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$s_{f, \cup} \rightarrow s, R$

$s, \cup \rightarrow \text{reject}$

$s, 0 \rightarrow s, R$

$f, \cup \rightarrow \text{accept}$

$s, 1 \rightarrow s, R$

$q_0 = st$

$q_4 = \text{reject}$

$f, 0 \rightarrow f, R$

$q_1 = s,$

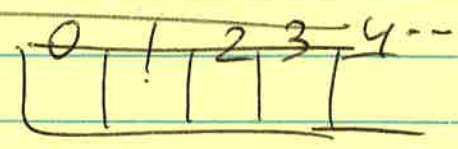
$q_2 = f$

$f, 1 \rightarrow s, R$

$q_3 = \text{accept}$

$S_0 = \cup, S_1 = 1, S_2 = 0$

~~state~~ ^{tape} [] :



int [] ~~state~~ ^{tape} = new int [100];

int ~~state~~ ^{location} = 0;

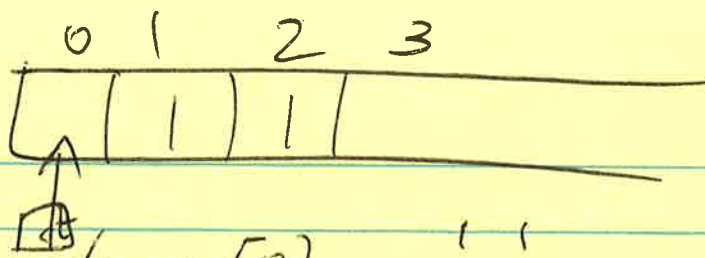
int ~~current~~ ^{location} = 0;

input [i]

while (! (state == N-2 || state == N-1)) {

int ~~symbol~~ ^{current symbol} = input ^{to} [location];

tape [location] = symbol [state, current symbol];

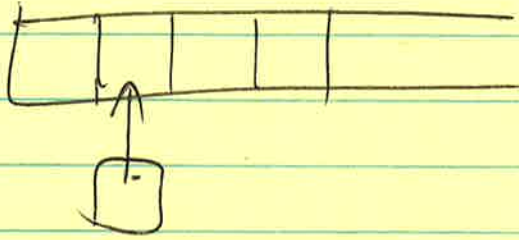


tape[0] = '1'
 tape[1] = '1';
 tape[2] = '1'
 tape[3] = '0';

location = 0;
 state = 0;
 curSymbol = ~~to~~
input[0]

```
while (! (state == N-2 || state == N-1)) {
  int curSymbol = tape[location];
  int tape[location] = symbol[state][curSymbol];
  int curState = state;
  state = state[curState][curSymbol];
  if (lr[curState][curSymbol] == 'L')
    { location --; }
  else if (lr[curState][curSymbol] == 'R')
    { location ++; }
```

location \equiv location of a head
state \equiv state of the head



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-M-

$$\boxed{S \rightarrow \epsilon}^{-0}$$

$$\boxed{S_0 \rightarrow S}$$

$$\begin{array}{l} S_0 \rightarrow \epsilon \\ V \rightarrow a \\ A \rightarrow BC \end{array}$$

$$\begin{array}{l} S \rightarrow a \\ S \rightarrow b \end{array}$$

$$\begin{array}{l} \cancel{S \rightarrow aSa} \\ \cancel{S \rightarrow bSb} \end{array}$$

step 0

$$\begin{array}{l} \cancel{S \rightarrow aa} \\ \cancel{S \rightarrow bb} \\ S_0 \rightarrow \epsilon \end{array}$$

$$\begin{array}{l} V \rightarrow uSv \\ V \rightarrow uv \end{array}$$

Step 1: $S_0 \rightarrow a$

$$\begin{array}{l} S_0 \rightarrow b \\ \cancel{S_0 \rightarrow aSa} \\ \cancel{S_0 \rightarrow bSb} \end{array}$$

$$\begin{array}{l} \cancel{S_0 \rightarrow aa} \\ \cancel{S_0 \rightarrow bb} \end{array}$$

