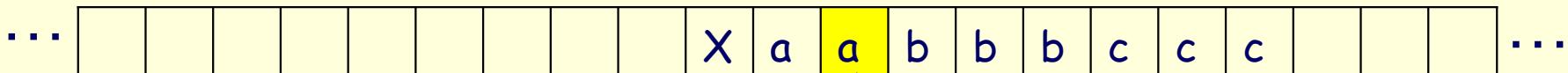
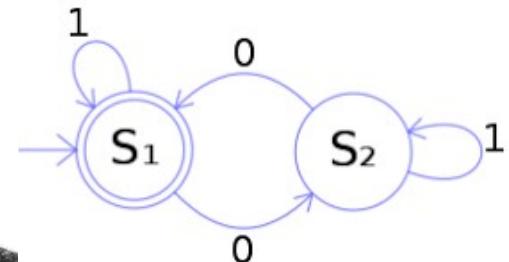
Turing machines



Turing machines



Turing machines



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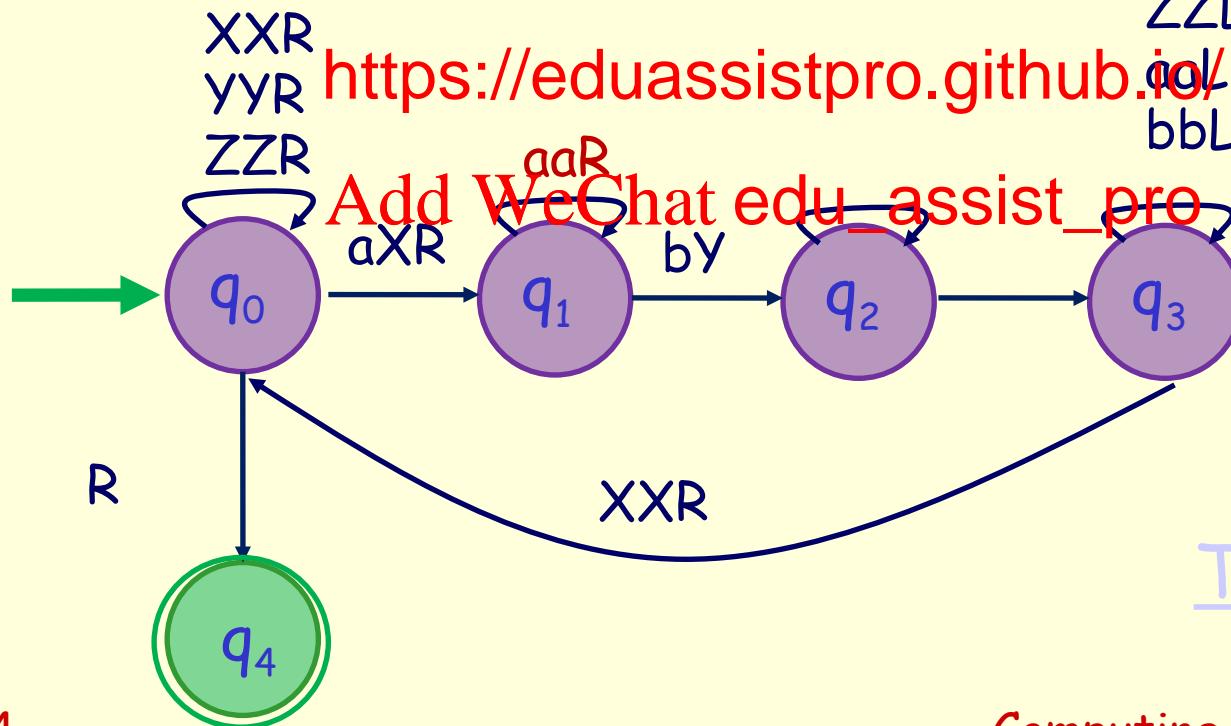
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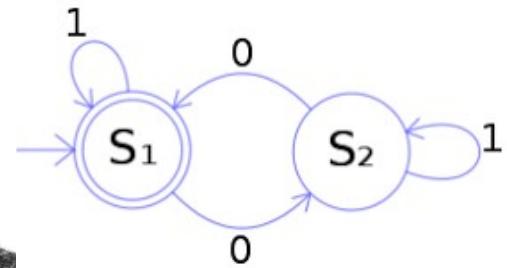
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Turing machines



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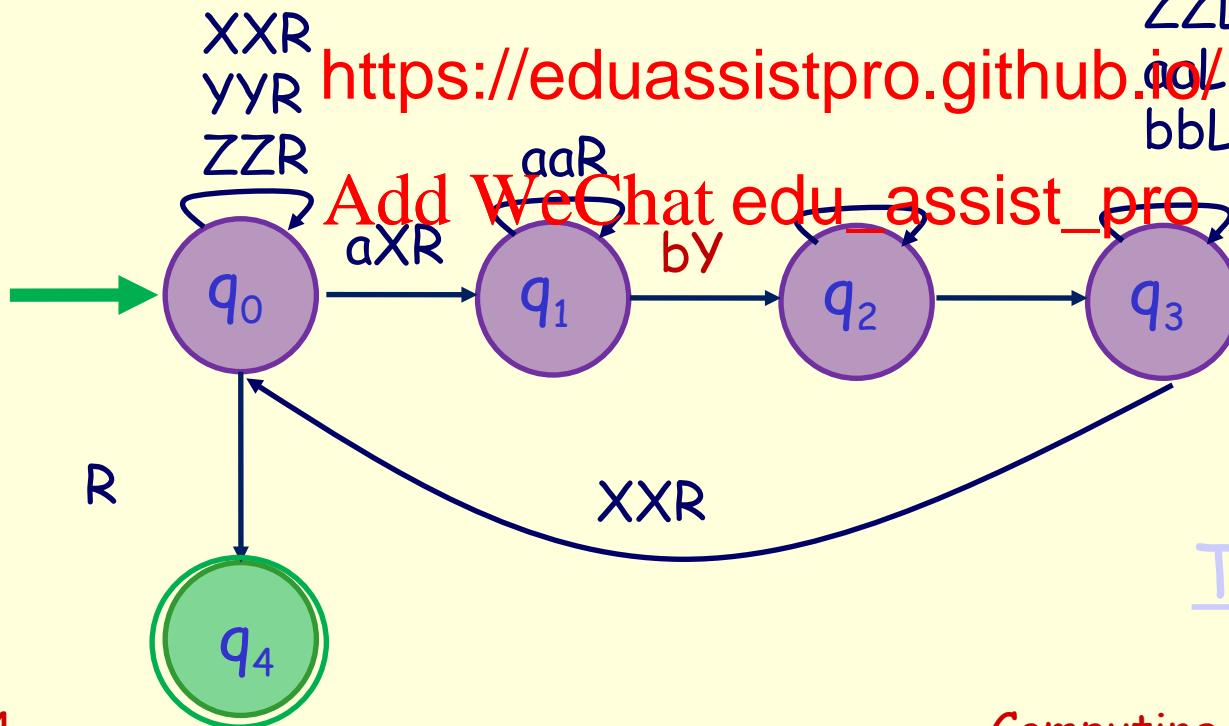
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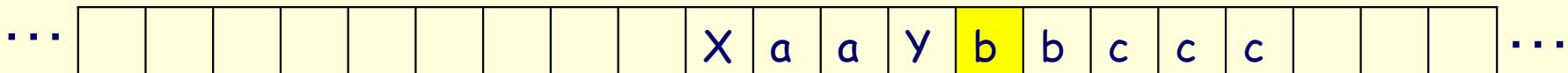
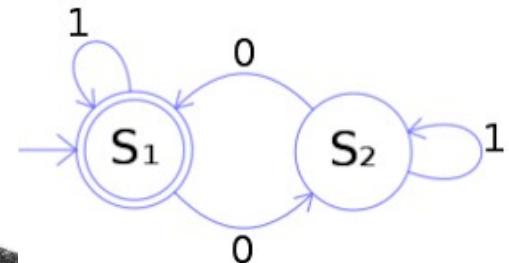
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Turing machines



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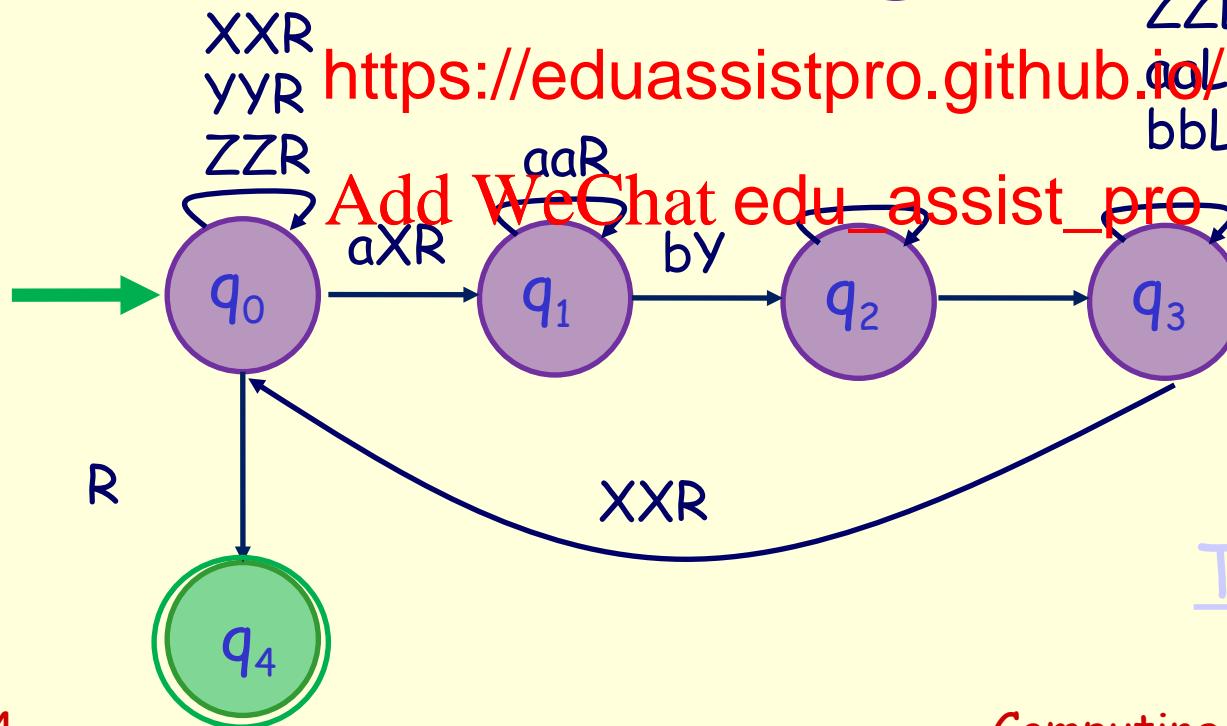
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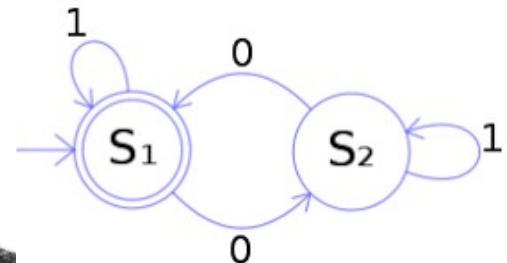
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Turing machines

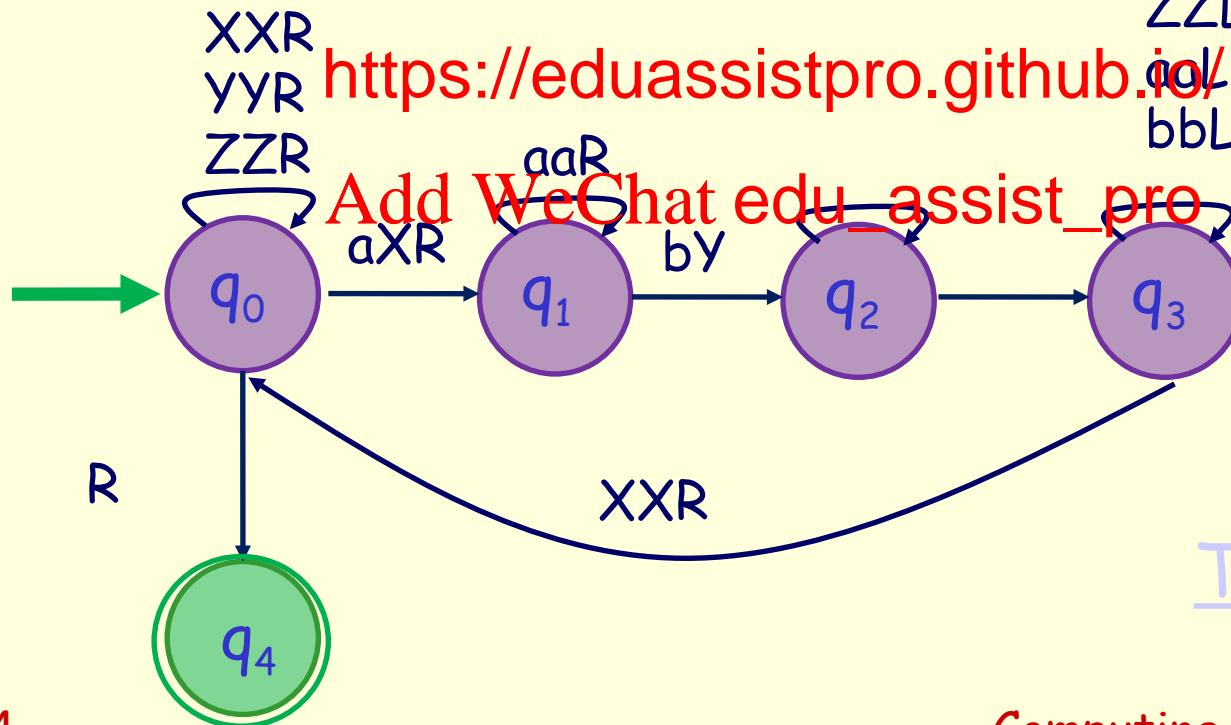


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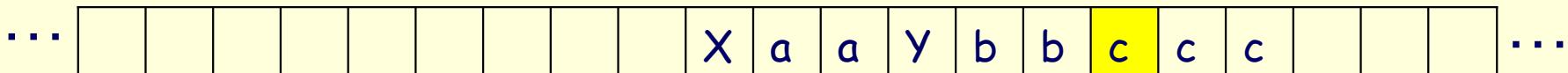
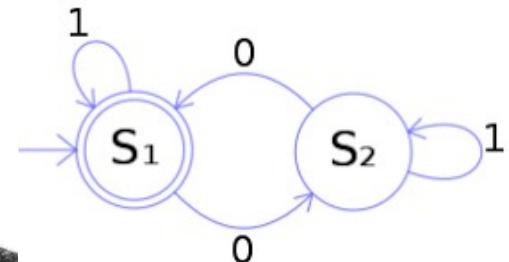
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Turing machines

