Question # 01

1) $S \rightarrow SS \mid a$

① Augment Grammar : $S' \rightarrow S$
$S \rightarrow SS \mid a$

② No null productions

③ Remove unit productions : $S' \rightarrow SS \mid a$
$S \rightarrow SS \mid a$

④ No useless productions

⑤ Final CNF : $S' \rightarrow SS \mid a$
$S \rightarrow SS \mid a$

2) $S \rightarrow aXX$
$X \rightarrow aS \mid bS \mid a$

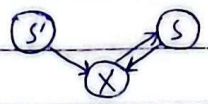
① Augment Grammar : $S' \rightarrow S$
$S \rightarrow aXX$
$X \rightarrow aS \mid bS \mid a$

② No null productions

③ Remove unit productions : $S' \rightarrow aXX$
$S \rightarrow aXX$
$X \rightarrow aS \mid bS \mid a$

④ No useless productions

Terminating = {S', S, X}



Date: Day:

⑤ Final CNF: $S' \rightarrow ZY$

$S \rightarrow ZY$

$X \rightarrow ZS \mid MS \mid a$

$Y \rightarrow XX$

$Z \rightarrow a$

$M \rightarrow b$

3) $E \rightarrow E+E$

$E \rightarrow E*E$

$E \rightarrow (E)$

$E \rightarrow 7$

$E \rightarrow E+E \mid E*E \mid (E) \mid 7$

① Augment Grammar : $E' \rightarrow E$

$E \rightarrow E+E \mid E*E \mid (E) \mid 7$

② No null productions

③ Remove unit productions: $E' \rightarrow E+E \mid E*E \mid (E) \mid 7$

$E \rightarrow E+E \mid E*E \mid (E) \mid 7$

④ No useless productions

Terminating = $\{E', E\}$ (E') → (E)

⑤ Final CNF: $E' \rightarrow ME \mid NE \mid OP \mid 7$

$E \rightarrow ME \mid NE \mid OP \mid 7$

$M \rightarrow EA$

$A \rightarrow +$

$N \rightarrow EB$

$B \rightarrow *$

$O \rightarrow QE$

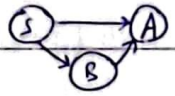
$P \rightarrow)$

$Q \rightarrow ($

Date: Day:

4) $S \rightarrow AAB \mid AB$
$A \rightarrow aA \mid aA \mid a$
$B \rightarrow Bb \mid bB \mid Bb \mid b \mid aA \mid aA \mid a \mid bb$

① No need for Augmentation
② No null productions
③ No unit productions
④ No useless productions
Terminating = {S, A, B}



⑤ Final CNF:
$S \rightarrow ZB \mid AB$
$A \rightarrow XA \mid a$
$B \rightarrow BY \mid YB \mid b \mid XA \mid a \mid YY$
$X \rightarrow a$
$Y \rightarrow b$
$Z \rightarrow AA$

Question # 2

1) $S \rightarrow AA \mid BA \mid AB$
$A \rightarrow AX \mid a$
$B \rightarrow b$
$X \rightarrow Aa \mid a$

Writing this in CNF form:

① $S \rightarrow AA \mid BA \mid AB$
② $A \rightarrow AX \mid a$
③ $B \rightarrow b$
④ $X \rightarrow AN \mid a$
⑤ $N \rightarrow a$

Date: Day:

Left Recursion in ②:

① S → AA | BA | AB

② A → aZ | a

Z → XZ | X

③ B → b

④ X → AN | a

⑤ N → a

uBv Rule violation in ④:

① S → AA | BA | AB

② A → aZ | a

Z → XZ | X

③ B → b

④ X → aZN | aN | a

⑤ N → a

Final GNF:

S → aZA | aA | bA | aZB | aB

A → aZ | a

Z → aZNZ | aNZ | aZ | aZN | aN | a

B → b

X → aZN | aN | a

N → a

3) S → ABABAB

A → a | ∧

B → b | ∧

Converting to CNF:

→ Removing null productions:

S → ABABAB | BABAB | AABAB | ABBAB | ABAAB | ABABB | ABABA | ABAB ...