Step 2: $V_a \rightarrow a$

$V_b \rightarrow b$ $S \rightarrow V_a V_a$

$$\begin{array}{l} S \rightarrow V_b V_b \\ \cancel{S \rightarrow V_a S V_a} \\ \cancel{S \rightarrow V_b S V_b} \end{array} \quad \begin{array}{l} S_0 \rightarrow V_a V_a \\ \cancel{S_0 \rightarrow V_a S V_a} \\ \cancel{S_0 \rightarrow V_b S V_b} \end{array} \quad \begin{array}{l} S_0 \rightarrow V_b V_b \end{array}$$

Step 3: $S \rightarrow V_a S V_a$

$V_a S \rightarrow V_a S$

$$S_0 \rightarrow V_a S V_a$$

$$S \rightarrow V_b S V_b$$

$V_b S \rightarrow V_b S$

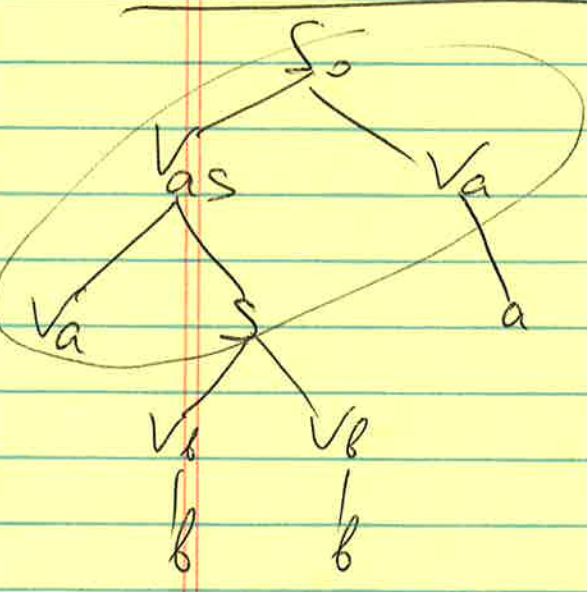
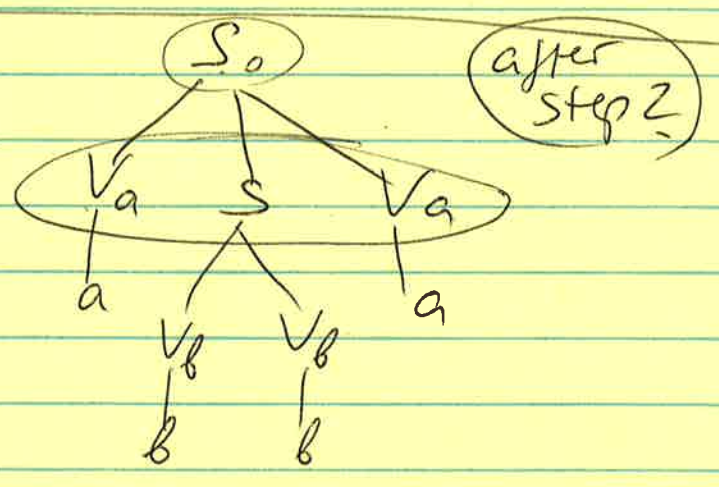
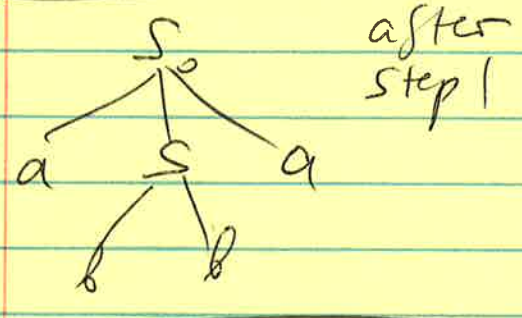
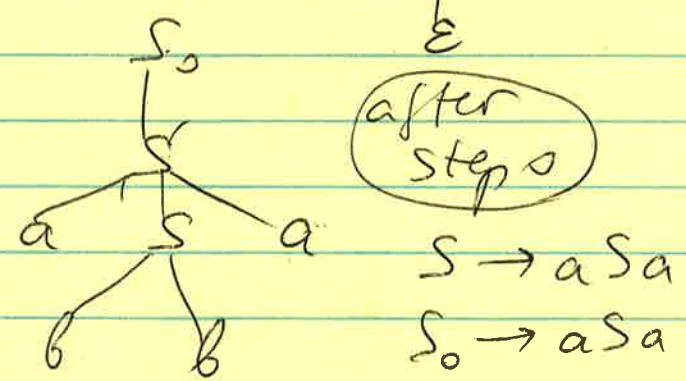
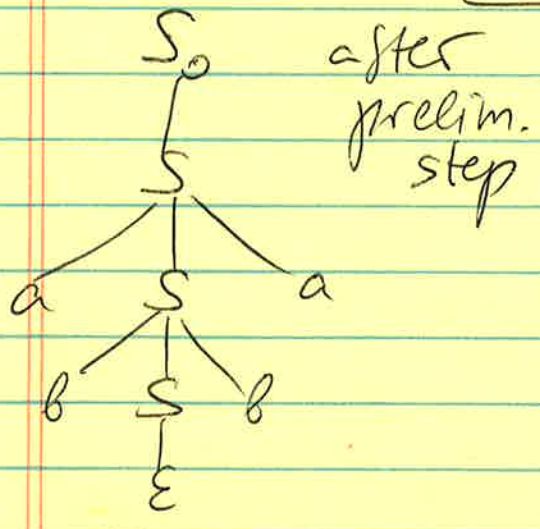
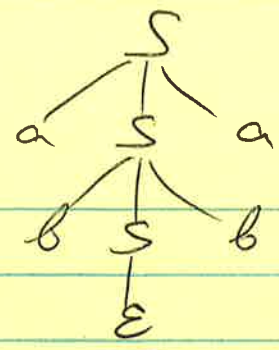
$$S_0 \rightarrow V_b S V_b$$

