Math 322

type 0, 1, 2, not 3

$\boxed{Q's}$ grammar type $P = \{S \to A, \ldots$

? left side is single non-term

type 0, type 1, type 2, type 3

? is it non-dec in length?

? right side: a, aA?

ex $P = \{S \to \lambda, A \to aA, B \to b, S \to ASB, \ldots\}$

type 0

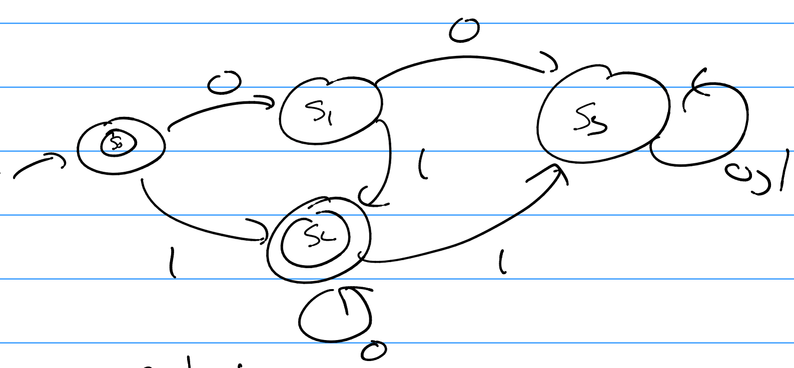
? type 1 (non-dec?)

not type 1 b/c $S \to \lambda$ and S on right side

$\boxed{\text{type 0 not 1}}$

Languages of M

M: start



Final States: path to ..

S_0 : λ

S_2 : $1, 10^*, 01, 010^*$

or $\boxed{L(M) = \lambda, (1, 01) 0^*}$

$= \boxed{\lambda \cup \{1, 01\} 0^*}$

T is a turing machine...

ex $f(n) = 2n$ $n = 0, 1, 2, 3, \ldots$

experiment:

$n=0$ --|B|1|B|-- $\xrightarrow{T}$ --|B|1|B|--

$n=1$ --B|1 1|B-- $\xrightarrow{T}$ ---B|1 1|1 B--
2 3

$n=2$ --B|1 1 1|B-- $\xrightarrow{T}$ --B|1 1 1|1 1 B--
3 5

$n=3$ ---B|1 1 1 1|B-- $\xrightarrow{T}$ ---B|1 1 1 1|1 1 1 B--
4 7

B 1 1 1 1 B B B
B 0 0 0 1 1 1
1 1 1 1

B 1 1 1 1 B B B
0 0 0 0 1 1 1
1 1 1 1 1 1 1

S_0
--BB1 1 1 BBB..

$(S_0, 1,$

..B 1 B.
0
1

B B 1 1 B B
1 1 0 0 0
1 1 1

(See video)

ex

S_0 S_1
--BB1 1 1B..

S_1
--B0 1 1B

S_2
B 0 0 1 B

S_2
--BB 0 0 1 B

S_1 ?!
--B1 0 0 1 B

S_2
.--B 1 0 0 0 B

$(S_0, 1, S_1, 0, R)$
$(S_1, 0, S_1, 0, R)$
$(S_1, 1, S_2, 0, L)$
$(S_2, 0, S_2, 0, L)$
$(S_2, 1, S_2, 1, L)$
$(S_2, B, S_3, 1, R)$
$(S_3, 1, S_3, 1, R)$
$(S_3, 0, S_1, 0, R)$

S_0 ← start state

S_1 ← moved "0" tally to a zero (seek a 1 tally)

S_2 ← find a tally to copy to left side

S_3 ← find old # (look for 0)

S_4 F make 0's 1's

$$\overset{S_2}{\vee}$$
.. B B 1 0 0 0 B ..

