Compiler Design

Today's Class Topics

-Left recursion and how to remove left recursion
-Left factoring and left factored grammar
-Parser classification
-First Function
-Follow Function

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Remove Left Recursion

Ex:- $S \to Sa \mid Ab$

$A \to aa \mid b$

$A \to A\alpha \mid \beta$ ⇒ $A \to BA'$, $A' \to \alpha A' \mid \in$

Soln: S, A

1) $S \to Sa \mid Ab$

$S \to AbS'$

$S' \to aS' \mid \in$

2) $A \to aa \mid Sb$

⇒ non left Recursive

$S \to ab \mid Ab$

$A \to Sa \mid b$ ⇒

1) $S \to ab \mid Ab$

2) $A \to Sa \mid b$

$A \to abA' \mid bA'$

$A \to aba \mid Aba \mid b$

$A \to Abaa \mid aba \mid b$

$A \to abA' \mid bA'$

$A' \to baA' \mid \in$

$S \to ab \mid Ab$

$A \to abA' \mid bA'$

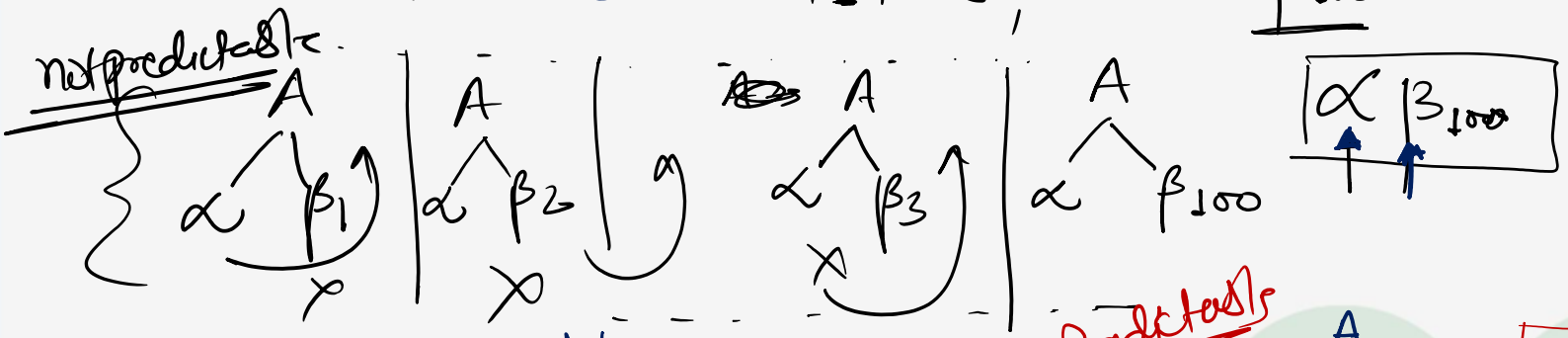
$A' \to baA' \mid \in$

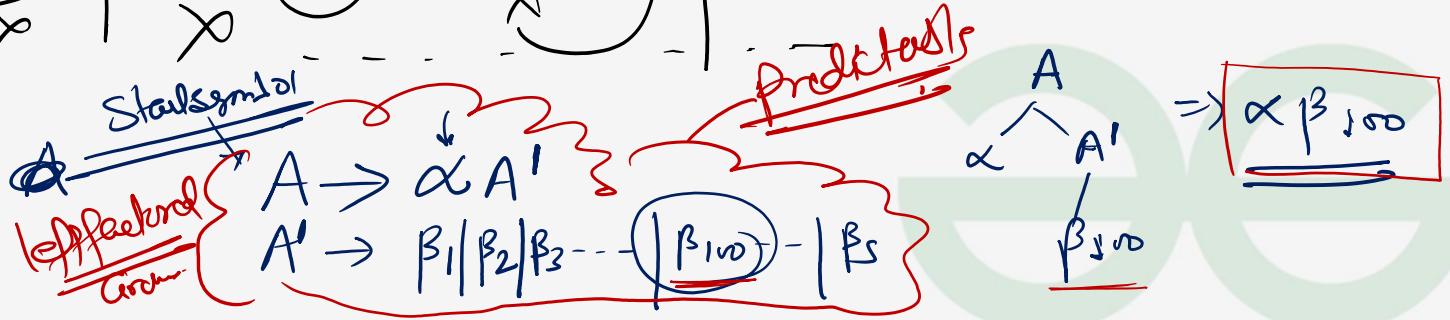
Left factoring and left factored grammar