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-N2-

$S \rightarrow \epsilon$
 $S \rightarrow a$
 $S \rightarrow b$

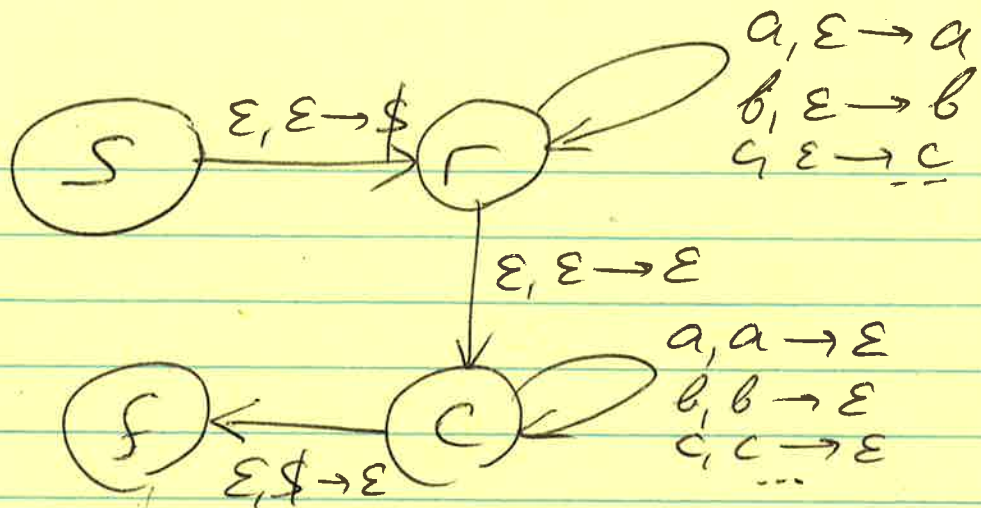
$S \rightarrow aSa$
 $S \rightarrow bSb$

