Tutorial # 1.
Machine , Simulations

Exercise 1. Warming up

Q1. Write the 0 letters of the word on a 2nd tape.

Write the 1 letters of the word on a 3rd tape.

Compare the length of the words on the 2nd & 3rd tapes

Q2. Replace the # by a 1, remove the last 1.

Given a string w on the tape, write the last part on a 2nd tape.

Then compute addition and compare the results.

Q3. Write a and b on the 2nd & 3nd tape.

Until the start of a is reached, step to the left (2nd tape)

$\left[\begin{array}{l} \text{Write } \langle 1^{st} \text{ tape} \rangle \# \langle 3^{rd} \text{ tape} \rangle \text{ on the } 1^{st} \text{ tape} \\ \text{and compute addition.} \end{array} \right.$

Exercise 2. Universal Turing Machines

Q1.

tape #1	a_1^1	a_2^1	a_3^1	$\cdots$	
tape #2	a_1^2	a_2^2	a_3^2	$\cdots$	
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\cdots$	$\vdots$
tape #k	a_1^k	a_2^k	a_3^k	$\cdots$	

where we encode each letter in binary

$\rightsquigarrow$

$\triangleright a_1^1$	$B a_1^2$	$\cdots$	$\triangleright a_1^1$	B	a_1^2	$\cdots$

and we have a tape whose size is at most

$$O(\log |\Gamma|) \times 2k \times s(|x|).$$

$$\overset{''}{O}(s(|x|)).$$

Q2. Use a tape for $\langle \alpha, x \rangle$

$\left. \begin{array}{l} \text{and a tape for the state of } M_\alpha \\ \text{and 2 tapes for the tapes of } M_\alpha. \end{array} \right\} C_\alpha$

$$\# \text{ used cells} \leq C_\alpha \times s(|x|)$$

Exercise 3. Stimulating Simulation.

Q1.

Q2. Write each letter of Γ in binary, the cost is $\lceil \log_2 |\Gamma| \rceil$.

Q3. Store the two tapes on an alphabet $\Gamma^2 \times \{B, \triangleright\}$.

We don't talk about the heads of both tapes.
Reduce the size of the alphabet w/ Q2.

Q4.