Eliminate Common prefix:

UnAmbiguous CFG → LeftFactoring Algo → Left-factored Grammar

$G = \{ A \to \alpha\beta_1 \mid \alpha\beta_2 \mid \alpha\beta_3 \mid \cdots \mid \alpha\beta_n \}$, $\omega = \alpha\beta_{100}$





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$G = \{ A \to \alpha\beta_1 \mid \alpha\beta_2 \mid \alpha\beta_3 \mid \dots \mid \alpha\beta_n \}$ ✗

⇓ Remove left factoring

left factored Grammar

$A \to \alpha A'$

$A' \to \beta_1 \mid \beta_2 \mid \beta_3 \mid \dots \mid \beta_n$

Ex: $G_1 = \{ S \to aS \mid ab \mid a \mid \epsilon \}$

⇓

$S \to aS' \mid \epsilon$

$S' \to S \mid b \mid \epsilon$

left factored Gramm

$G_2 = \{ S \to aAb \mid aAa \mid aS \mid b,\ A \to aA \mid b \}$

⇓

$S \to aS' \mid b$

$S' \to Ab \mid Aa \mid S$

$A \to aA \mid b$

⇒

$S \to aS' \mid b$

$S'' \to AS'' \mid S$

$S'' \to b \mid a$

$A \to aA \mid b$

left factored Grammar

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Q-1) G

$S \rightarrow Aa \mid bcA$

$A \rightarrow bd \mid e$

G'

$S \rightarrow bda \mid ea \mid bcA$

$A \rightarrow bd \mid e$

$S \rightarrow bS' \mid ea$

$S' \rightarrow da \mid cA$

$A \rightarrow bd \mid e$

leftfactored Grammar.