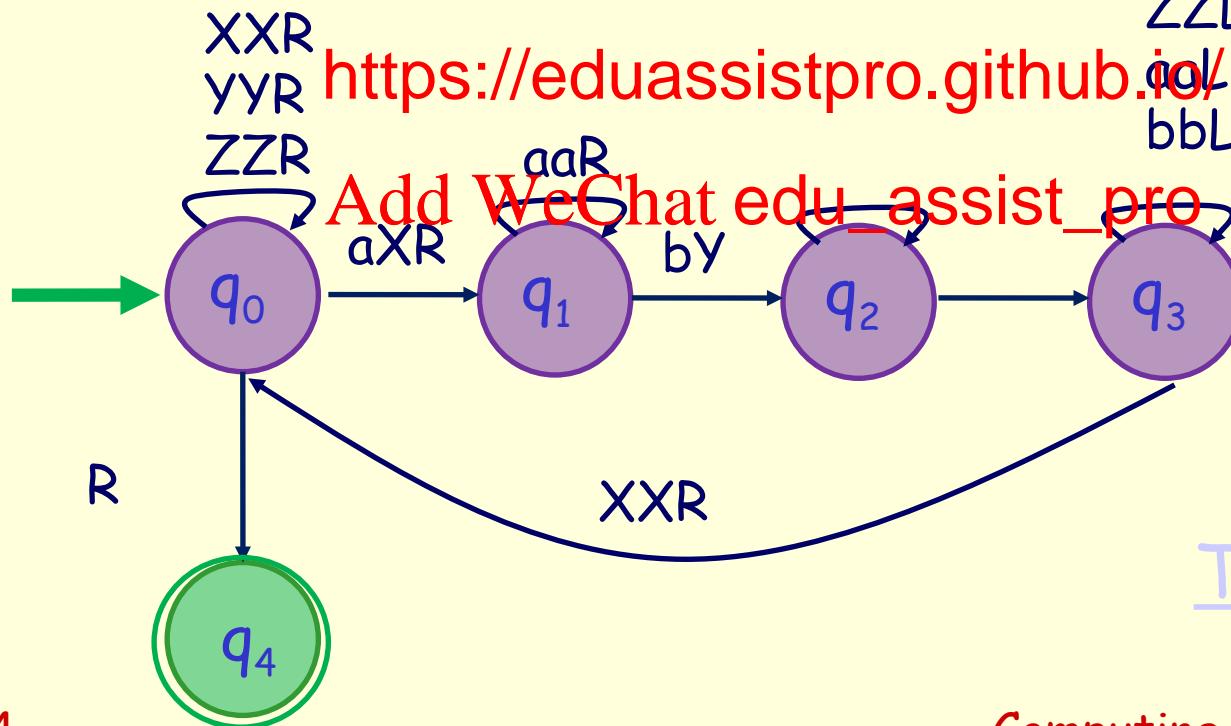


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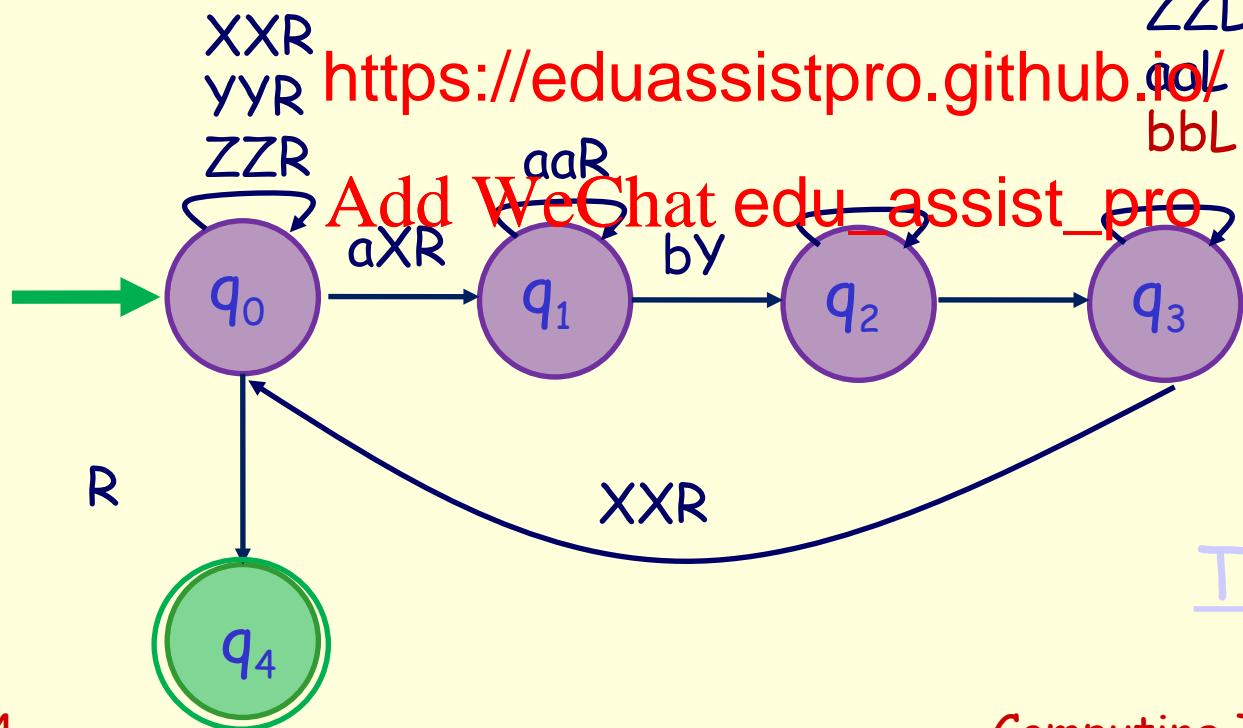
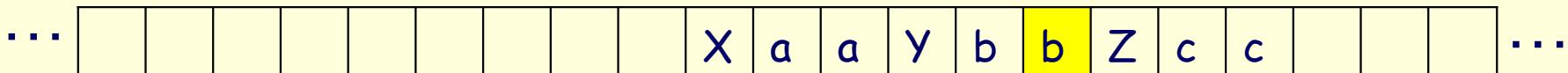
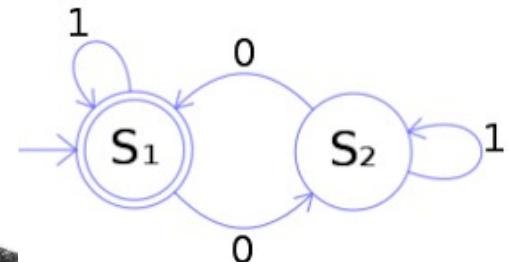
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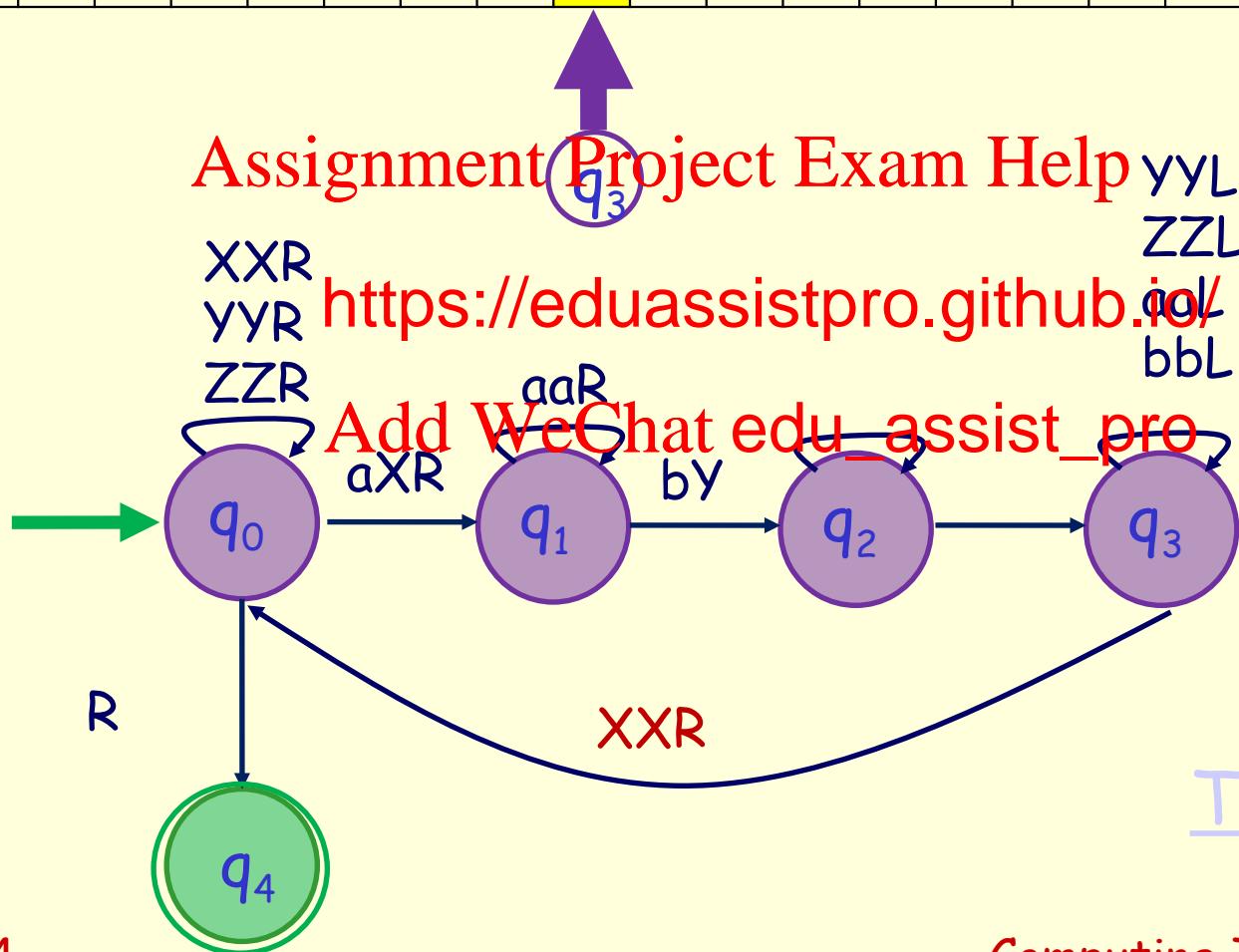
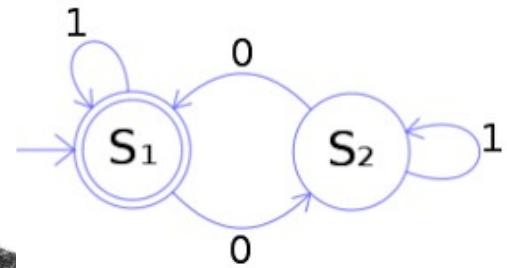


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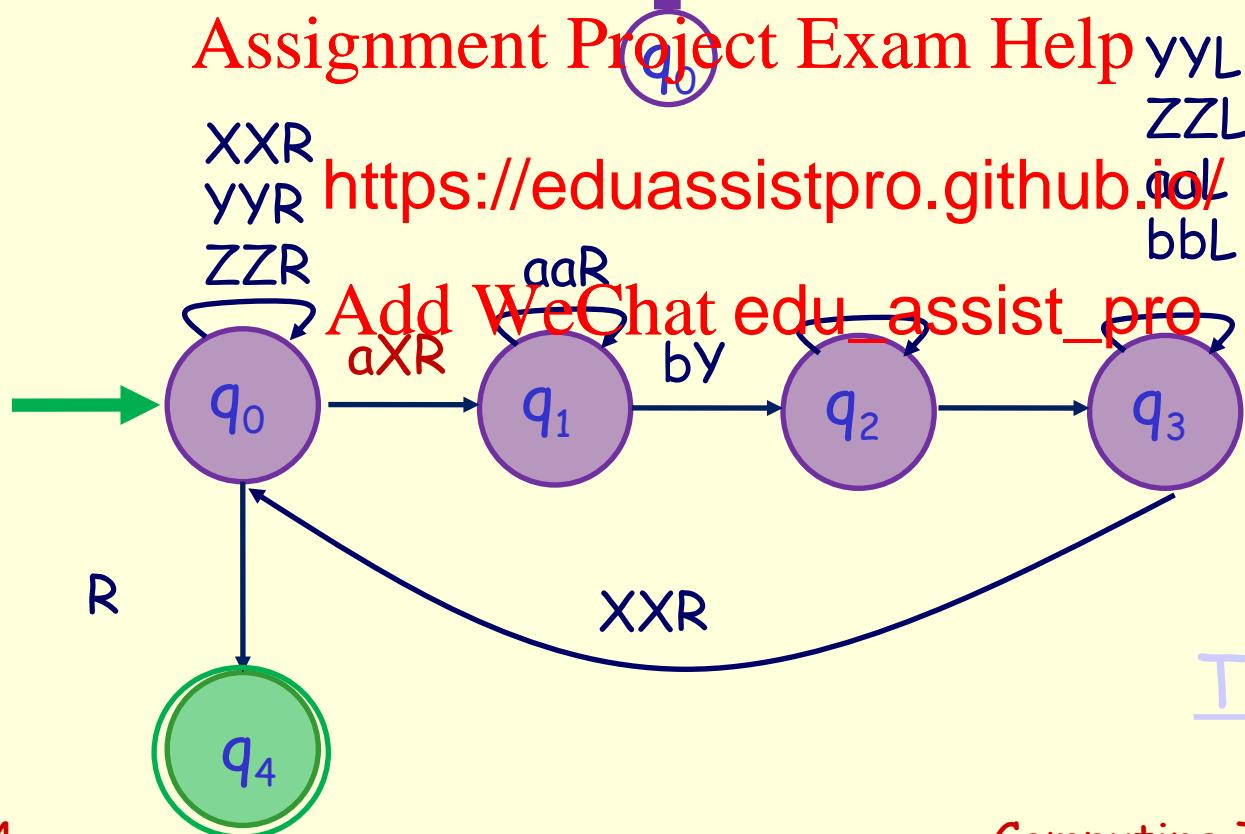
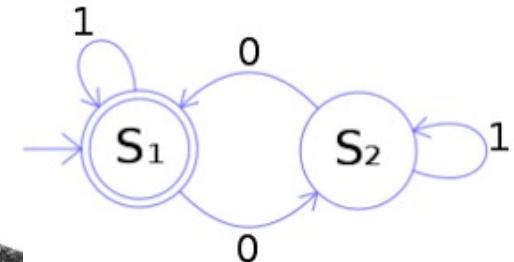
Turing machines



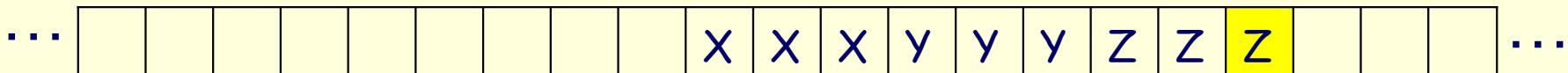
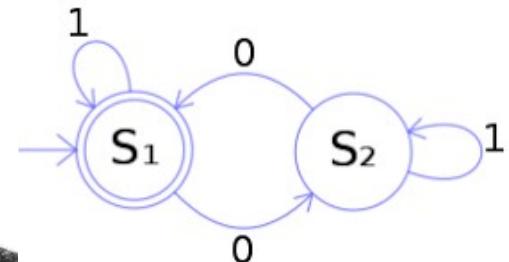
Turing machines



Turing machines



Turing machines



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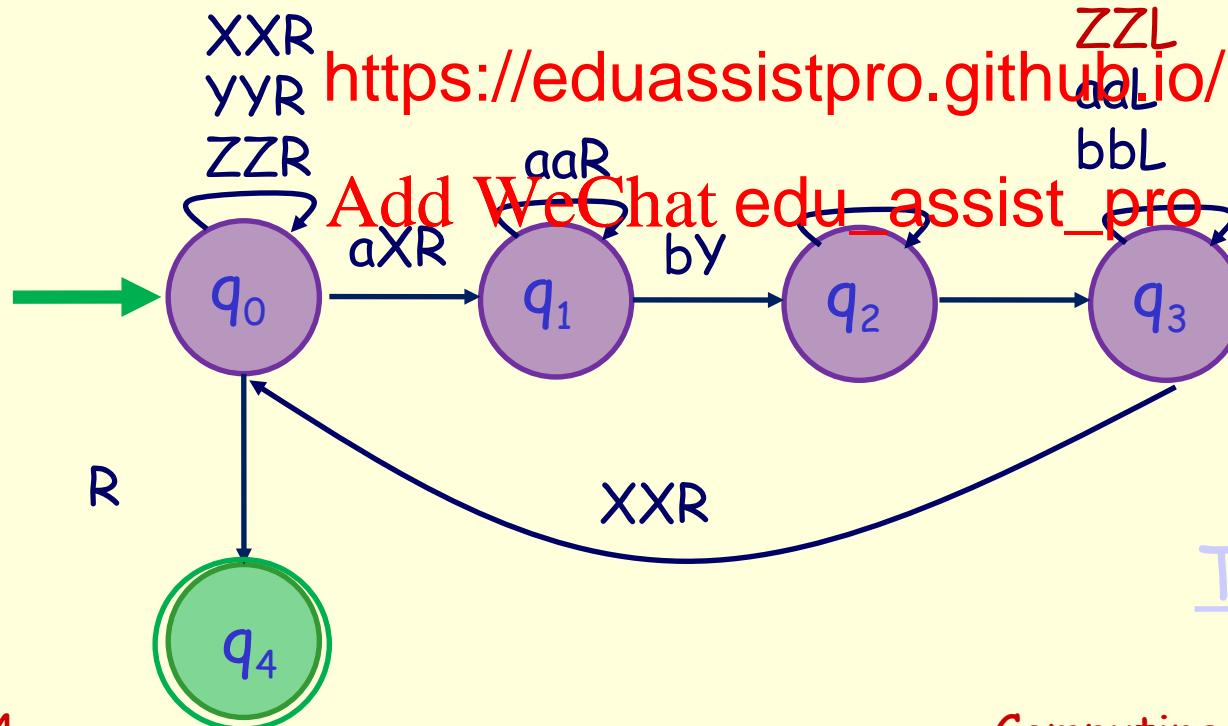
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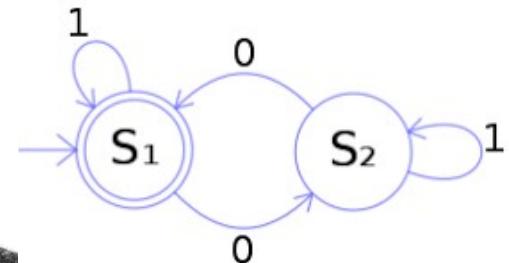
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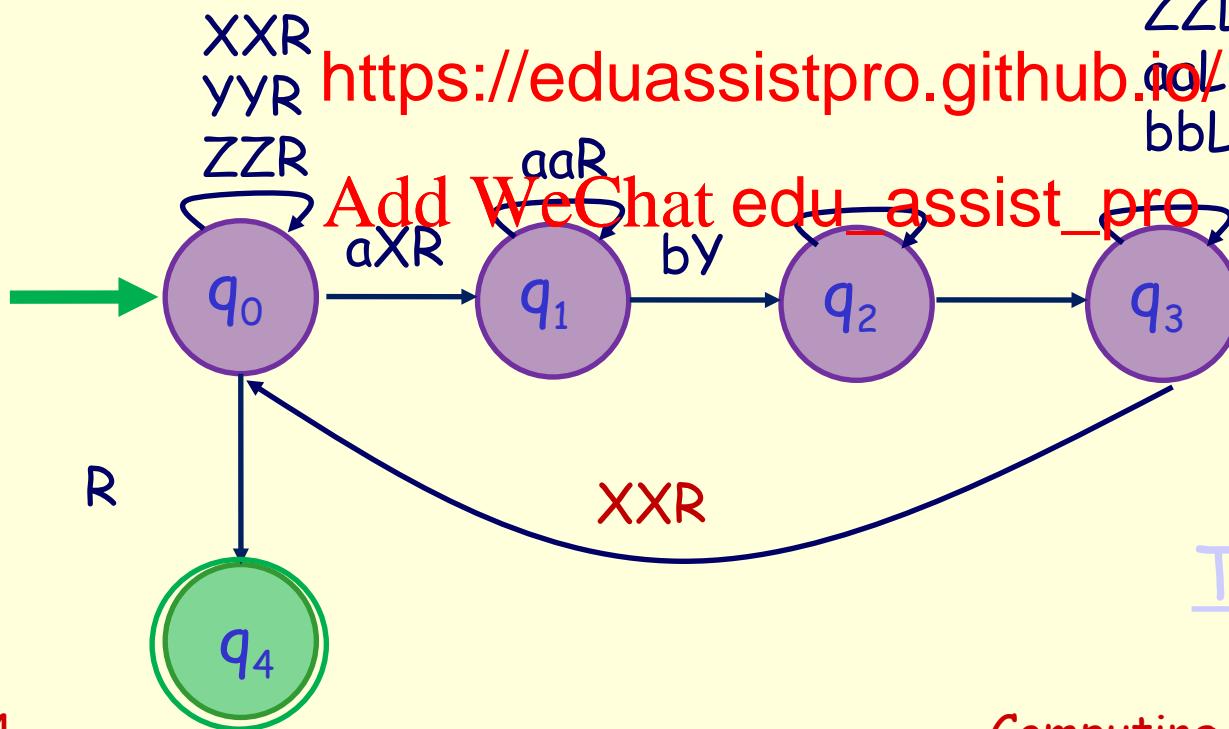
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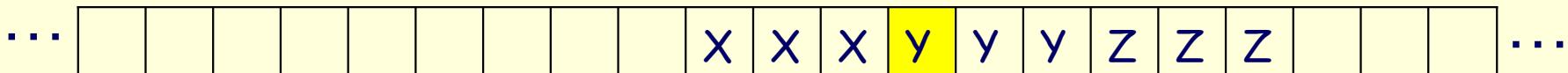
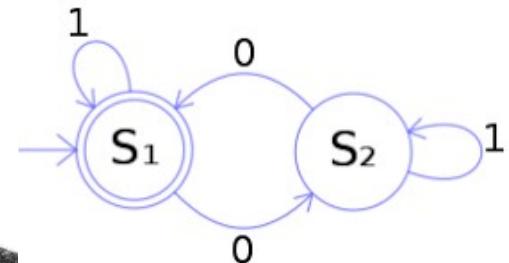
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Turing machines