A → a

B → b

Date: Day:

Converting to GNF:

$S \rightarrow aBABAB \mid bABAB \mid aADAB \mid aBBAB \mid bAAB \mid$
$aBABB \mid aBABA \mid aBAB \mid bBAB \mid aBBB \mid bABA \ldots$

$A \rightarrow a$

$B \rightarrow b$

2) $S \rightarrow aS \mid bS \mid BB \mid aC$

$A \rightarrow aA \mid a$

$B \rightarrow Bb \mid bB$

$C \rightarrow cc \mid cC$

Augmenting Grammar:

$S' \rightarrow S$

$S \rightarrow aS \mid bS \mid BB \mid aC$

$A \rightarrow aA \mid a$

$B \rightarrow Bb \mid bB$

$C \rightarrow cc \mid cC$

Remove unit productions:

$S' \rightarrow aS \mid bS \mid BB \mid aC$

$S \rightarrow aS \mid bS \mid BB \mid aC$

$A \rightarrow aA \mid a$

$B \rightarrow Bb \mid bB$

$C \rightarrow cc \mid cC$

Removing useless productions:

$S' \rightarrow aS \mid bS \mid aC$

$S \rightarrow aS \mid bS \mid aC$

$C \rightarrow cc \mid cC$

Final GNF: $S' \rightarrow aS \mid bS \mid aC$

$S \rightarrow aS \mid bS \mid aC$

$C \rightarrow cX \mid cC$