abba

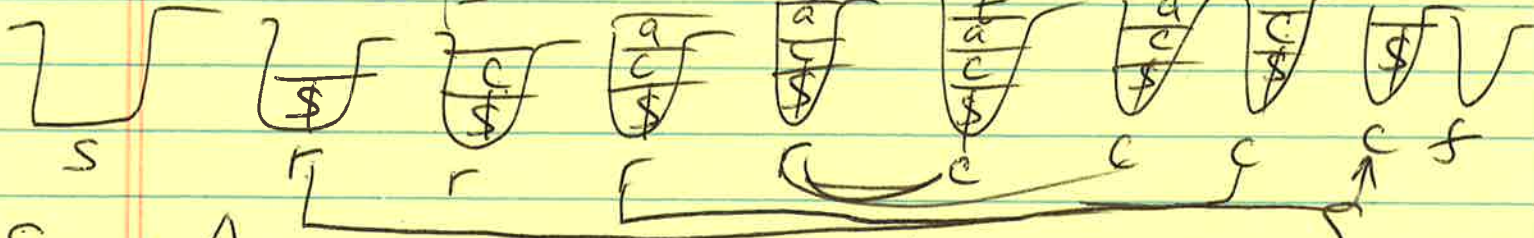


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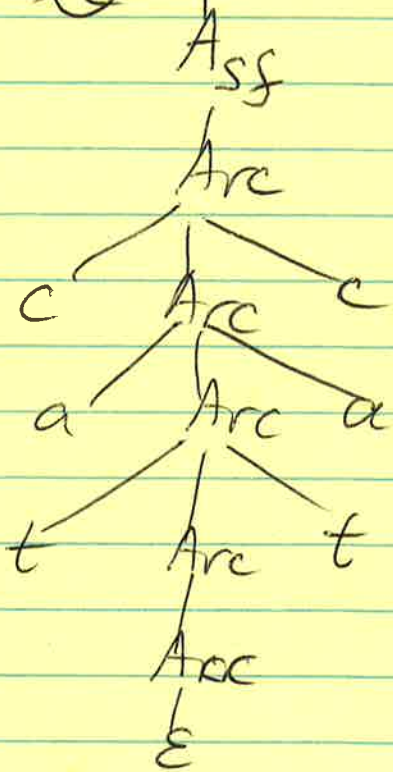
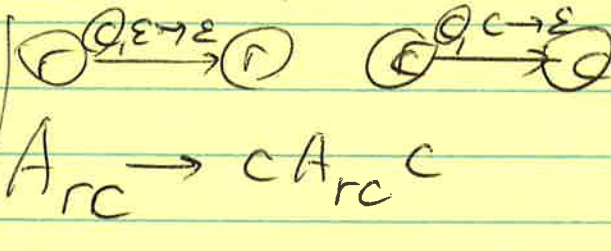
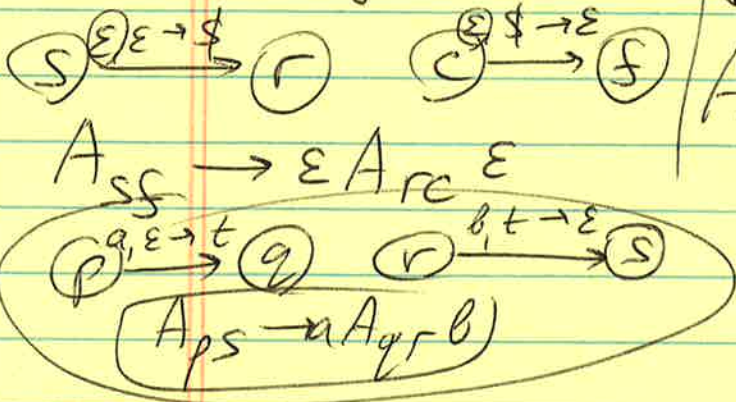
-NB-



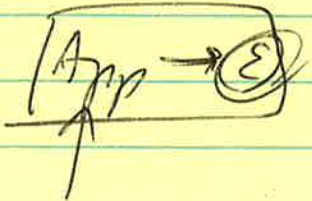
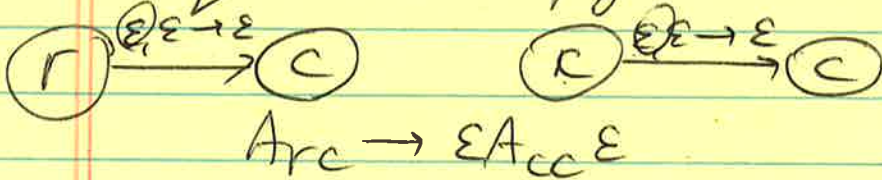
cattac