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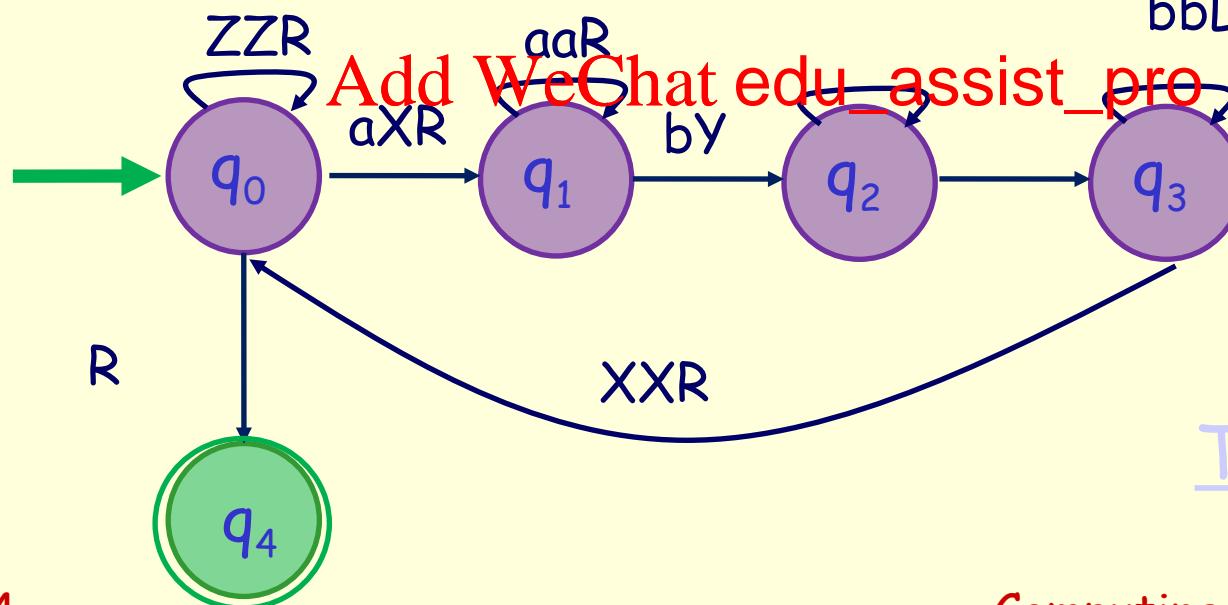
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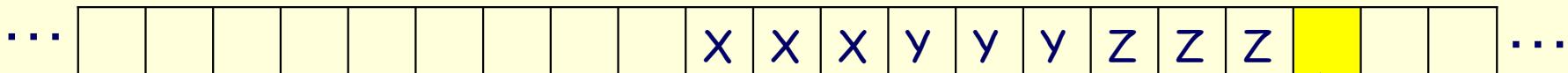
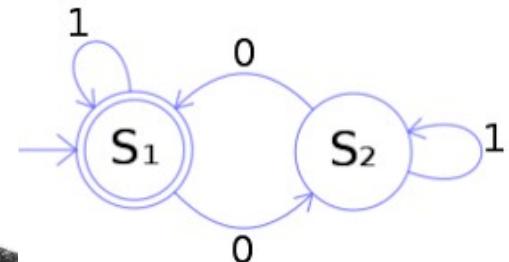
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Turing machines



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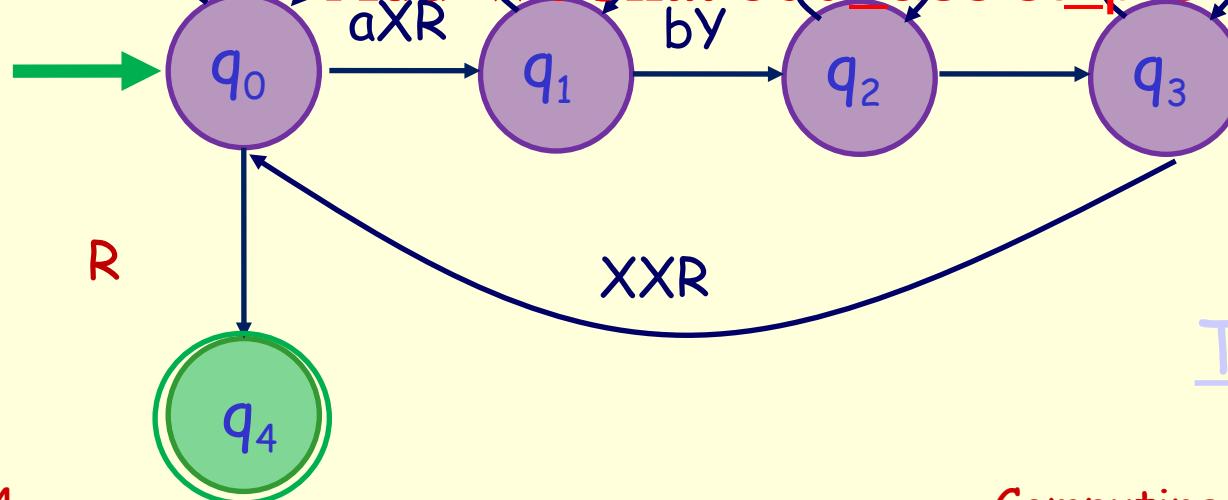
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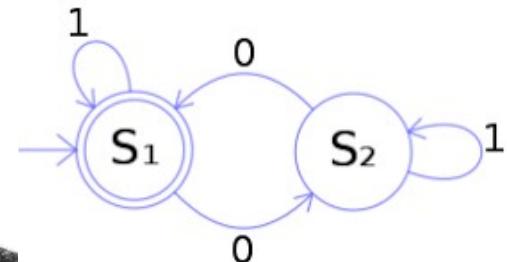
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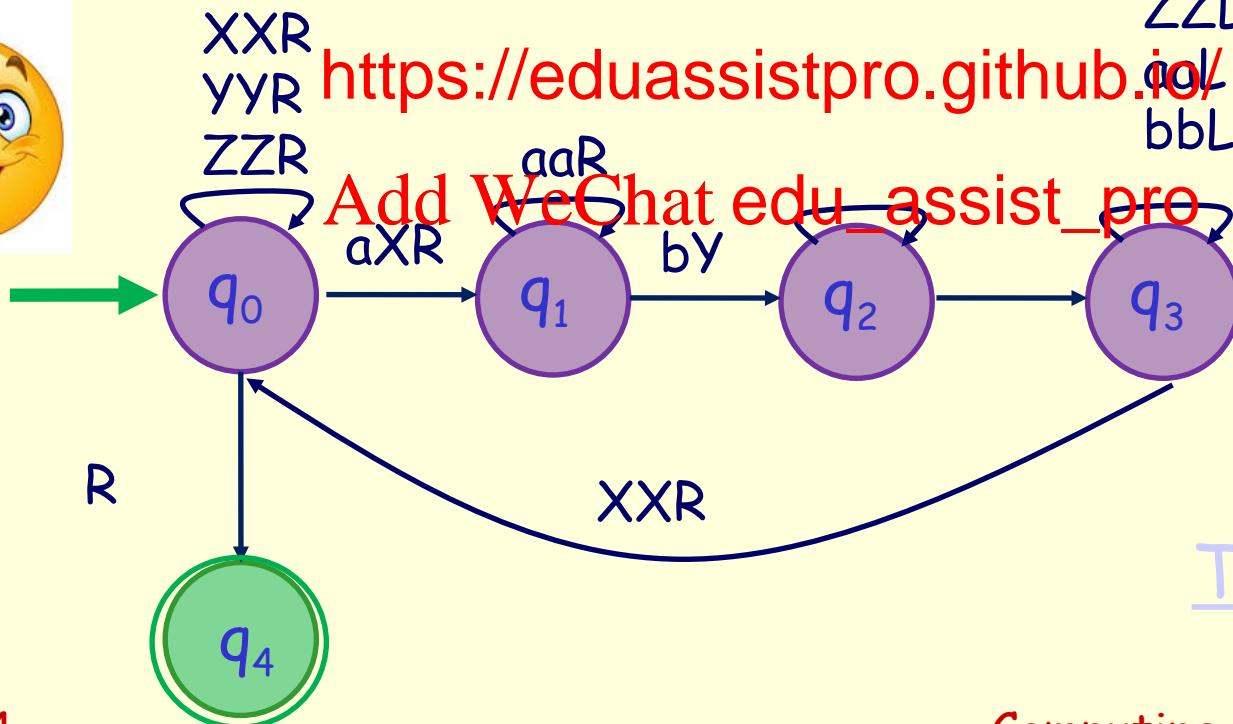
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Turing machines

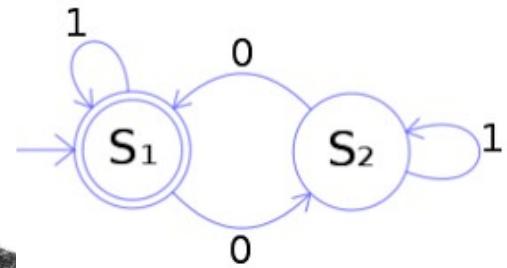


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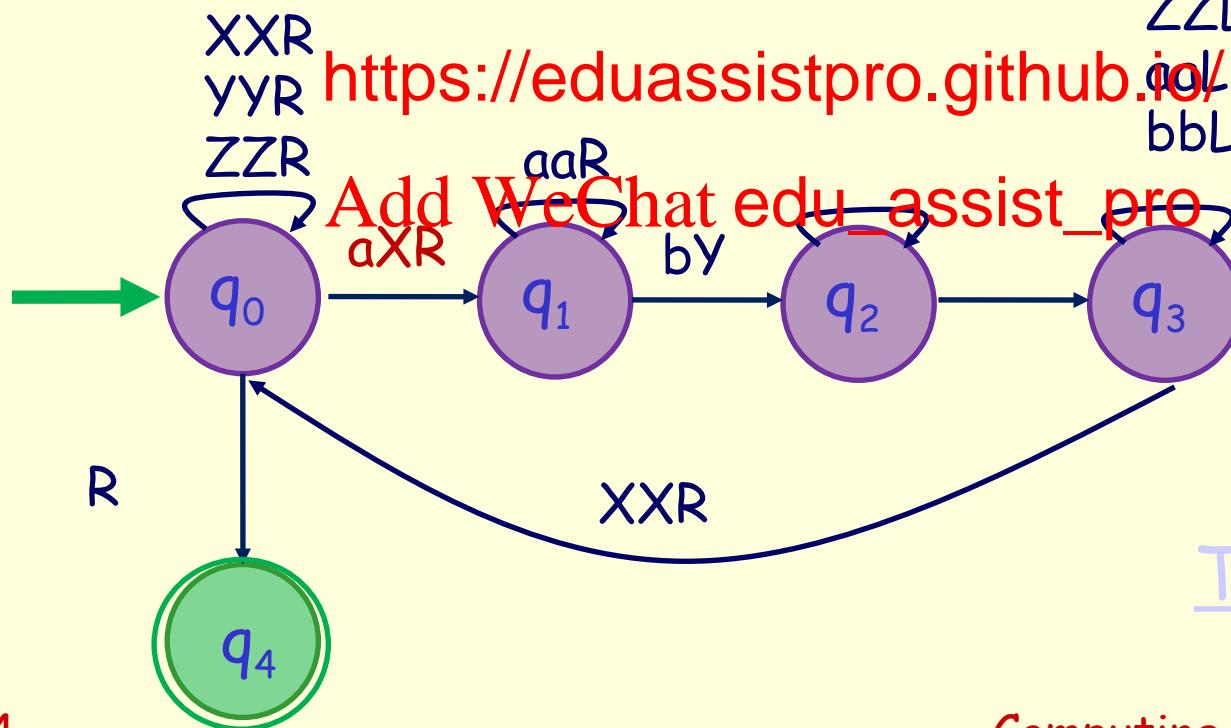
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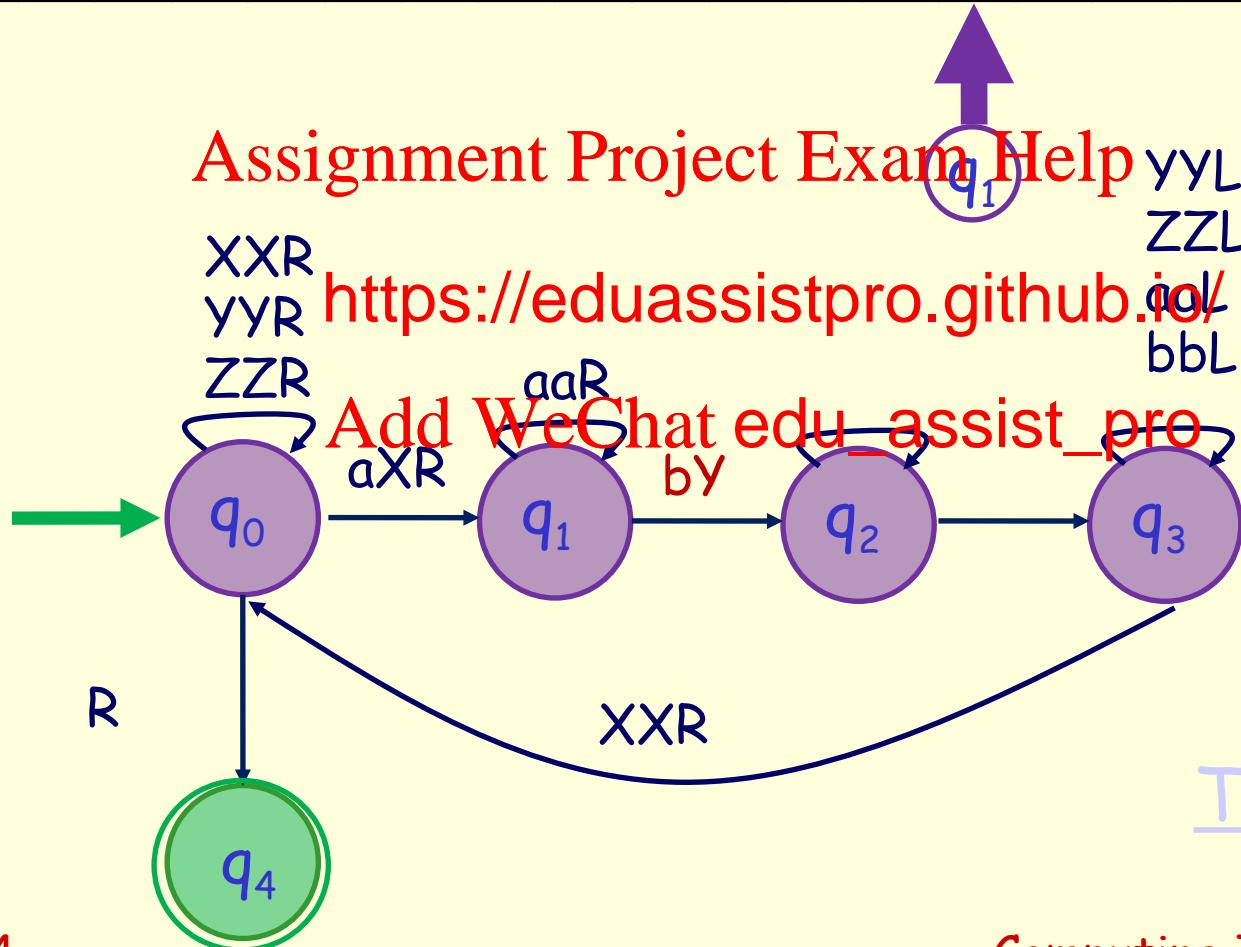
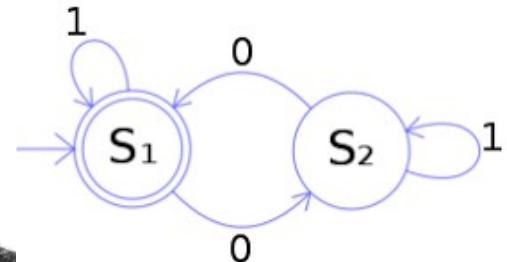
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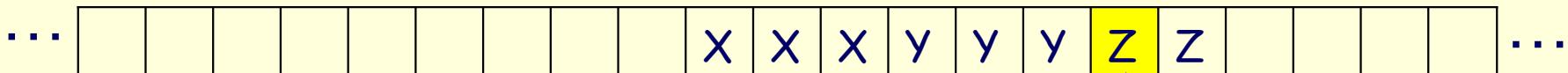
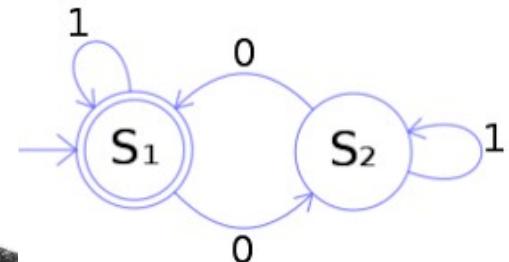
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Turing machines