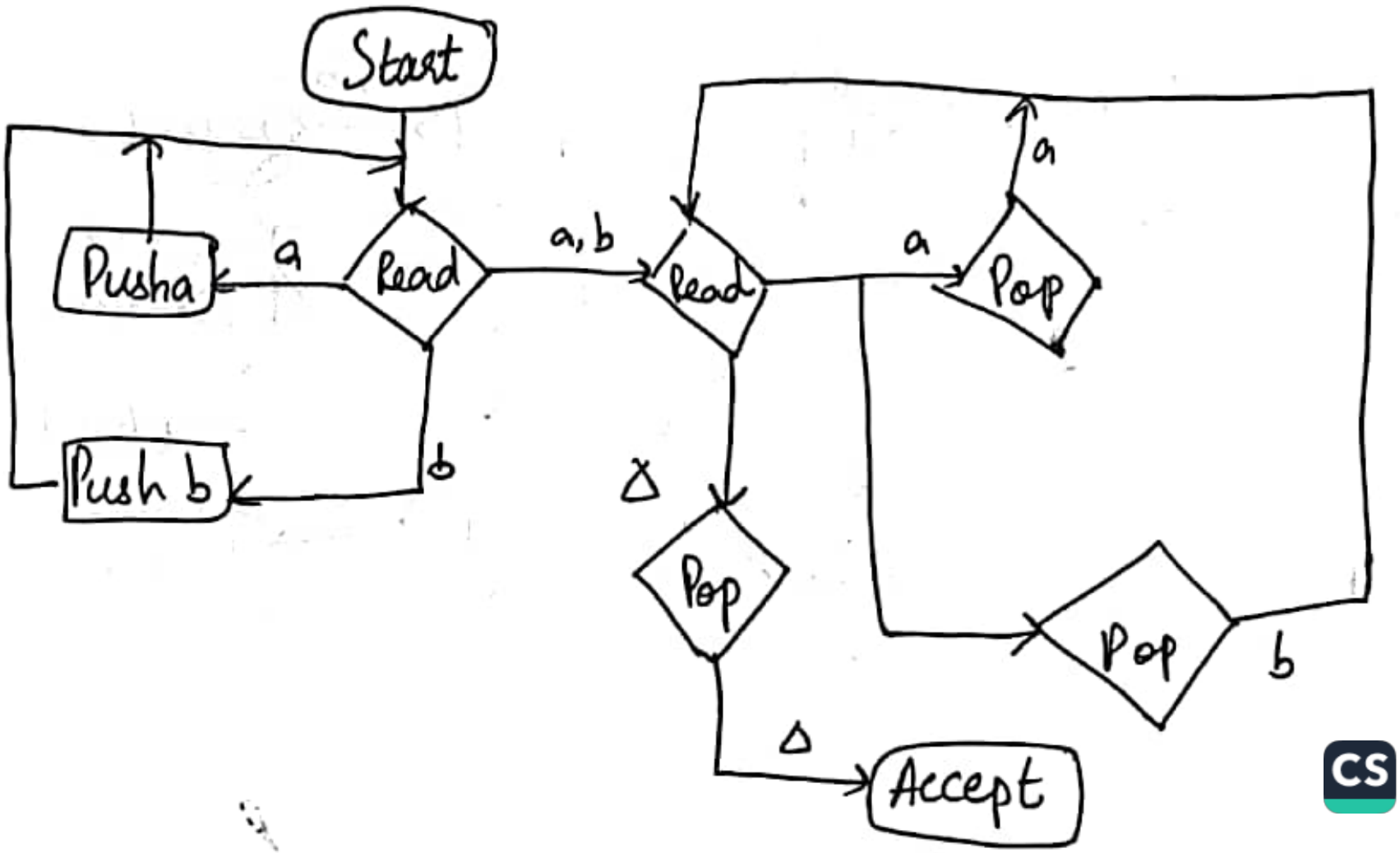
$X \rightarrow c$

Question 3

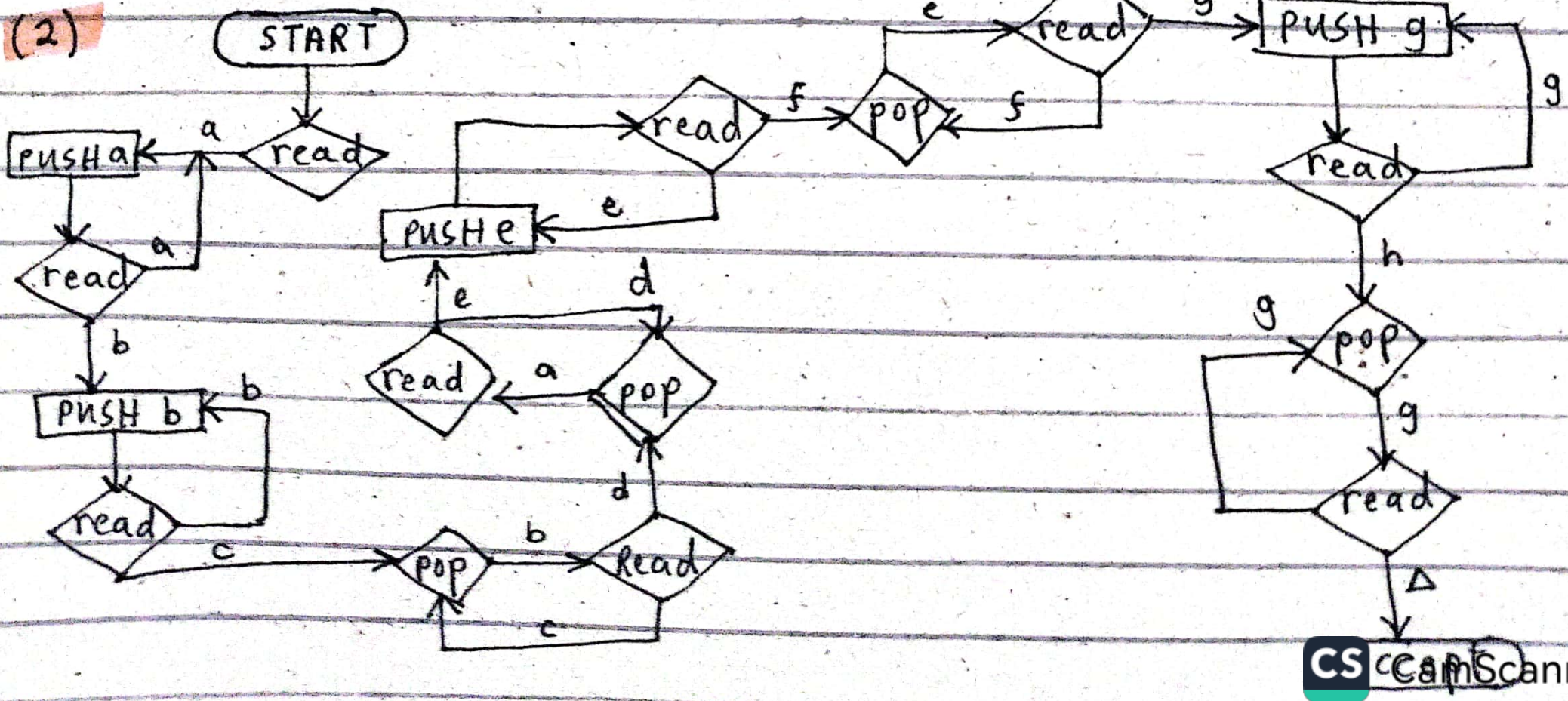
@ Palindrome

CFG: $S \rightarrow aSa \mid bSb \mid a \mid b \mid \lambda$

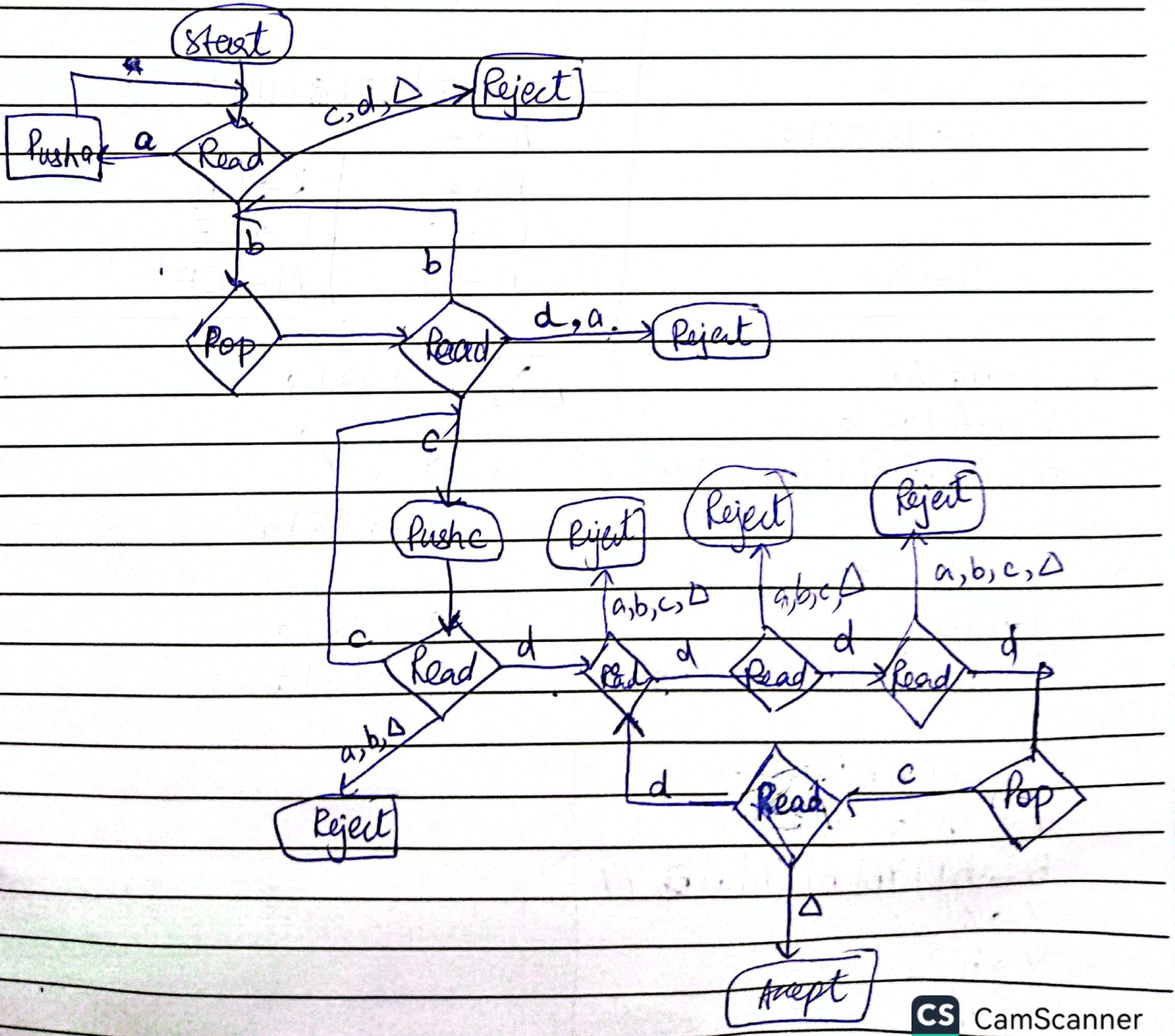
PDA:



(2)



(3) $a^n b^n c^m d^{4m}$


Start
Push a
a
Read
c, d, Δ
Reject
b
b
Pop
Read
d, a
Reject
c
Push c
Reject
Reject
Reject
Reject
a, b, c, Δ
a, b, c, Δ
a, b, c, Δ
c
Read
d
Read
d
Read
d
Read
d
a, b, Δ
Reject
d
Read
c
Pop
Δ
Accept

4 No 'abb'