$S \rightarrow A_{sf}$



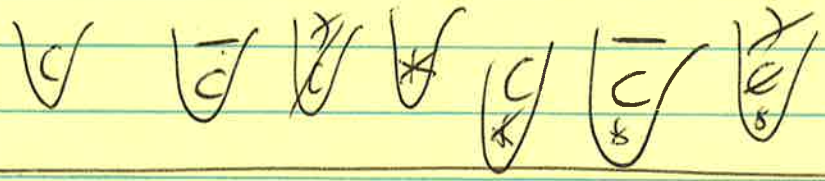
A_{pq} ≡ set of all words that allow you to go from p with empty stack to q with empty stack



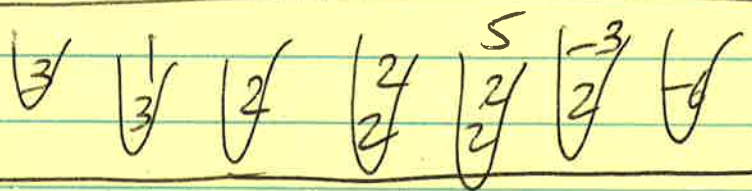
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-14-

$$\frac{(3-1) * (2-5)}{3 \quad 1- \quad 2 \quad 5- *}$$



$$\frac{3 \quad 1- \quad 2 \quad 5 \quad *}{3 \quad 1- \quad 2 \quad 5 \quad *}$$



$\forall CFG \exists p \forall w (\text{len}(w) \geq p \rightarrow \exists u, v, x, y, z$
 $(w = uvxyz \& \text{len}(vy) > 0 \& \text{len}(vxy) \leq p$
 $\& \forall i (uv^i xy^i z \in L))$

$L = \{a^n b^n c^n\}$ is not CFP

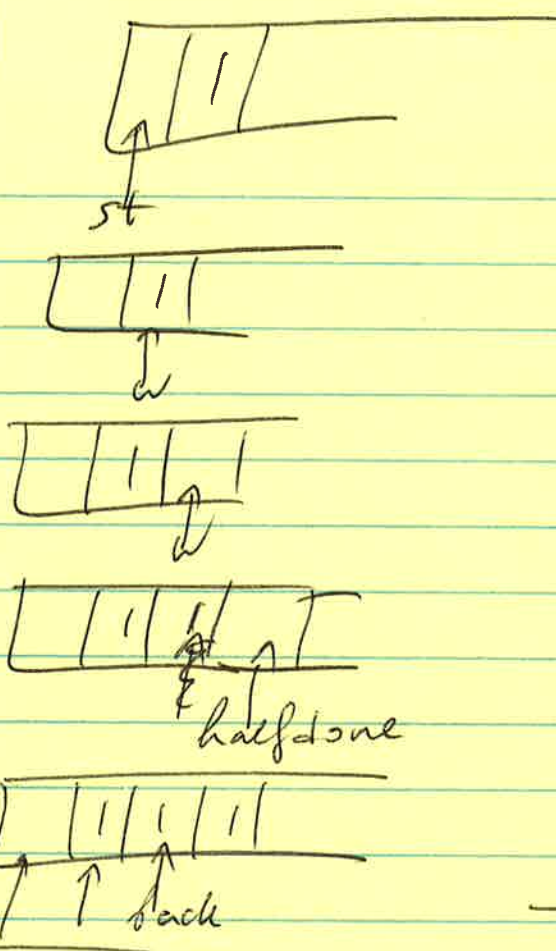
By contradiction. Let's assume L is ~~CFG~~ CFP
 Then by pumping lemma $\exists p$ such that...

Take $w = a^p b^p c^p$, $\text{len}(w) = \underbrace{a \dots a}_{p \text{ times}} \underbrace{b \dots b}_{p \text{ times}} \underbrace{c \dots c}_{p \text{ times}}$
 $\text{len}(w) = 3p \geq p$

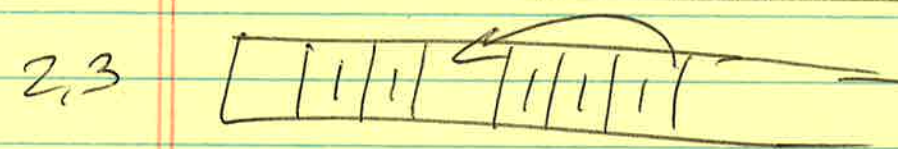
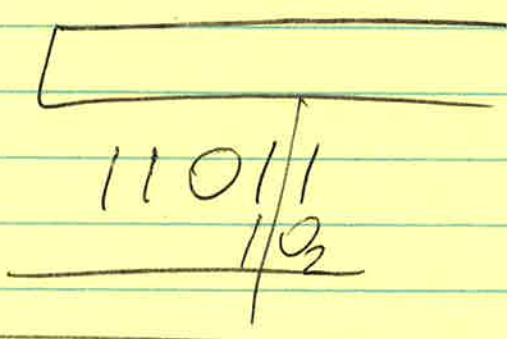
$u \quad v \quad x \quad y \quad z$