Turing machines



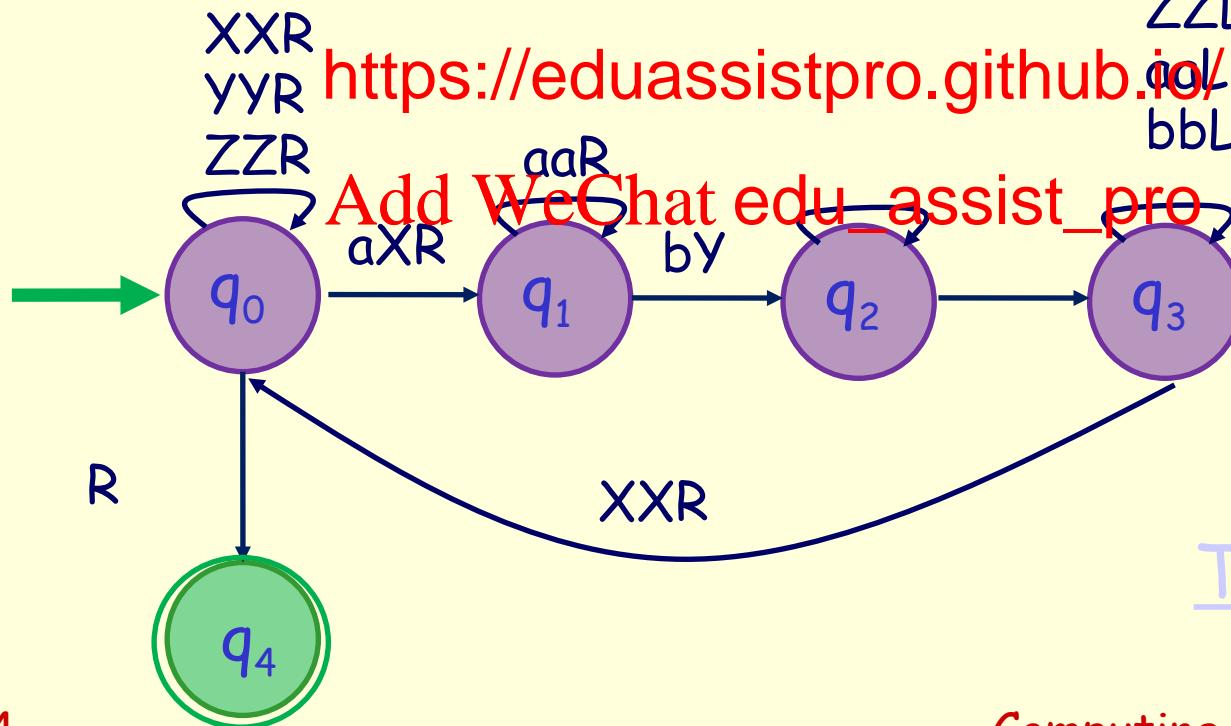
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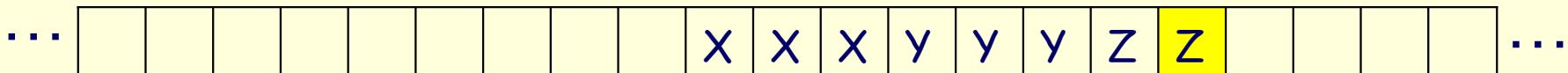
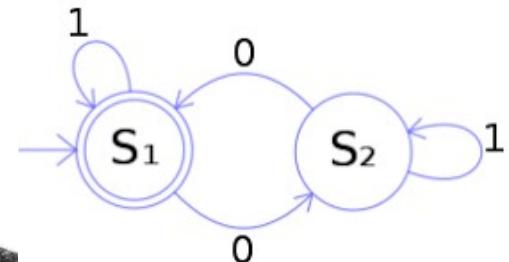
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Turing machines



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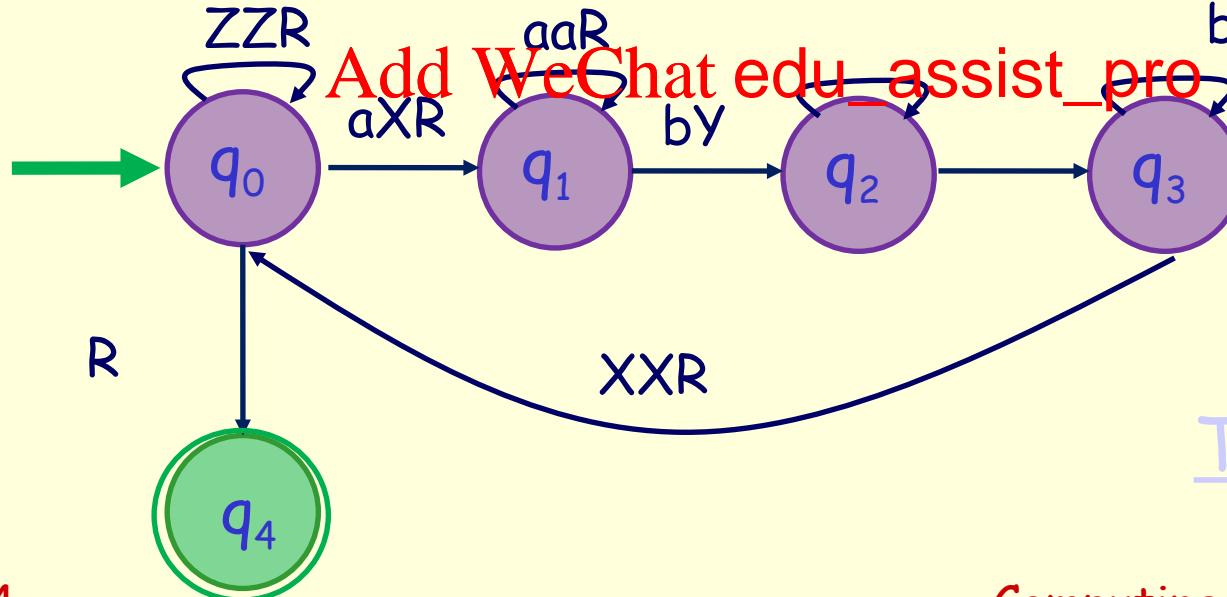
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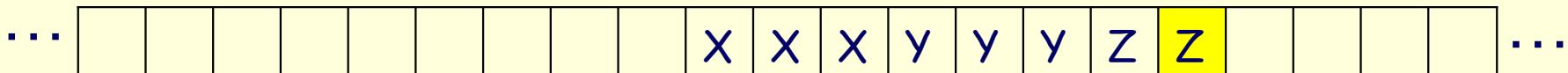
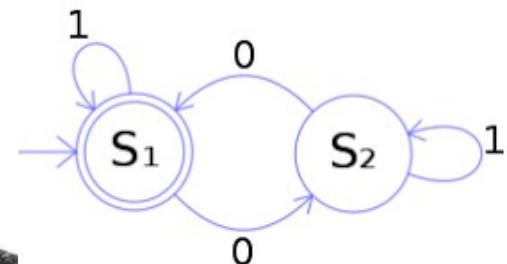
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Turing machines

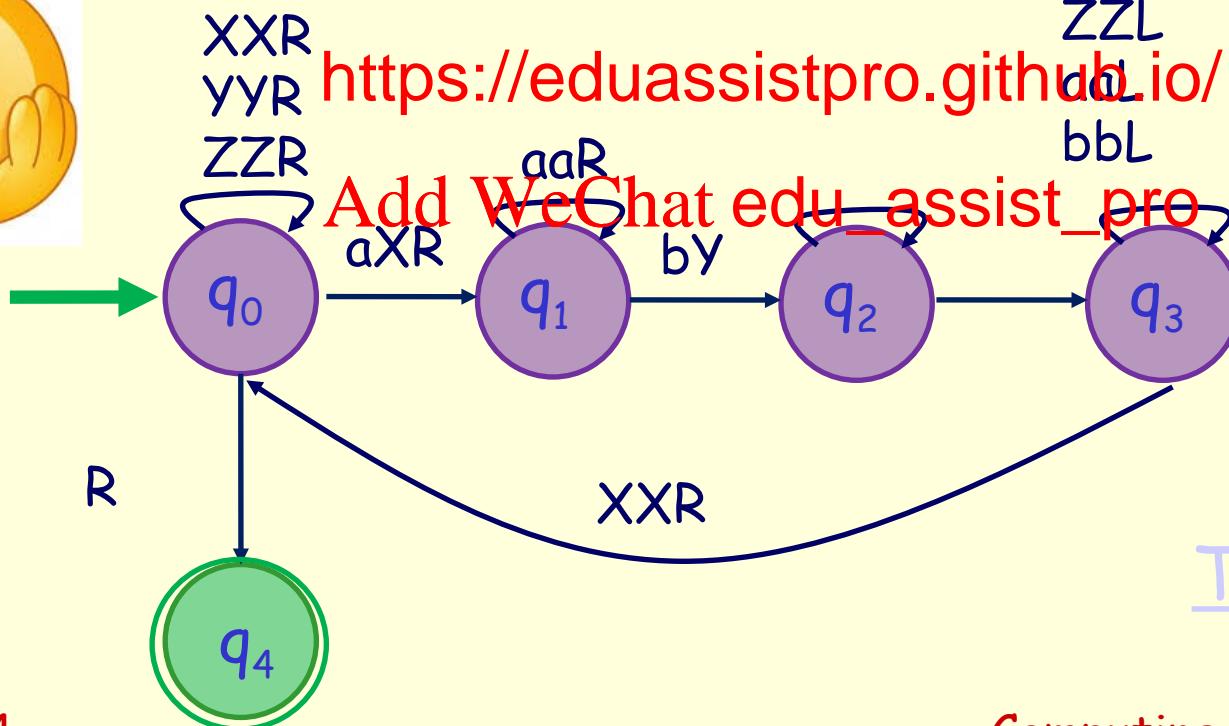


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Assignment Project Exam Help

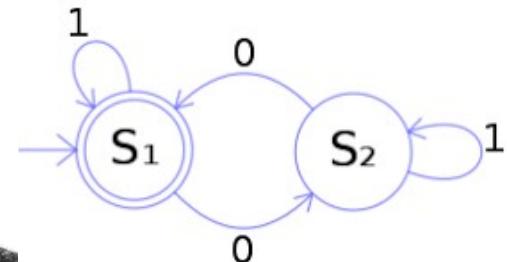
q_2

???



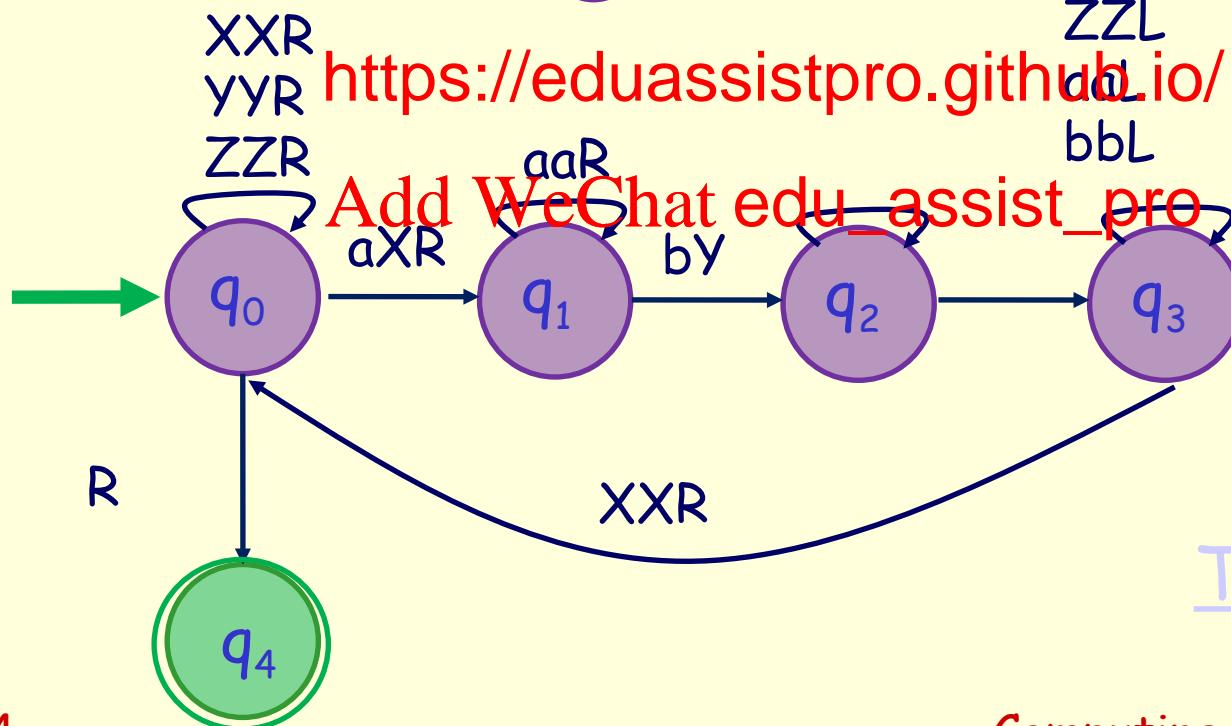
TM1.jff

Turing machines



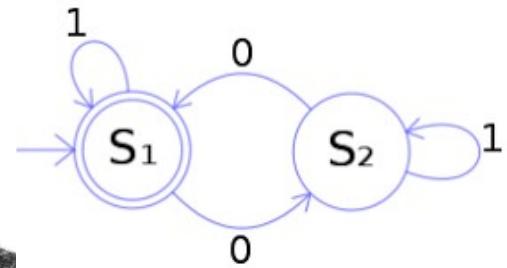
$$L(M) = \{ a^n b^n c^n \mid n \geq 0 \}$$

Assignment Project Exam Help



TM1.jff

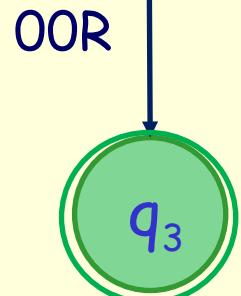
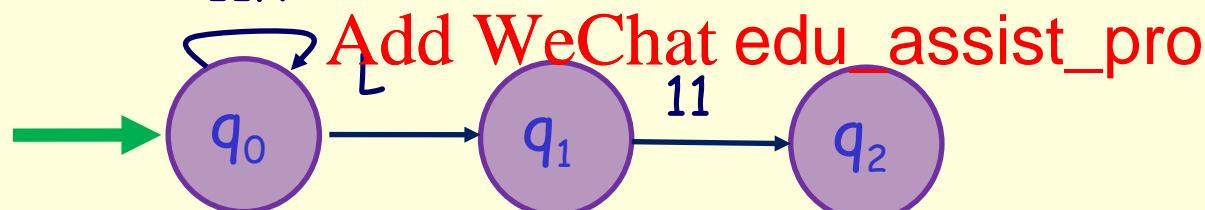
Turing machines



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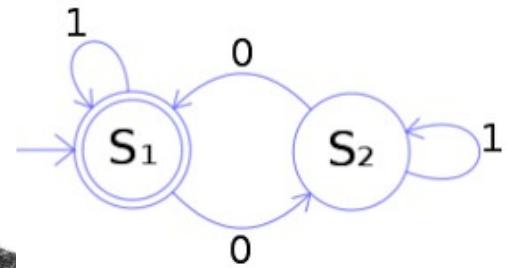
00R <https://eduassistpro.github.io/>