Q-2) $S \rightarrow iEtS \mid iEtSeS \mid a$

$E \rightarrow b$

$S \rightarrow iEtSS' \mid a$

$S' \rightarrow eS \mid \epsilon$

$E \rightarrow b$

leftfactored Grammar

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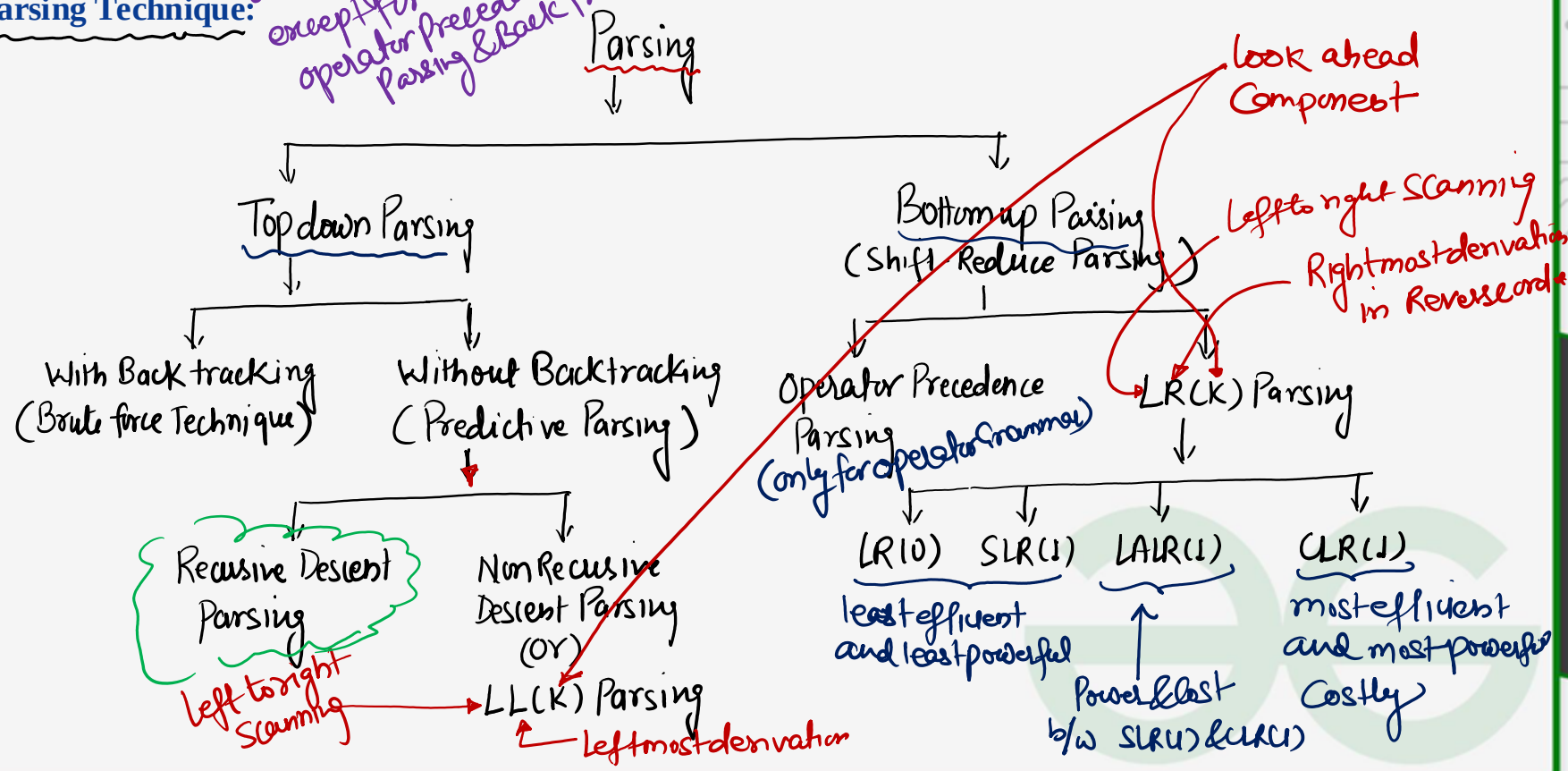
Parsing Technique:

Grammar should be Unambiguous, except for operator Precedence Parsing & Back Track Parsing



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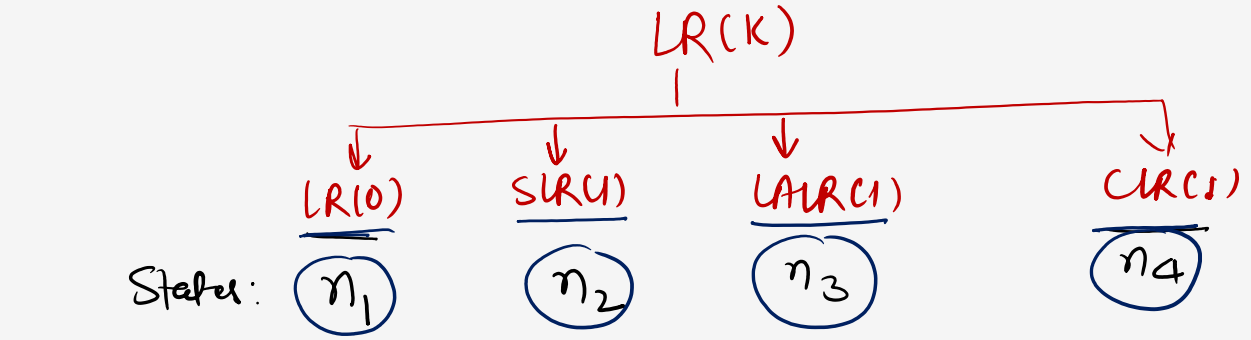

Note:

1) $n_1 = n_2 = n_3 \leq n_4$

2) No. of Shift entries of in $LR(0) = SLR(1) = LALR(1) \leq CLR(1)$

3) No of Reduce entries $LR(0) \geq SLR(1) \geq LALR(1) \geq CLR(1)$

4) Power of $LR(0) < SLR(1) < LALR(1) < CLR(1)$

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(LL(k))

Top down Passing:

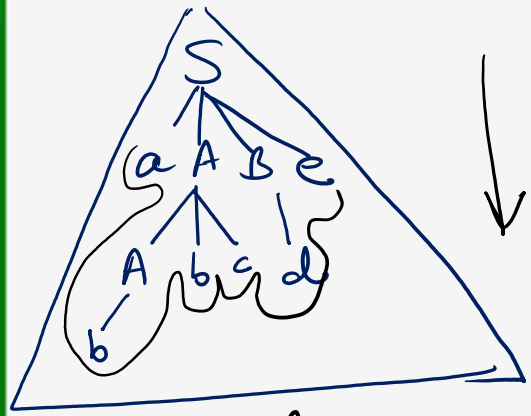
Ex:- $S \to aABe$

$A \to Abc \mid b$

$B \to d$

L → R

$\omega = abbcde$



abbcde

(LR(k))

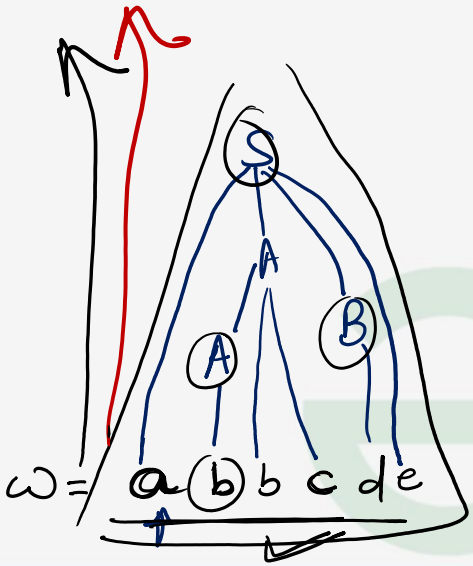
Bottomup passing

Ex:

$S \to aABe$

$A \to Abc \mid b$

$B \to d$



Rightmost derivation in Reverse order

$S \to aABe$

$B \to d$

$A \to Abc$

$A \to b$

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First and Follow Function:

First Function: First(A) is the set of terminals that are the first symbols on the right side of the arrow in every production of A

$A \rightarrow a - | b - | \epsilon - | \epsilon -$

$First(A) = \{a, b, c, \epsilon\}$

Ex: $A \rightarrow aA | bb | cB$

$First(A) = \{a, b, c\}$

$A \rightarrow aA | \epsilon$

$First(A) = \{a, \epsilon\}$

$A \rightarrow aA | BC$

$First(A) = \{a, ?\}$

Ex: $A \rightarrow BC, B \rightarrow bB | aC$

$First(A) = First(B)$ iff $First(B)$ doesnot Contain ϵ

$First(A) = \{a, b\}$, $First(B) = \{a, b\}$

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Procedure:

1. First(a) = {a}
2. if A → a ⇒ First(A) = {a}
3. if A → ∈ ⇒ First(A) = {∈}
4. if A → BC ⇒ First(A) = First(B) iff First(B) does not contain ∈
5. if A → BC ⇒ First(A) = (First(B) − {∈}) ∪ First(C)

First(abc) = {a}

First(a) = {a}

A → BC

First(A) =

A → BC

A → BC

A → BCDE

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Ex: Find First Set

1) G: { S → ABC, A → a, B → bB | a, C → ∈ }

First(S) = {a}

first(A) = {a}

first(B) = {b, a}

first(C) = {e}

2) G: { S → ABC, A → aA | ∈, B → bB | a, C → aC | a }

S → aBC

First(S) = {a, b}

first(A) = {a, ∈}

first(B) = {b, a}

first(C) = {a}

⇒

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Ex1- $G = \{S \to ABC, A \to aA \mid B, B \to bB \mid \epsilon, C \to aC \mid b \mid \epsilon\}$

