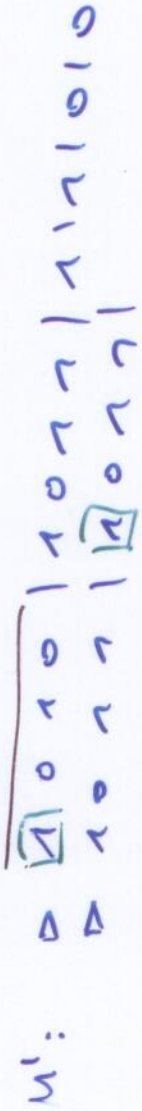
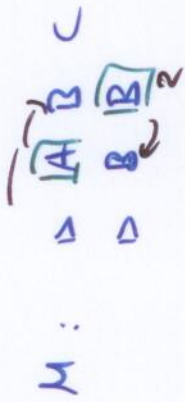
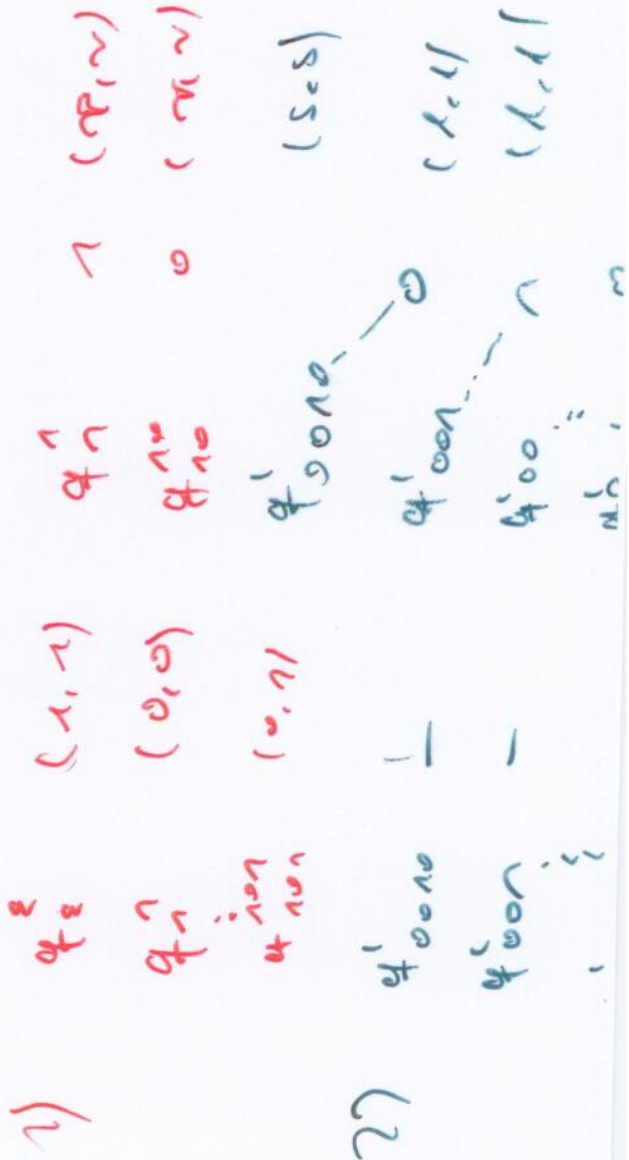


$$\mu = (\Gamma, \alpha, \delta), |\Gamma| > 4 \rightsquigarrow \mu' = (\tau_1, \sigma, \rho, \omega, \nu)$$

Idea: encode $\sigma \in \Gamma$ with $\log |\Gamma|$ bits



$$\delta(\tau_1, (\mathbf{A}, \mathbf{B})) = (\tau_1, 2, (\nu, \rho))$$



$$|\Gamma| > 4 \rightsquigarrow |\Gamma| = 4$$

3) movement
 $\log |\Gamma|$

read $\log |\Gamma|$

update $\log |\Gamma|$

TM computing pal

(3 tapes)

state	k symbols	new state	k-1 symbols	movements
start	Δ, Δ, Δ	q10	Δ, Δ	(r, r, r)
q10	$0, \Delta, \Delta$	q10	$0, \Delta$	(r, r, s)
	Δ, Δ, Δ	left	Δ, Δ	(l, s, s)
left	Δ, Δ, Δ	left	Δ, Δ	(l, s, s)
	Δ, Δ, Δ	compare	Δ, Δ	(r, l, s)
compare	$0, 0, \Delta$	compare	Δ, Δ	(r, l, s)
	Δ, Δ, Δ	*	Δ, Δ	(r, l, s)
	Δ, Δ, Δ	halt	Δ, Δ	—
	Δ, Δ, Δ	halt	Δ, Δ	—

linear time

Universal TM

M given by α , 1 input, 1 work, 1 output tape

$$V = \{0, 1, \square, \Delta\}$$

\rightarrow quadratic slowdown

u

$M \rightarrow$ input x

$M \rightarrow$ work

$\boxed{\alpha}$ — description of M

$[q$ — state of M

$M \rightarrow$ output

multiple tape \rightarrow single tape

