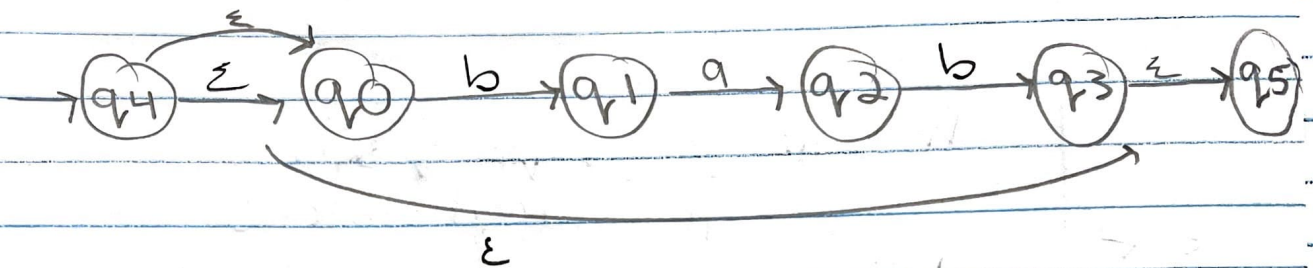


Final

Akash Vasishth

1)  $(b^* ab^* a)^*$



2) Useless productions

$S \rightarrow ab|aA|BC|aca|B$

↳ since  $S \rightarrow BC$  exists  $B$  &  $C$  reachable

$S \rightarrow ab|aA|aca|B$

$A \rightarrow b|BC|aaD|\lambda$

$B \rightarrow A|Ba|Db$

$C \rightarrow DCa|aCb$

$D \rightarrow a|b|cbb|B|\lambda$

Non-terminal symbols  $A, C, D$

$S \rightarrow ab|aA|aca|B$

$C \rightarrow DCa|aCb$

$D \rightarrow a|b|cbb|B|\lambda$

remove redundant sym

$C$  &  $D$

so ans =

$S \rightarrow ab|aA|aca|B$

$D \rightarrow a|b|cbb|B|\lambda$

$S \rightarrow 0S1S$

$S \rightarrow \epsilon$

3)  $S \rightarrow 0S1 \mid 0S11 \mid \epsilon$

PDA: State  $q_0, q_1, q_2, q_3, \dots$

initial  $q_0$  accept state: 3

Transitions

$q_0, \epsilon, Z_0 \rightarrow q_1, Z_0$ : start reading 0's

$q_1, 0, Z_0 \rightarrow q_1, 0Z_0$ : continue 0's

$q_1, \epsilon, Z_0 \rightarrow q_2, Z_0$ : reading 1's & 0's

$q_2, 1, 0 \rightarrow q_2, \epsilon$ : continue reading

$q_2, \epsilon, Z_0 \rightarrow q_3, Z_0$ : condition  $n \leq m \leq 2n$

4) Creating a TM that multiplies two numbers which are represented by zeros & separated by 1's.

$00100 \times 2 = 3 \times 2 = 6 = 000000$

$3 = 000 \quad 2 = 00$

$000 + 000$

$0000 + 000$

$00000 + 00$

$= 000000$

This TM involves repeatedly

Moving from second group

of zeros to the end of the

current sum & adding a zero

After which moving

back & decrementing the

second group of zeros until

none are left.

$q_3, 1, 0 \rightarrow q_3, \epsilon$  continue reading & check condition  
 $q_3, \epsilon, Z_0 \rightarrow q_4, Z_0$  accept state