$First(S) = \{a, b, \epsilon\} \cup \{b, \epsilon\} \cup \{c, b, \epsilon\} = \{a, b, c, \epsilon\}$

$First(A) = \{a, b, \epsilon\}$

$First(B) = \{b, \epsilon\}$

$First(C) = \{b, c, \epsilon\}$

$S \to ABC$

$A \to \epsilon$

$A \to aA \mid B$

$\{a, b, \epsilon\}$

$S \to BC$

$B \to bB$

$B \to Ca$

$C \to aA$

$C \to a$

Ex2 $G = \{S \to aA \mid BC, A \to Aa \mid \epsilon, B \to Ca \mid bB, C \to cA \mid \epsilon\}$

$First(S) = \{a, b, c\}$

$First(A) = \{\epsilon, a\}$

$First(B) = \{b, c, a\} = \{a, b, c\}$

$First(C) = \{c, \epsilon\}$

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Ex:- $G = \{ S \to ACB \mid CbA \mid Ba,\ A \to da \mid BC,\ B \to g \mid \epsilon,\ C \to h \mid \epsilon \}$

$First(S) = \{d, g, h, \epsilon, b, a\} = \{d, g, h, \epsilon, b, a\}$

$First(A) = \{d, g, h, \epsilon\}$

$First(B) = \{g, \epsilon\}$

$First(C) = \{h, \epsilon\}$

H.W

Ex:- $G = \{ S \to AaB \mid bC,\ A \to BC \mid bA,\ B \to aB \mid \epsilon,\ C \to SA \mid a \}$

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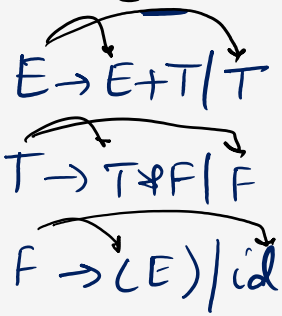
Ex:- $G = \{ E \to E+T \mid T,\ T \to T*F \mid F,\ F \to (E) \mid id \}$



$first(E) = first(T) = first(F) = \{ (, id \}$

∎

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Follow Function: Follow(A) is the set of terminals that present immediately to the right side of A wherever A is on the RHS of the arrow

Procedure:

1- follow(S) = {$} if S is the start symbol (Start Symbol)

2- if $A \rightarrow \alpha B \beta \Rightarrow follow(B) = first(\beta)$ iff First(β) does not contain $\in$

3- if $A \rightarrow \alpha B \beta \Rightarrow follow(B) = (first(\beta) - \{\in\}) \cup follow(A)$

4- if $A \rightarrow \alpha B \Rightarrow follow(B) = follow(A)$

$first(\beta) = \{x, y\}$

$A \rightarrow \alpha B$

$first(\beta) = \{x, y, \in\}$

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Ex:- Find the follow of each non terminal of the following Grammar

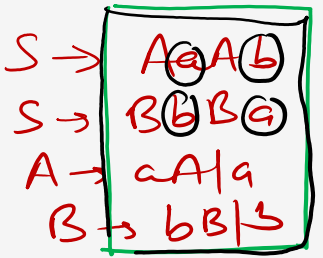
$G = \{ S \to AaAb \mid BbBa,\ A \to aA \mid a,\ B \to bB \mid b \}$

$Follow(S) = \{\$\}$

$Follow(A) = \{a, b\}$

$Follow(B) = \{a, b\}$

Any



Ex:- $G = \{ S \to AaBb \mid AC,\ A \to aB \mid b,\ B \to a,\ C \to c \}$

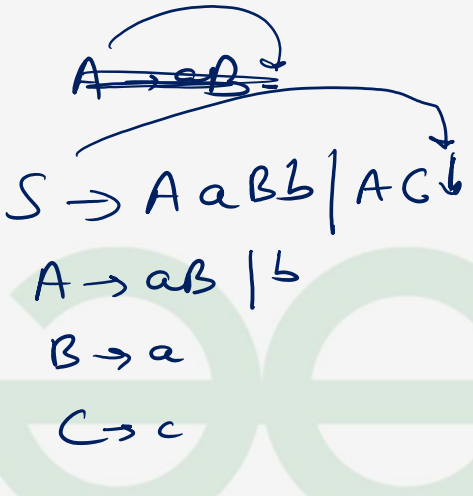
$Follow(S) = \{\$\}$

$Follow(A) = \{a, c\}$

$follow(B) = \{b, follow(A)\} = \{b, a, c\}$

$follow(C) = \{follow(S)\} = \{\$\}$

Any



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Ex:- $G = \{ S \to ABC, A \to aA/\epsilon, B \to bB/\epsilon, C \to cC/\epsilon \}$