11R



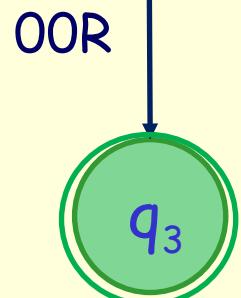
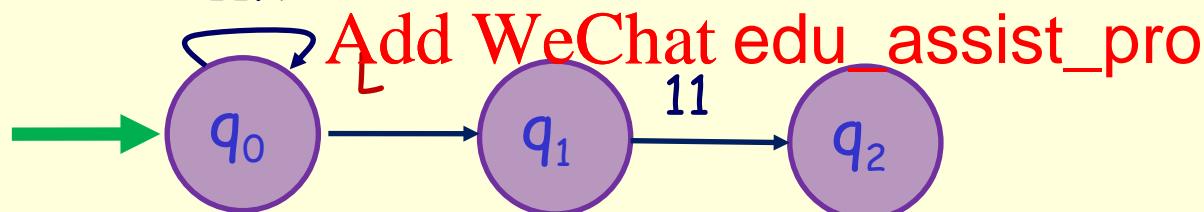
TM2.jff

Turing machines



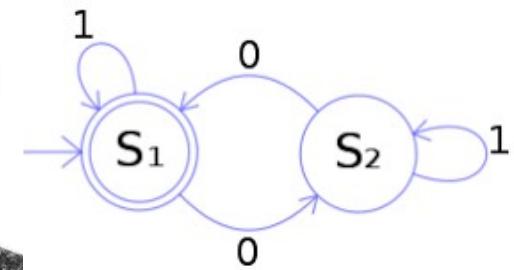
Assignment Project Exam Help q_0

00R https://eduassistpro.github.io/
11R



TM2.jff

Turing machines

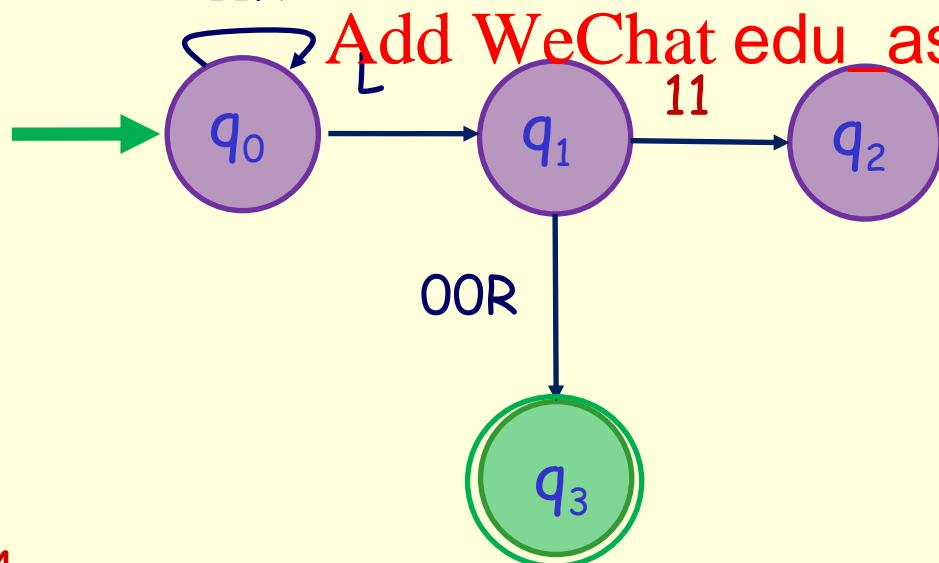


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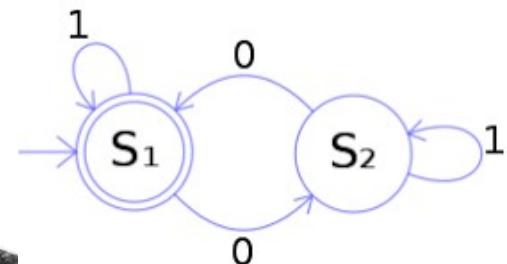
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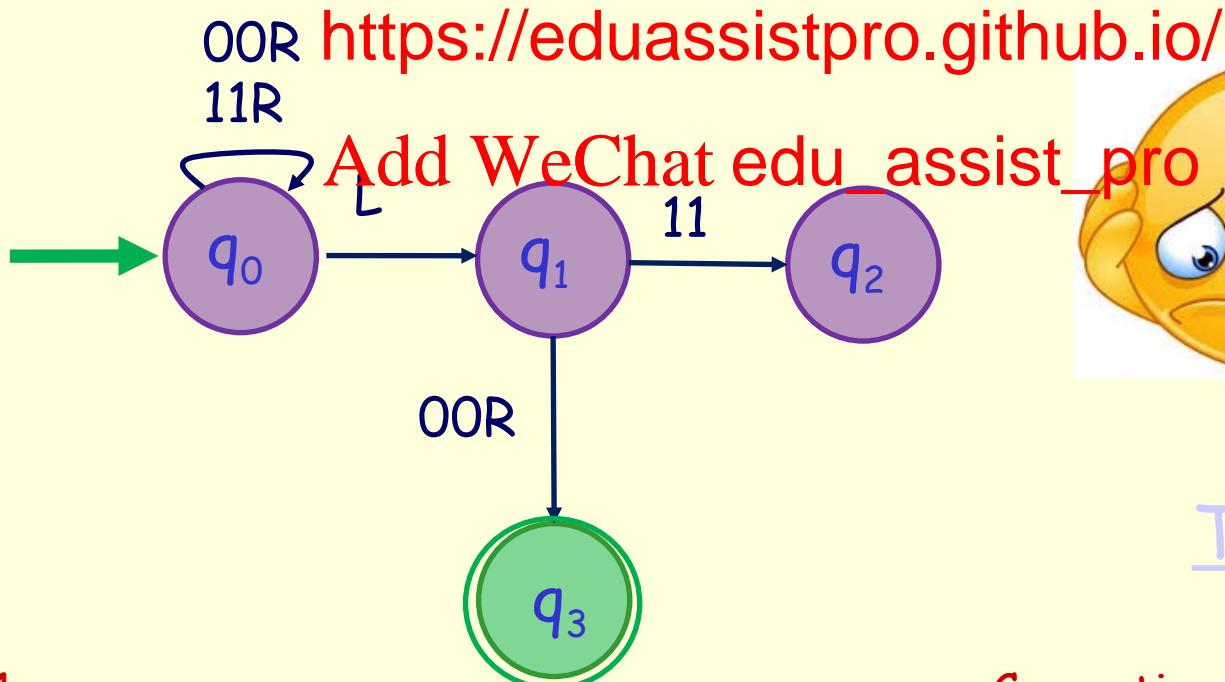


TM2.jff

Turing machines

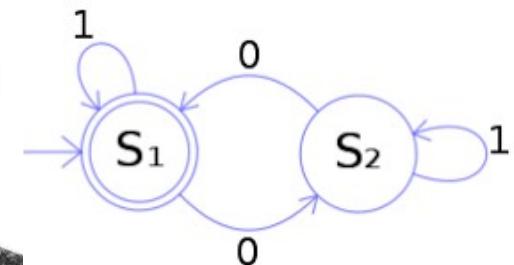


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Assignment Project Exam Help



TM2.jff

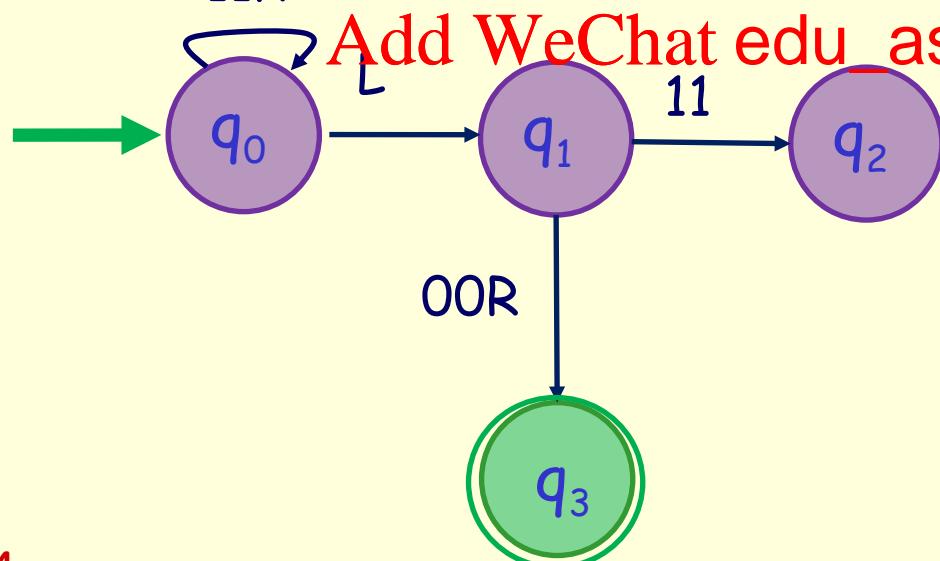
Turing machines



Assignment Project Exam Help

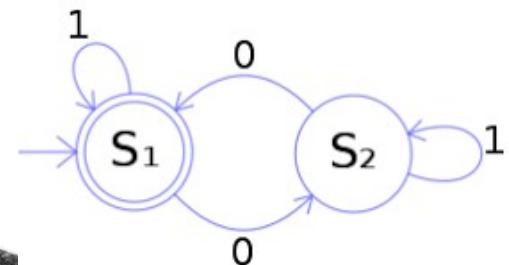
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TM2.jff

Turing machines



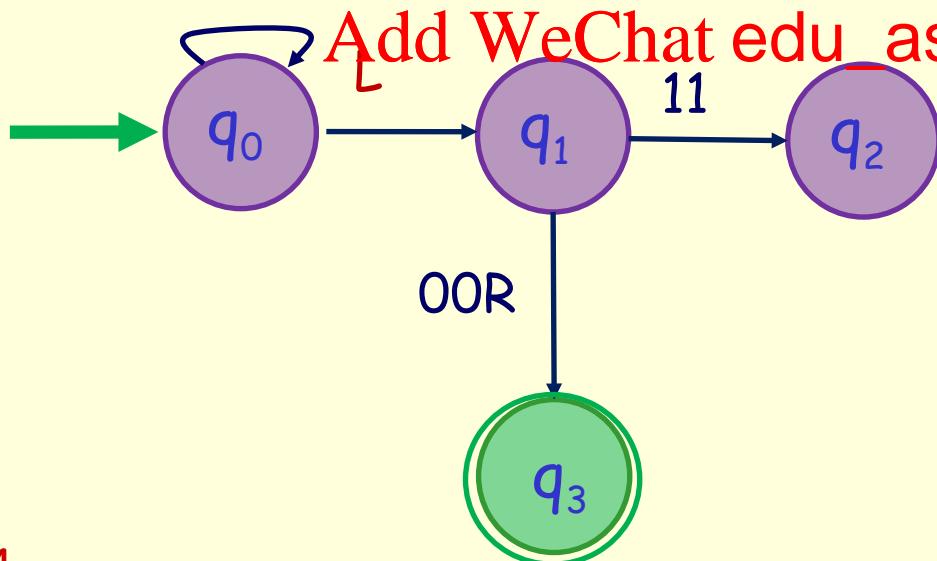
Assignment Project Exam Help

q_0

00R https://eduassistpro.github.io/

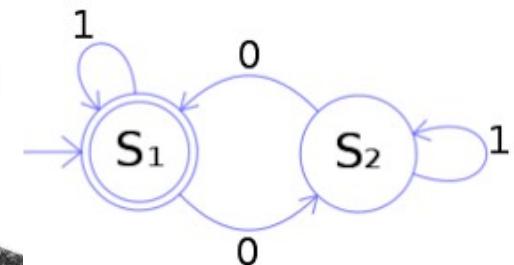
11R

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TM2.jff

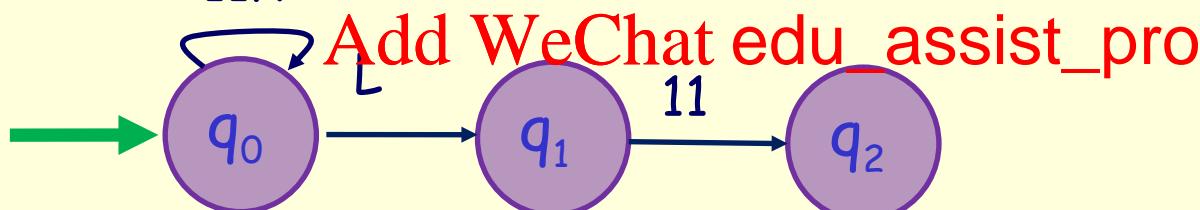
Turing machines



Assignment Project Exam Help

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11R

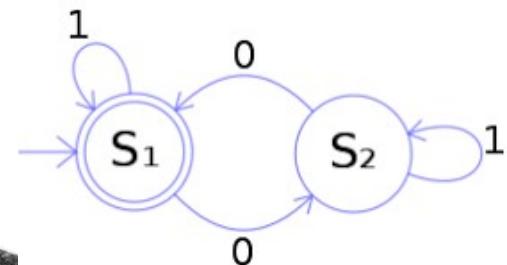


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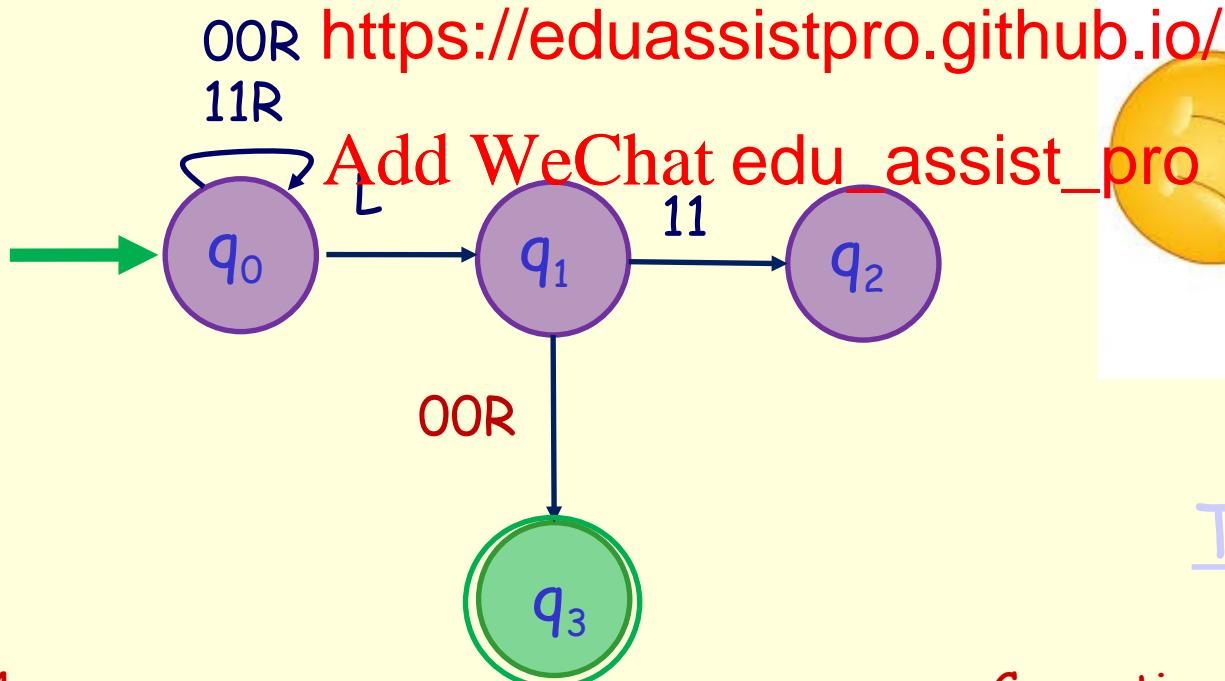


TM2.jff

Turing machines

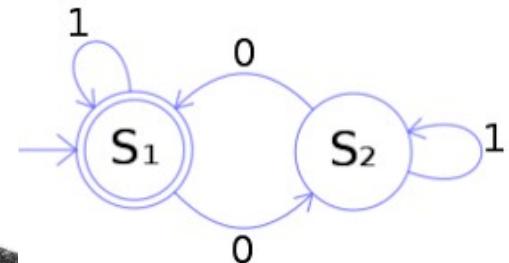


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Assignment Project Exam Help



TM2.jff

Turing machines



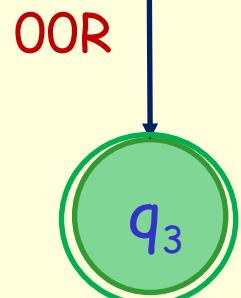
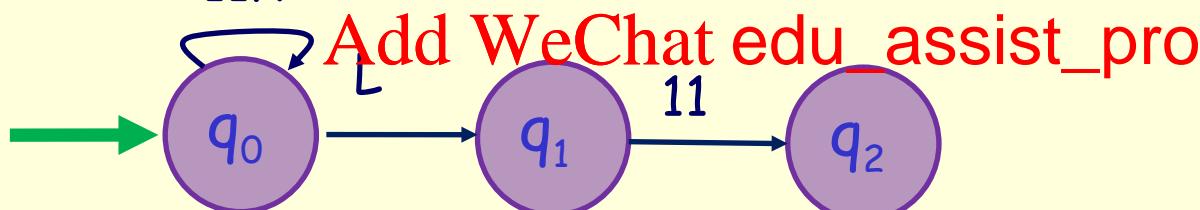
$L(M) = ??$

Assignment Project Exam Help

$L(M) = \{\text{strings over } \{0, 1\} \text{ ending in } 00\}$

00R <https://eduassistpro.github.io/>

11R



TM2.jff

Questions?



Questions?

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<https://eduassistpro.github.io/>

Questions?

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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!) <https://eduassistpro.github.io/>



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<https://eduassistpro.github.io/>

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Are you ready?

Week 4

Are you sure?

Computing Theory

Go!