(S_1, B, S_4, B, L)

B 1 1 0 0 0 B .. (S_1)

$(S_4, 0, S_4, 1, L)$

B 1 1 0 0 0 B .. (S_1)

$(S_4, 1, S_F, 1, L)$

B 1 1 1 1 1 B (S_4)

T is $S = \{S_0, S_1, S_2, S_3, S_4, S_F\}$ ← each S_i has a specific task / knowledge

$I = \{B, 0, 1\}$

$P = \{ (S_0, 1, S_1, 0, R), \ (S_3, 1, S_3, 1, R),$
$(S_1, 0, S_1, 0, R), \ (S_3, 0, S_1, 0, R),$
$(S_1, 1, S_2, 0, L), \ (S_1, B, S_4, B, L),$
$(S_2, 0, S_2, 0, L), \ (S_4, 0, S_4, 1, L),$
$(S_2, 1, S_2, 1, L), \ (S_4, 1, S_F, 1, L),$
$(S_2, B, S_3, 1, R), \ (S_4, B, S_F, B, L) \}$

$P = \{ (s, i, s, i, m), \ldots \}$

all possible 5-tuples $= |S|\,|I|\,|S|\,|I| \cdot 2$

$= 2\,|S|^2\,|I|^2$ ↑

but T is simply taking __some__ of these 5-tuples
↑ subset

so $|T| = 2^{2|S|^2|I|^2}$

ex from above $|S| = 5$ $|I| = 3$

all possible $|T| = 2^{2 \cdot 25 \cdot 9} = 2^{450}$

290735489718242756219729523155201813741456544274927224112596079672255715\
245359169330476420285505426222430500864250647117341384065144586 24

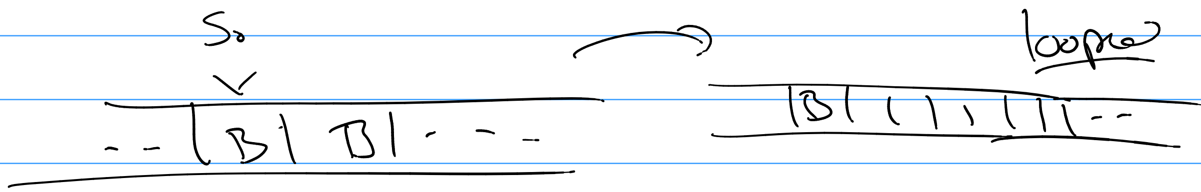
the one example we did does $f(n) = 2n$

$$|S||I||S||I|\cdot 2 = 2|S|^2|I|^2$$

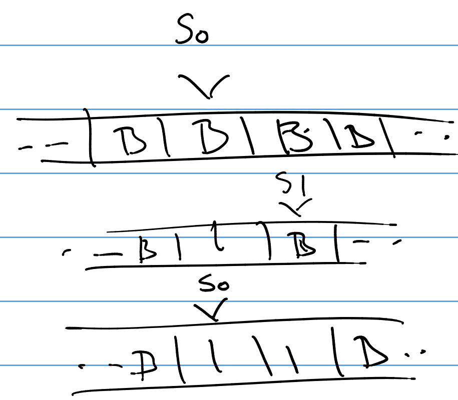
Q for these turing machines of . . .

– 1 state	$\lvert S\rvert = 1$	$I = \{B, 1\}$	$\lvert 5\text{ tuples}\rvert = 2\cdot 1^2\cdot 2^2$	– $\lvert T\rvert = 2^{8\cdot 1}$
– 2 states	$\lvert S\rvert = 2$	$I = \{B, 1\}$	$\lvert 5\text{ tuples}\rvert = 2\cdot 2^2\cdot 2^2$	– $\lvert T\rvert = 2^{8\cdot 4}$
– 3 states	$\lvert S\rvert = 3$	$I = \{B, 1\}$	$\lvert 5\text{ tuples}\rvert = 2\cdot 3^2\cdot 2^2$	– $\lvert T\rvert = 2^{8\cdot 9}$
– 4 states	$\lvert S\rvert = 4$	$I = \{B, 1\}$	$\lvert 5\text{ tuples}\rvert = 2\cdot 4^2\cdot 2^2$	– $\lvert T\rvert = 2^{8\cdot 16}$
⋮	⋮		⋮	– $\lvert T\rvert = 2^{8\cdot 25}$

ex pick just $\{(S_0, B, S_0, 1, R)\} = P$ of T



ex $P = \{ (S_0, B, 1, S_1, R)$
$(S_1, B, 1, S_0, L) \}$



Function: for $|S| = n$ $\quad I = \{B, 1\}$

for each $|T| = 2^{8\cdot n^2}$ possible turing machines

for the T's that halt but

$B(n)$ = max number of 1's on the tape at halt.

$B(n)$ = busy beaver function

$B(2) = 4$

$B(3) = 6$

$B(4) = 13$

$B(5) \geq 4098$

$B(6) \geq 3.5 \times 10^{18267}$

uncomputable