Soln:

$follow(S) = \{\$\}$

$follow(A) = \{b, c, follow(S)\} = \{b, c, \$\}$

$follow(B) = \{c, follow(S)\} = \{c, \$\}$

$follow(C) = \{follow(S)\} = \{\$\}$

Ans

follow(A):- first( )

$S \to A$

$S \to AB$

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H.W

Ex: $G = \{ S \to SAB \mid \in,\ A \to AB \mid \in,\ B \to BC \mid Ca,\ C \to aCb \mid a$

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H.W

Ex:- $G = \{S \to ACB \mid CbB \mid Ba, A \to da \mid BC, B \to c \mid \epsilon, C \to e \mid \epsilon\}$

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H.W

Ex:- $G = \{E \to E+T/T,\ T \to T*F/F,\ F \to (E)/id\}$

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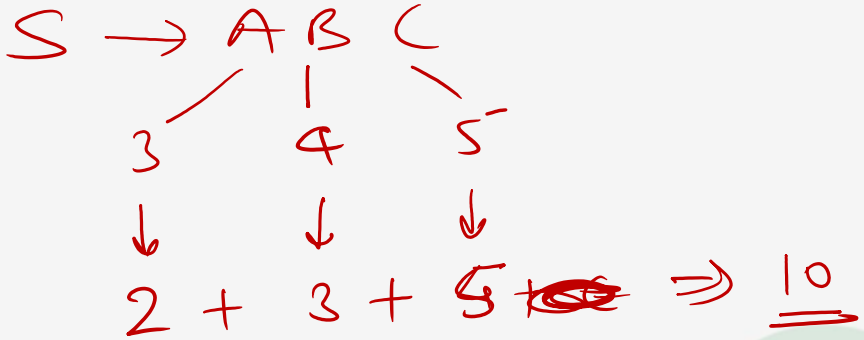
Q. Consider the following Production $S \rightarrow ABC$, of the no. of elements in First(A), First(B), and First(C) are 3,4,5 elements respectively and all these First sets contain 'ϵ' and the remaining all symbols are different. Then find no. of elements in First(S)?



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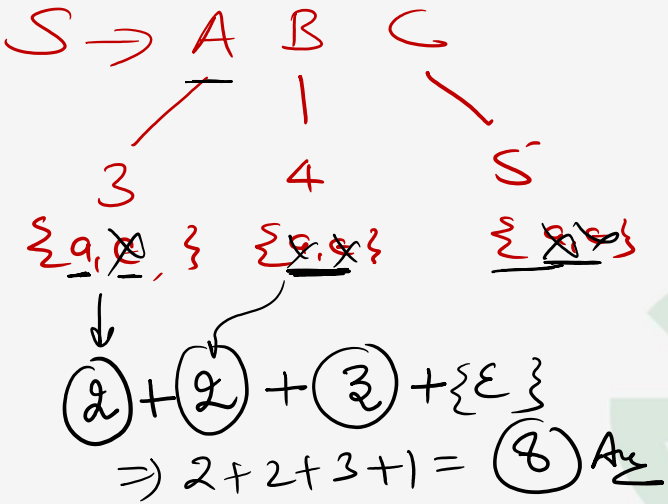
Question: Consider the following Production $S \rightarrow ABC$, if the no. of elements in First(A), First(B) and First(C) are 3, 4, 5 elements respectively and all these First sets Contains $\{a, \epsilon\}$ and the remaining all symbols are different. Then find no. of elements in First(S)?



Thank You !