The pictures will take 2 minutes to disappear!
Thomas music means 30 seconds left!



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<https://eduassistpro.github.io/>

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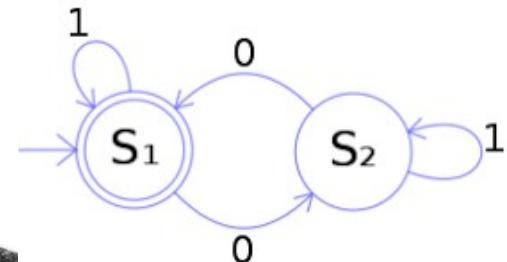


How did you go?

Question 1: Which of the following statements are correct?

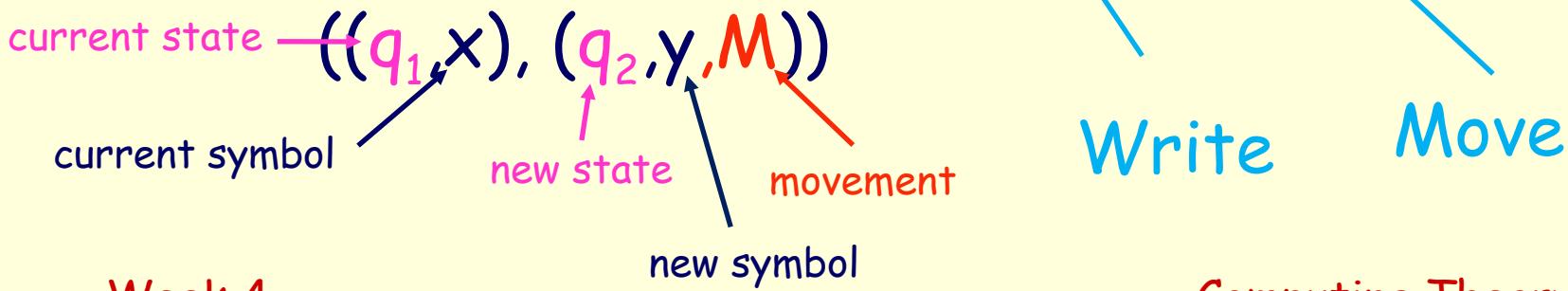
- Turing was an English mathematician. **True**
- The highest award for Computer Science is named after him. **True**
- Turing invented the **Turing Test** for artificial intelligence. **True**
- Turing was a key member of the team that cracked the German Enigma cryptosystem. **True**
- Turing was a 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**

Formal Definition

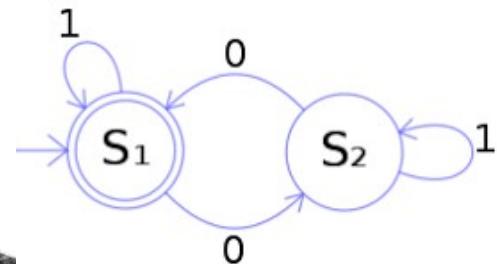


A Turing machine M is a 6-tuple (Q, Σ, q_0, F)

- Q is a finite set of **states**
- Σ is a finite ~~alphabet~~ Assignment Project Exam Help
- δ is the **blank symbol**
- $Q \times (\Sigma \cup \{\delta\})^2$ is the **partial transition function**
- q_0 is the **start state** of the machine
- $F \subseteq Q$ is the set of **accepting or final states**



FSA vs PDA vs TM

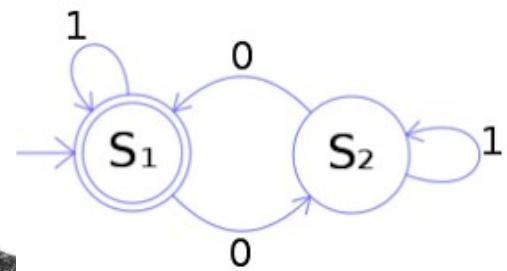
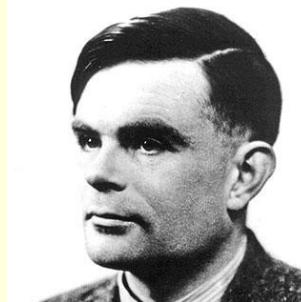


	FSA	PDA	TM
Input	String	String	String
Output	Yes or no	Yes or no	Yes or no*
Processing	One symbol at a time, left	Add WeChat edu_assist_pro	One symbol at a time, moving one step in either direction
Memory	Current state	Current stack	Current state + tape (infinite!)
Acceptance	Final state	Final state + empty stack	Final state
Non-determinism?	Yes	Yes	Yes
Termination?	Always	Always	Sometimes ... Computing Theory

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

Week 4

Turing machines



<http://aturingmachine.com/>

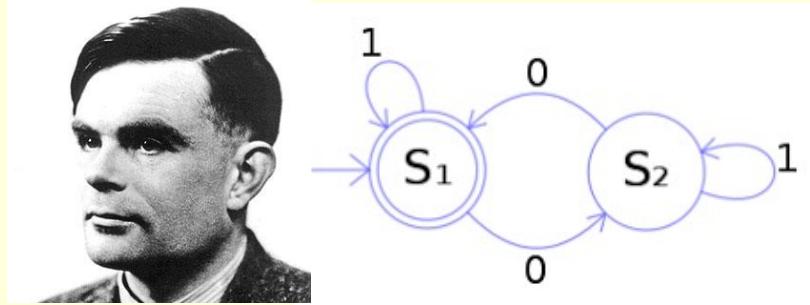
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<https://eduassistpro.github.io/>

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"My goal in building this project was to embody 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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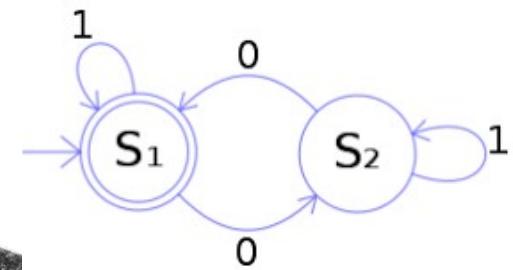
<https://eduassistpro.github.io/>

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

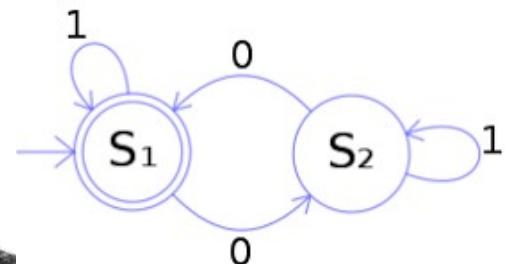
<https://www.youtube.com/watch?v=FTSAiF9AHN4>

Turing machines



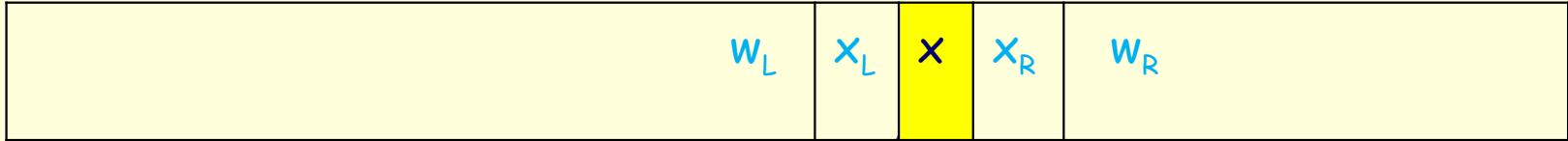
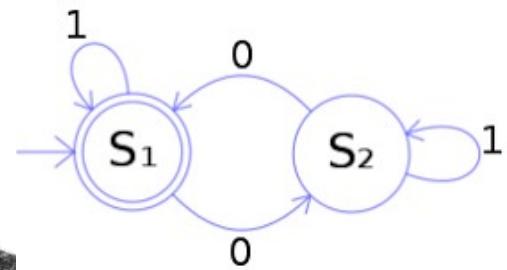
- Finite number of states
- Infinite memory (tape)
- Process one Assignment Project Exam Help
- Can move left he tape
- Halt when the https://eduassistpro.github.io/
- Can be used to
 - Recognise languages (like Add WeChat edu_assist_pro)
 - *Compute functions (tape as output)*
- Are as powerful as you can get (!!)
- Extra features can be added, but do not increase power
 - Different varieties of tape (?)
 - Nondeterminism (!?!)
 - ...

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 travel salesman problem (TSP) <https://eduassistpro.github.io/>
- Encrypt/decrypt
- Check if a number is prime
- Add WeChat edu_assist_pro
- Add, multiply, divide, find sq 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!"*

Turing machines



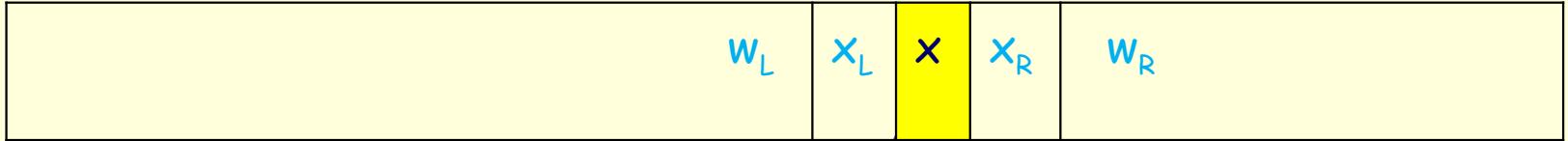
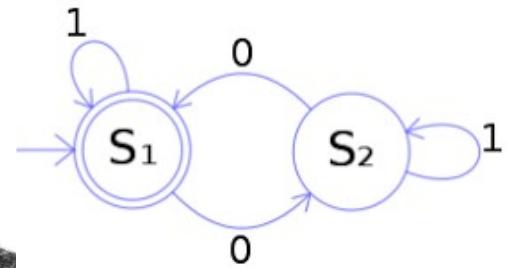
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A configuration of M ($w_L x_L x x_R w_R$) where

- 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



Assignment Project Exam Help

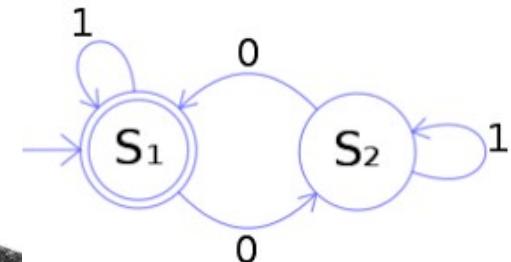
M evolves from $(q, w_L, https://eduassistpro.github.io/)$ written as

$(q, w_L x_L y, x_R w_R)$ Add WeChat edu_assist_pro

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

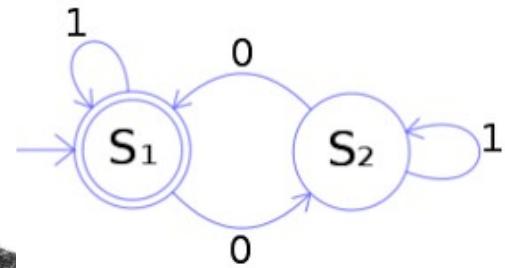


A string w is accepted if there exists a configuration (q, w_L, x, w_R) such that

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 $(q_0, \underline{x}, v) * (q_L \underline{y} q_R)$

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

Turing machines



Assignment Project Exam Help

A string w is accepted if $\text{M} \text{ halts in } (q_f, w_L, y, w_R)$ such that

$A(q_0, x, v) \xrightarrow{*} (q_f, w_L, y, w_R)$

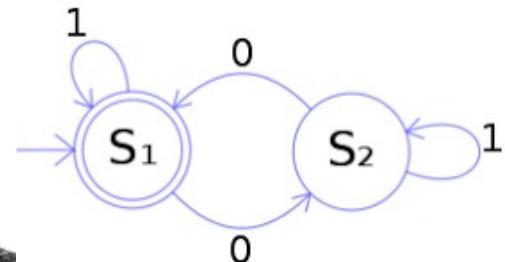
where $w = xv$, $q_f \in F$ and M halts in (q_f, w_L, y, w_R)

0 or more steps

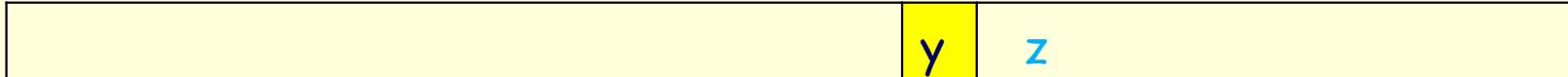
No transition for (q, y)

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

Turing machines



...



Assignment Project Exam Help

A Turing machine M ~~co~~^{https://eduassistpro.github.io/*} iff there is a configuration (q, w_L, y, w_R) such that $f(q, y, w_R) = v$

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$(q_0, x, v) \xrightarrow{*} (q_f, y, z)$

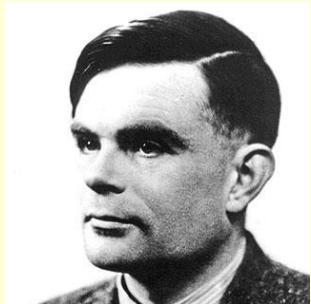
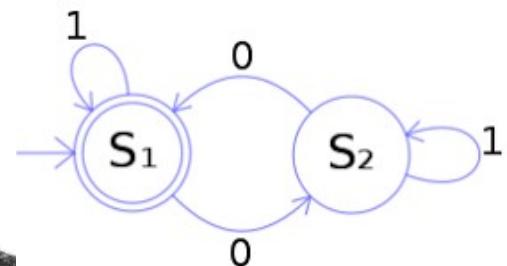
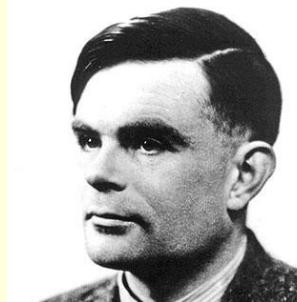
where $w = xv$, $v = yz$, $q \in F$, M halts in (q_f, y, z)

0 or more steps

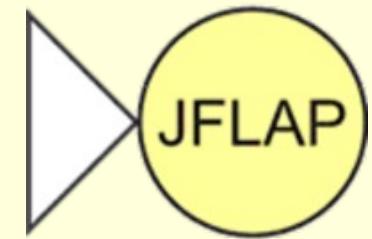
No transition for (q, y)

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

Turing machines



JFLAP is your friend!
Assignment Project Exam Help



Y <https://eduassistpro.github.io/>
Add WeChat edu_assist_pro **is!**



twinkl.com

Questions?



Questions?

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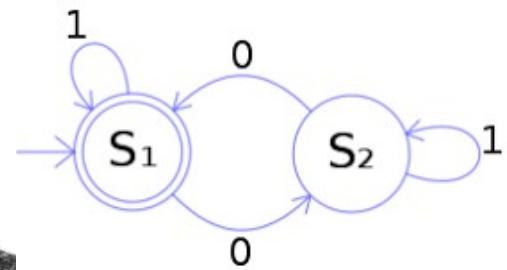
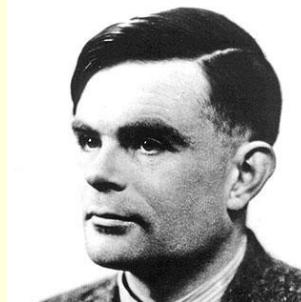
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Questions?

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Varieties

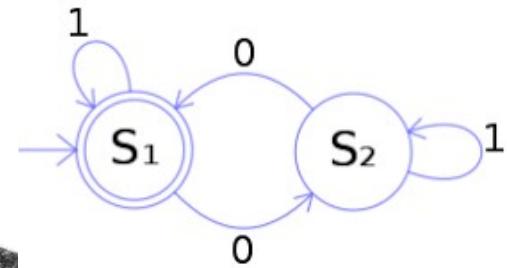
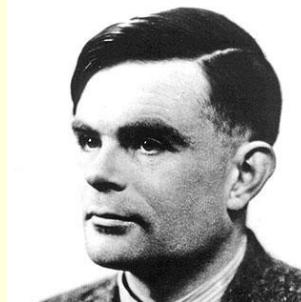


What if we altered Turing machines?

- Added a second tape (with its own head)
- Added n tapes (each with its own head)
- More heads on
- Two-dimension <https://eduassistpro.github.io/>
- Semi-infinite tape?
- More symbols?
- Less symbols?
- Nondeterminism?
- ...

Can we “improve” on Turing machines?

“Infinite” space ...



What is this old lamp?



Assignment Project Exam Help

Master, I grant you three wishes.

What is y

<https://eduassistpro.github.io/>



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A box of chocolate frogs

ns out!



Master, what about your other two wishes?



Two more of the same please!

What is the joke?