- 1) vxy is in a's, then in uv^2xy^2z we add a's but not b's and c's so balance is disrupted and $uv^2xy^2z \notin L$
- 2) vxy is in a's and b's, then we add a's and b's not c's - balance ...
- 3) vxy is in b's
- 4) b's and c's
- 5) in c's

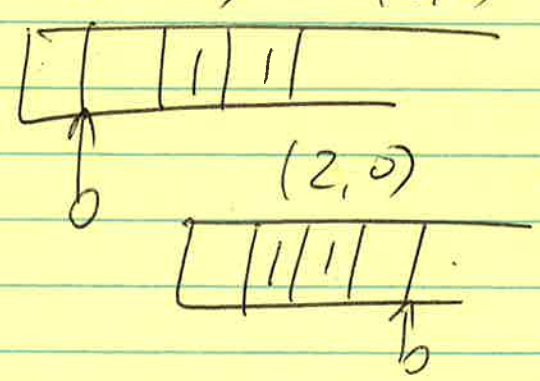
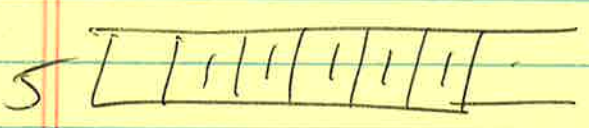
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-NS-



start, $\cup \rightarrow w, R$
 $w, l \rightarrow R$
 $w, \cup \rightarrow h, l, R$
 $h, \cup \rightarrow \text{back}, l, L$
 $b, l \rightarrow L$
 $b, \cup \rightarrow \text{halt}$

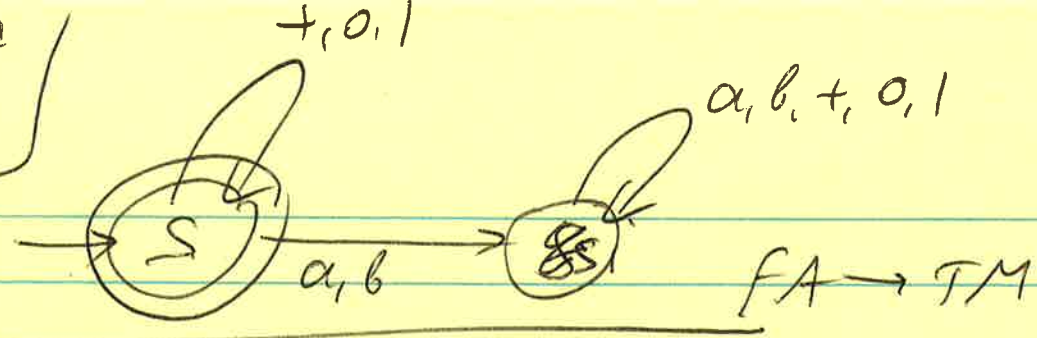


(2,3) (0,2)



start, $\cup \rightarrow \text{in1st}, R$
 $\text{in1st}, l \rightarrow R$
 $\text{in1st}, \cup \rightarrow l, \text{in2nd}, R$
 $\text{in2nd}, l \rightarrow R$
 $\text{in2nd}, \cup \rightarrow \text{readyTo Delete}, L$
 $\text{readyTo Delete}, l \rightarrow \cup, \text{back}, L$
 $\text{back}, l \rightarrow L$
 $\text{back}, \cup \rightarrow \text{halt}$

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NB



$s, \cup \rightarrow s, R$
 $s, + \rightarrow s, \textcircled{R}$
 $s, a \rightarrow s, R$
 s, b

$s, \cup \rightarrow \text{accept}$
 $s, \cup \rightarrow \text{reject}$