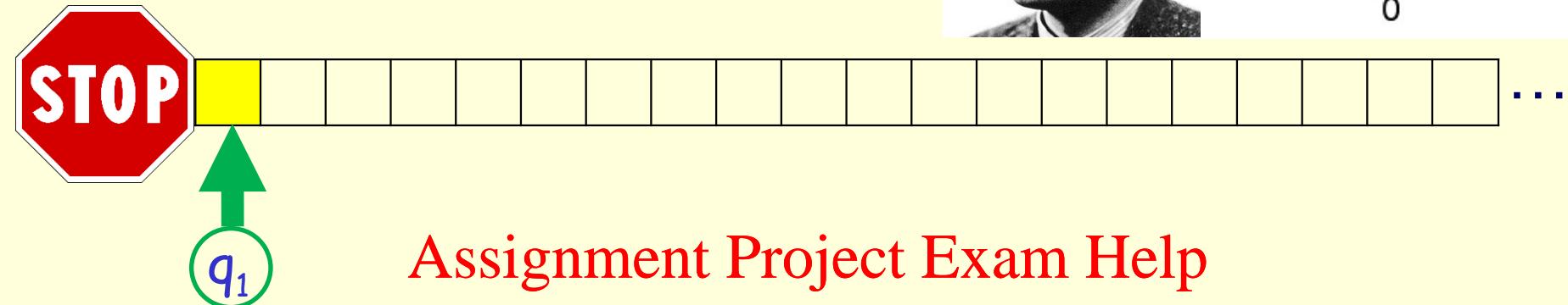
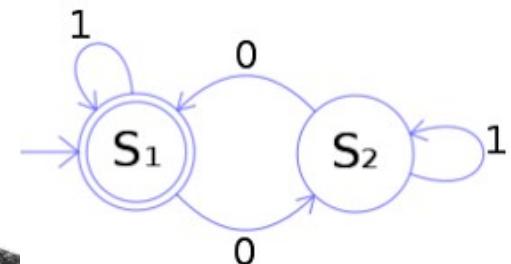


Any
infinite
space is
enough!

ng Theory

Week 4

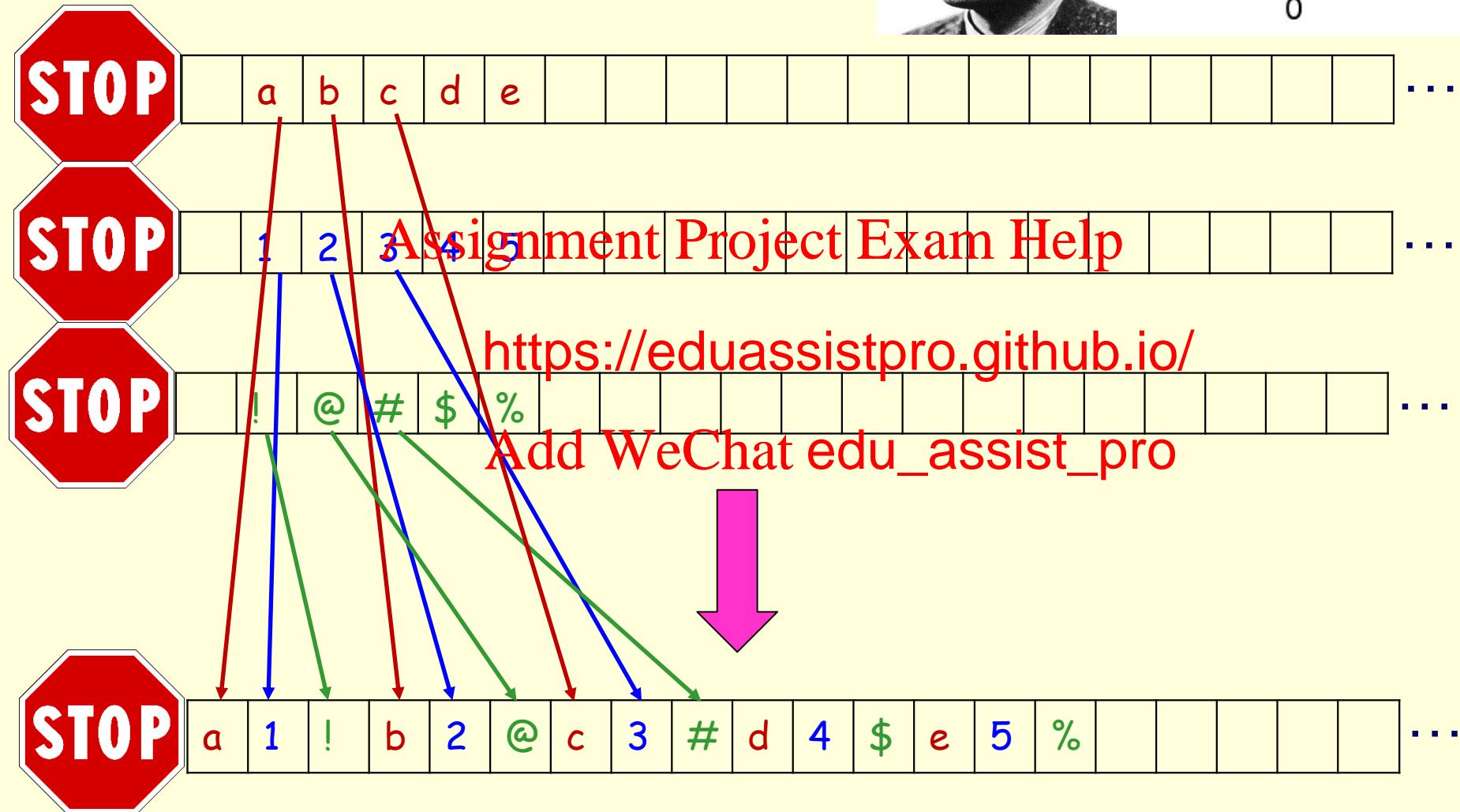
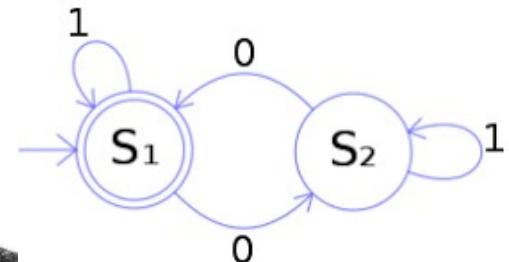
Semi-infinite tape



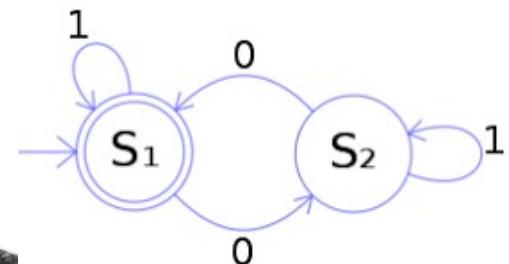
Assignment Project Exam Help

- Tape has a **lefthan** <https://eduassistpro.github.io/> ly to the right
- Machine halts abnormally if it tries to move the lefthand end
- Common in textbooks Add WeChat **edu_assist_pro**
- “simplest” form of Turing machines
- No less powerful than any other kind of Turing machine!

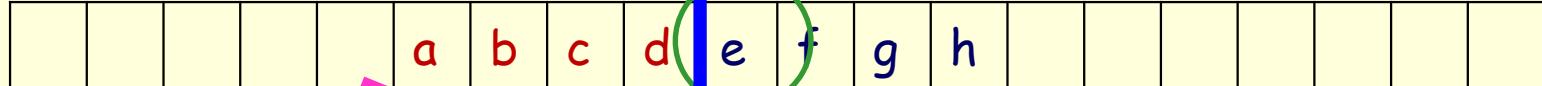
Multi-track tape



Multi-track tape



...



Pick a start cell

Assignment Project Exam Help



d c b a https://eduassistpro.github.io/



e f g h

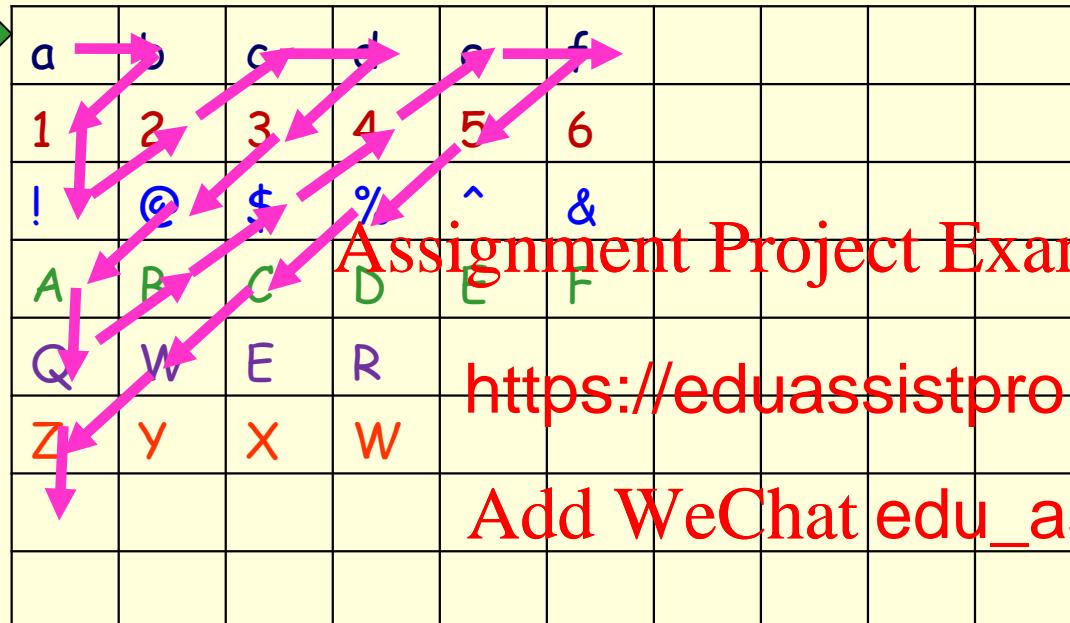
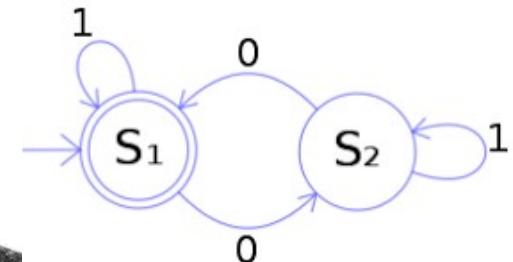
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d e c f b g a h

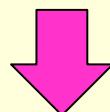


2-dimensional tape



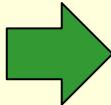
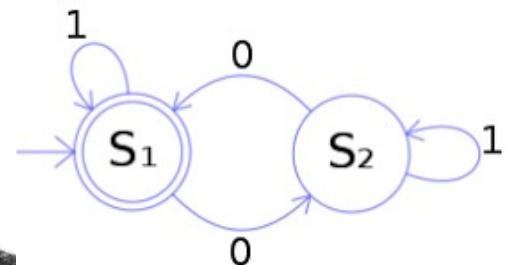
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<https://eduassistpro.github.io/>
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...



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

2-dimensional tape



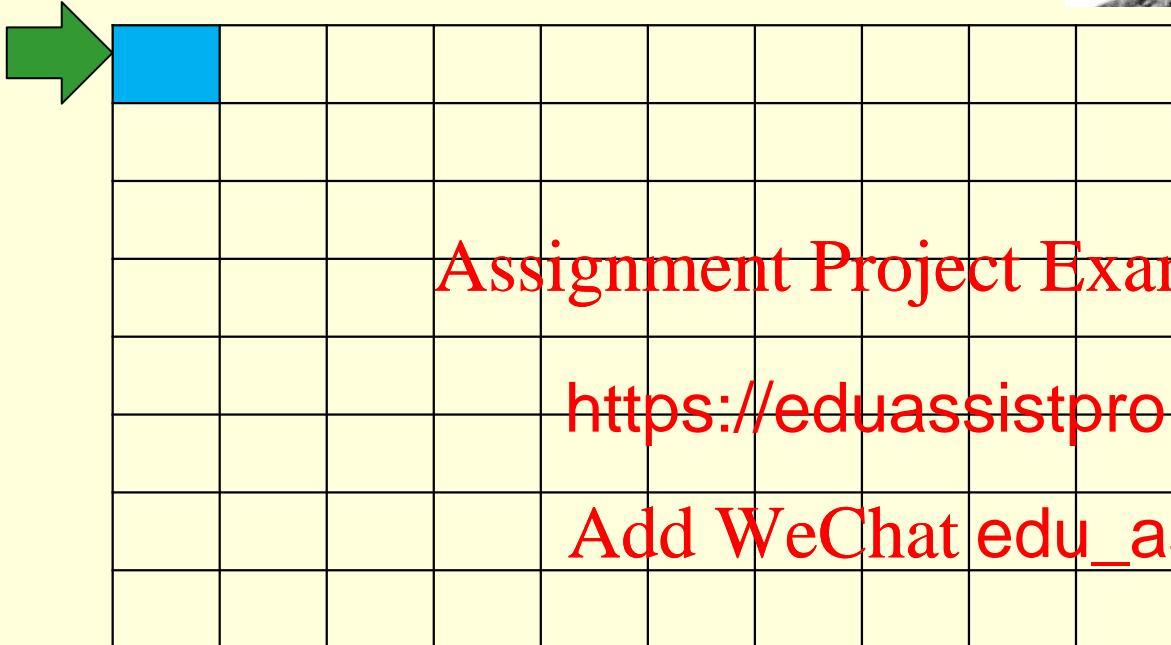
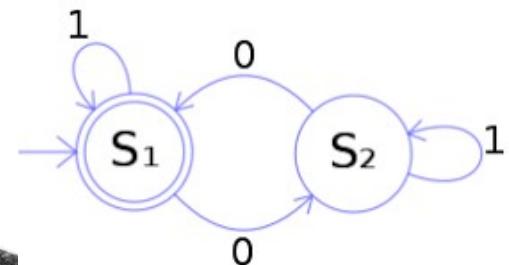
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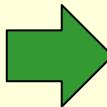
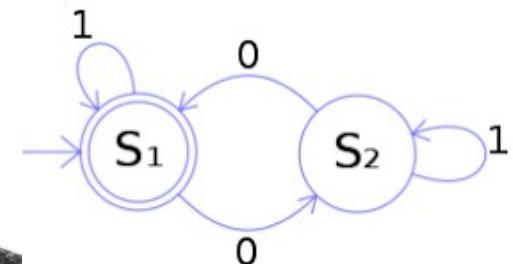
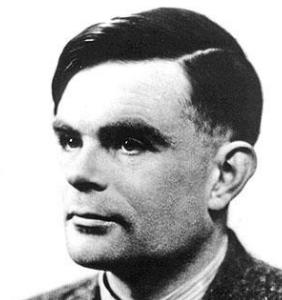
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2-dimensional tape



2-dimensional tape



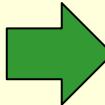
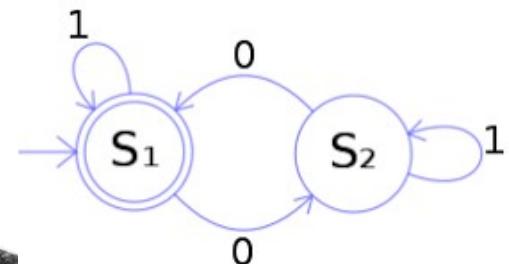
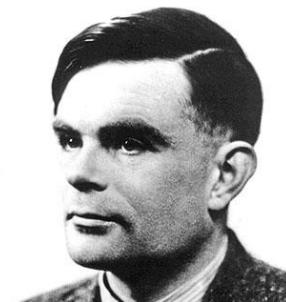
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2-dimensional tape



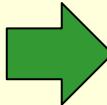
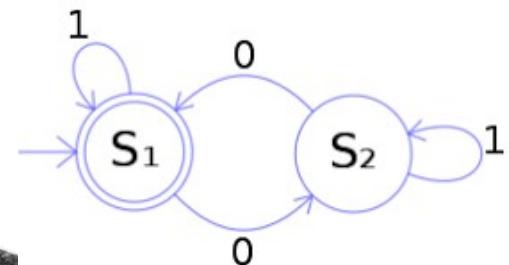
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2-dimensional tape



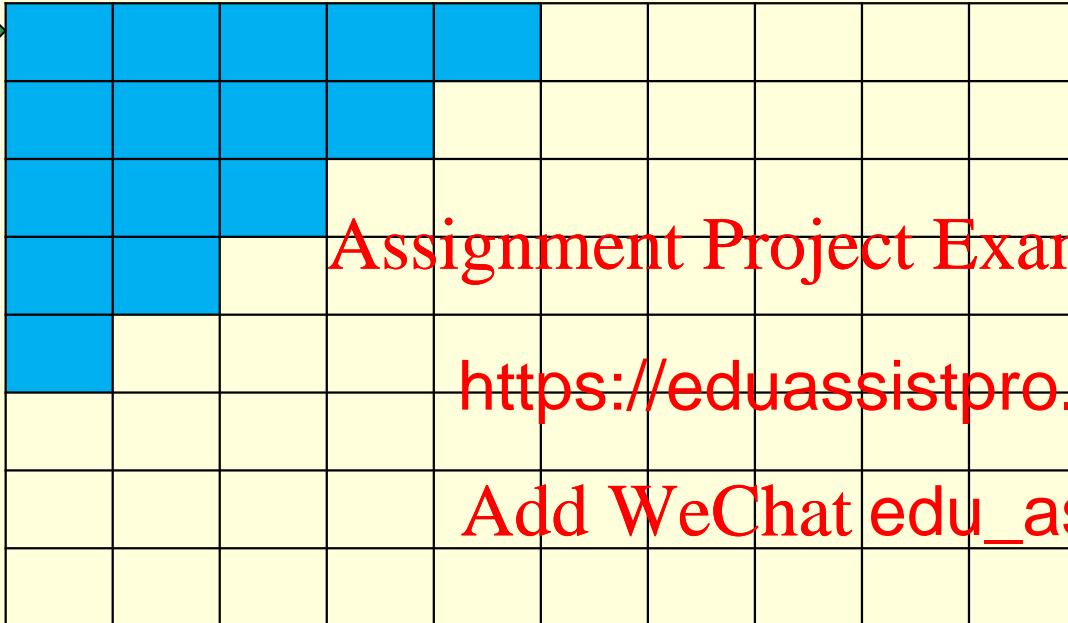
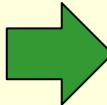
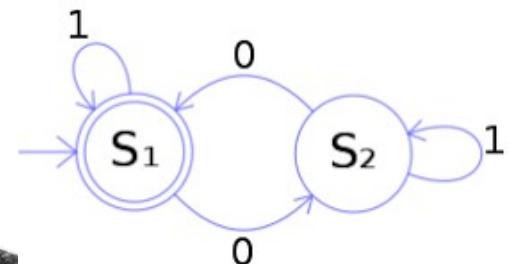
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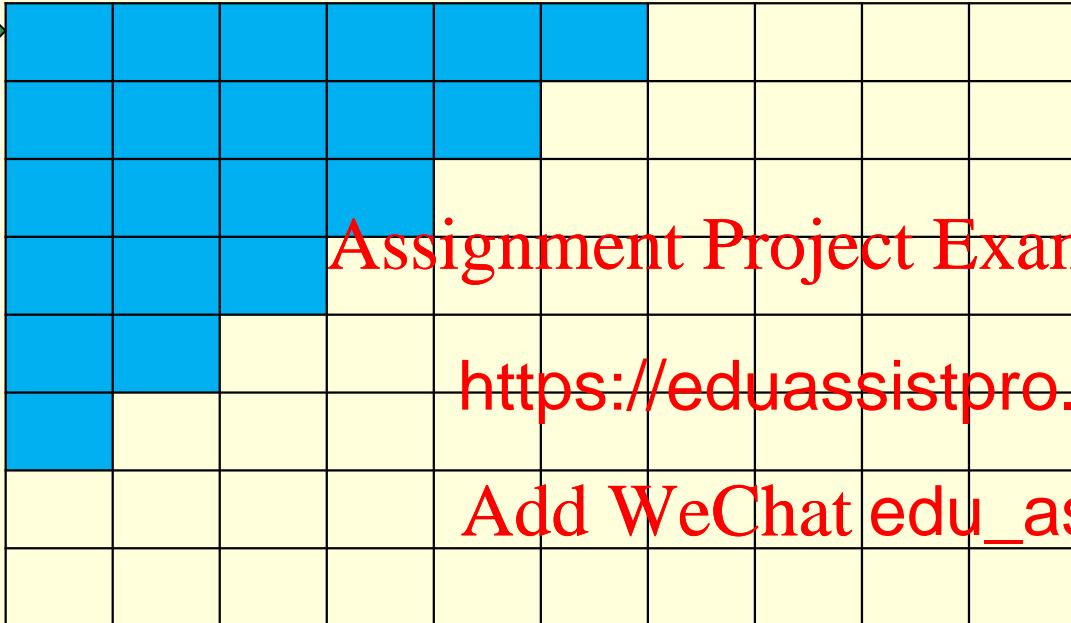
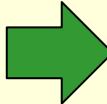
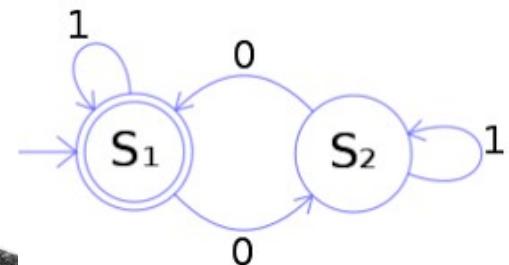
....

2-dimensional tape



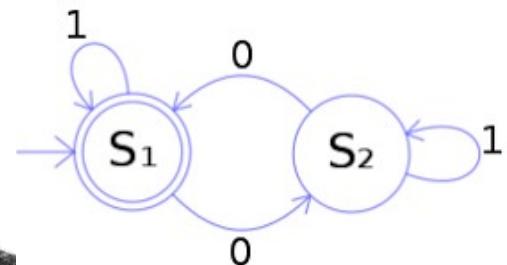
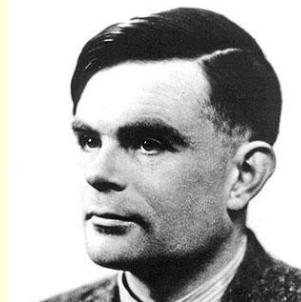
....

2-dimensional tape



....

Varieties

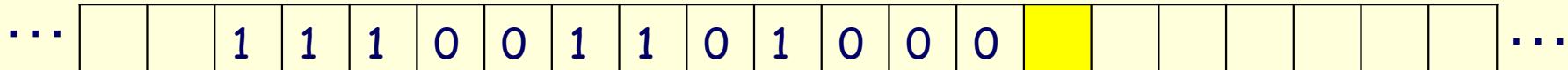
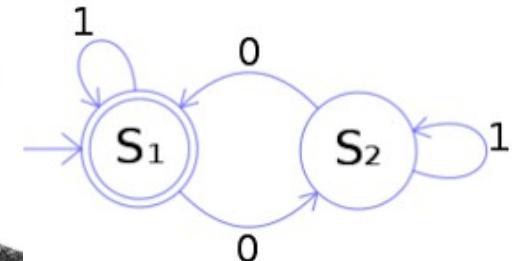


There are **bijections** between all of the following

	1 semi-infinite tape
x	Assignment Project Exam Help tapes
x x	https://eduassistpro.github.io/ finite tapes
x x x	Add WeChat edu_assist_pro finite tape
x	2 doubly infinite tapes
x x	3 doubly infinite tapes
	2-dimensional tape

Any set bijective with \mathbb{N} works as an “index” set for a Turing machine

Varieties

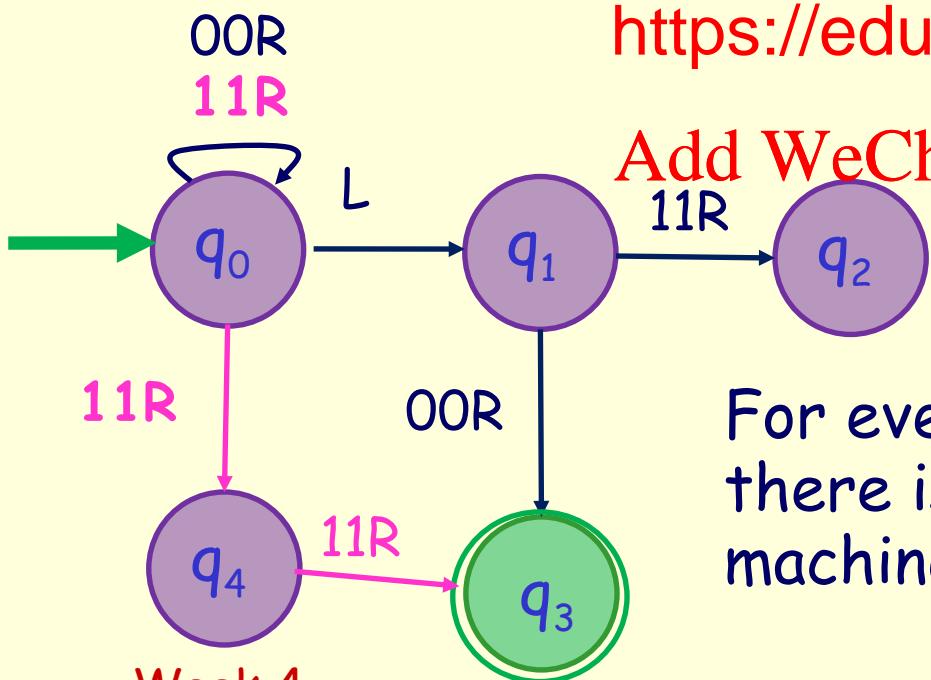


Nondeterminism
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For a given state and symbol, there can be

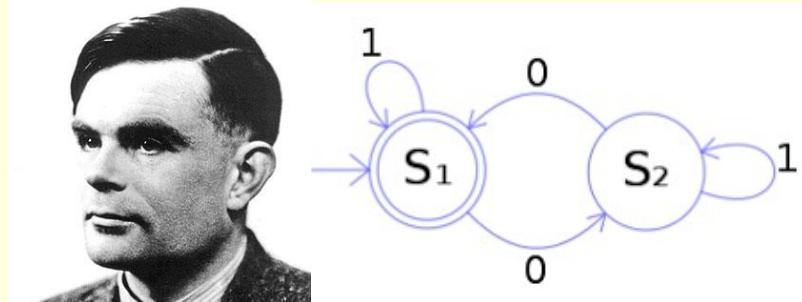
<https://eduassistpro.github.io/>

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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 st

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For any Turing machine M , there is a 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!

'father of Information Theory'

Claude Shannon

Computing Theory

Questions?



Questions?

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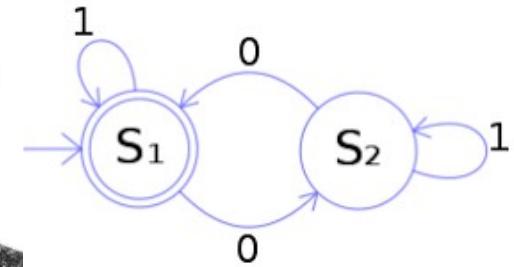
<https://eduassistpro.github.io/>

Questions?

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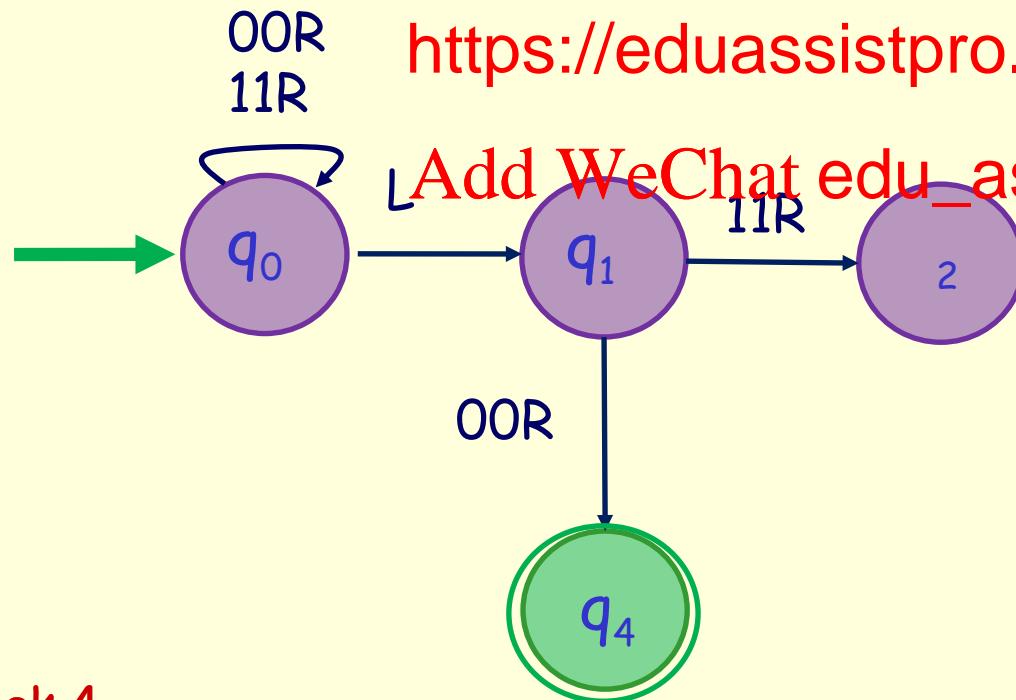


Turing machines



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

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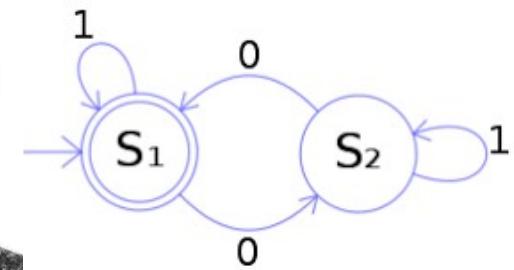
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q_0	0	0	R	q_0
q_0	1	1	R	q_0
q_0			L	q_1
q_1	1	1	R	q_2
q_1	0	0	R	q_4

states

alphabet

Turing machines



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

Assignment Project Exam Help

- A Turing machine
- Each row can be represented by a string
- Rows of strings can be represented by a string

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...

A Turing machine can be represented as a string

q_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!) <https://eduassistpro.github.io/>



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Are you ready?

Week 4

Are you sure?

Computing Theory

Go!

The pictures will take 1 minute to disappear!

Thomas music means 30 seconds left!

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twinkl.com



How did you go?

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

Question 2: Correct statements?

- Turing machines can recognise ~~Programming Languages~~ **Assignment Project Exam True Help**
- Turing machines can compute functions. ~~ue~~ **True**
- Turing machines ar ~~formalisms can be.~~ **True**
- Turing machines ca ~~LSE (infinite memory)~~ **https://eduassistpro.github.io/**

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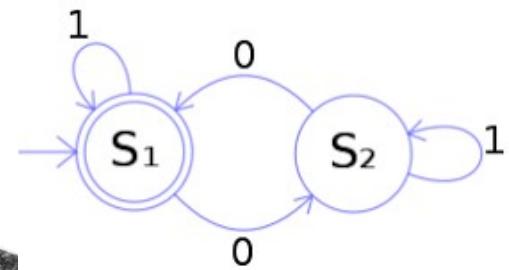
Question 3: Which of the following changes increase the power of a Turing machine?

- 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_0	L



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

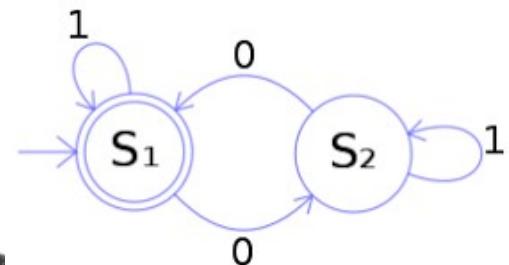
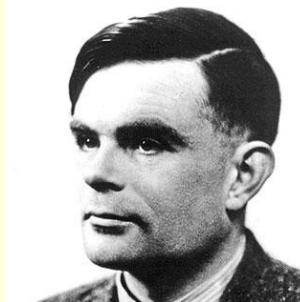
input
state
input
state
move

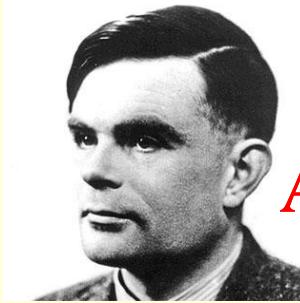
| colour |
|--------|--------|--------|--------|--------|--------|--------|
| animal |
| tree |

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Turing machines



	Assignment Project Exam Help
Infinite tape	https://eduassistpro.github.io/
1 machine per tape	Add WeChat edu_assist_pro

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)

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The Platypus Game



Survey results (so far)

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The Platypus Game



Survey results (so far)

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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.

Assignment Project Exam Help
There are two brackets
the "Losers Bracket" and the "Winners Bracket".
he first time it joins
to be fully out of the tournament.

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Sounds interesting!

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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 ..

Computing Theory

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 who es to play with)..

Sounds interesting too! <https://eduassistpro.github.io/>

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The Platypus Game



Survey results (so far)

Are there any other suggestions or comments about scoring?

For the tiebreaker, maybe let the machine that matches the green cell with platypus be the winner.

Interesting --- so we're <https://eduassistpro.github.io/>

I would like a change to the scoring system to reward 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 s

*Good thought. Presu
be linked like this.* <https://eduassistpro.github.io/>
*nd tree options should
Add WeChat edu_assist_pro*

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!**

Week 4

Computing Theory



The Platypus Game

Why 268 machines?

						
Assignment	Project	Exam	Help			
2	2	2				
4	4	4	https://eduassistpro.github.io/			
2	2	2	2	2	2	

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$$16 \times 16 \times 16 \times 16 \times 16 \times 16 = 16^7$$

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

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?

								More columns for more colours
								
m	m	m						
n	n	n	https://eduassistpro.github.io/					
2	2	2	2^2	2^2	2^2	2^2	2^2	Add WeChat edu_assist_pro

$2mn \quad 2mn \quad 2mn \quad 2mn \quad 2mn \quad 2mn \quad 2mn \quad 2mn$

$mn-1$ times

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



Computing Theory

Week 4

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	2,020,000,000
6	2	20,480,000,000,000

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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



Questions?



Questions?

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Questions?

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That's it!



I am out of here!

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Questions?



Questions?

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Questions?

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Questions?



Questions?

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Questions?



Questions?

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Questions?

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Questions?



Questions?

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Questions?

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



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I AM BACK!

Marking Computing Theory

Marking

Why did I lose marks for ...??



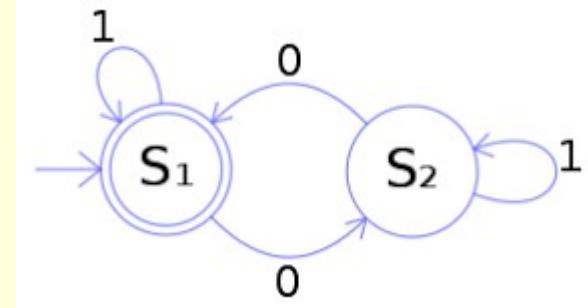
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At <https://eduassistpro.github.io/>

Perhaps you should add WeChat `edu_assistpro` at night ...

Never feed them after midnight!

...



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.

Assignment Project Exam Help

Exceeds Expectations - **Performance!**

Acceptable - demonstrat <https://eduassistpro.github.io/>

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

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).

Marking

Computing Theory

Alternative Scheme?



Troll	Dreadful	Poor	Acceptable	Exceeds Expectations	Outstanding
-------	----------	------	------------	----------------------	-------------

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Assignment Project Exam Help

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Marking

Computing Theory