

CD CAT1 QB – Answers

1. a) Explain different types of translators with example.

Ans 1. a) A translator is a program that takes a program in high level language as input and produces a program in machine language. Beside program translation, the translator performs another very important role, the error-detection.

Types of Translators

1) Interpreter –

- An interpreter is a program that appears to execute a source program as if it were machine language.
- An interpreter translates the entire source code line by line.
- Examples of interpreted languages are **Perl, Python and MATLAB**

2) Compiler –

- A compiler is a program that translates a high-level language program into a functionally equivalent low-level language program.
- A compiler translates the entire source code in a single run.
- Examples of compiled languages are **C, C++, C#, Java**

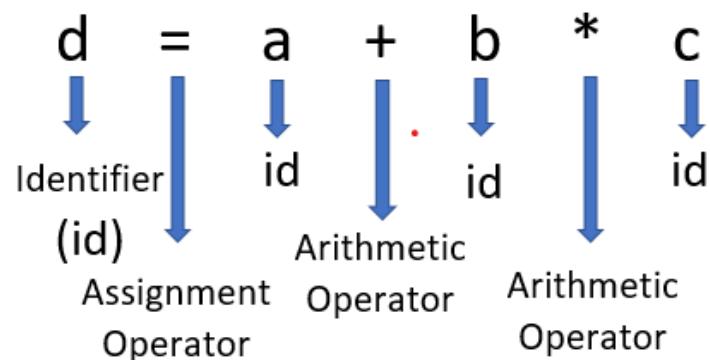
1. b) Explain various phases of compilers comes under front end.

Ans 1. b) Phases of Compilers - Front End

I. Lexical Analyzer (Scanner)

- Left to Right scanning
- Then separation of continuous expressions into single element which we will call ‘Token’.
- Example

$d = a + b * c$



- Steps we performed are:-

- i. Scanning
- ii. Tokenization
- iii. Naming of each token

II. Syntax Analyzer (Parser)

- Syntax Analyzer → checks syntax
- Semantic Analyzer → checks logic
- Generates a Parse Tree

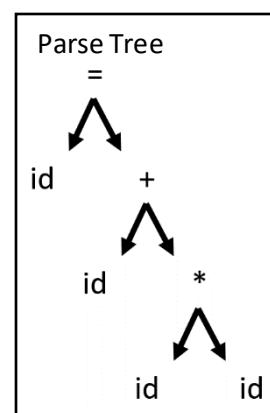
III. Intermediate Code Generation

- Three Address Code
- $c = a + b$
- Example

$id = id + id * id$



$id = id + id \because (id * id = id)$



2. a) Explain the following terms.

Ans 2. a)

i) Cross Compilers

- Cross compiler is a compiler that runs on one machine & produce the object code on another machine.
- The Cross Compiler is used to implement the compiler which is characterized by 3 languages
 - a) The Source Language
 - b) The Object Language
 - c) The Language in which it is written

ii) Bootstrap Compilers

- The compiler which is written in its own language is called bootstrap compiler.
- The technique for producing a self-compiling compiler

iii) Just in time Compiler

- A way of executing computer code that involves compilation during execution of a program (at run time) rather than before execution.
- This reduces overall time taken for compilation of code to machine language.

2. b) Explain various phases of compilers comes under back end.

Ans 2. b) Phases of Compilers - Back End

I. Code optimization

- Attempt to improve the intermediate code
- necessary to have a faster executing code or less consumption of memory.

II. Code generation

- Generates code for the target machine
- Assembly code

3. a) Explain Top-Down Parser with example.

Ans 3. a) Top-Down Parser:

- A parsing technique that involves starting with the highest-level nonterminal symbol of the grammar and working downward to derive the input string.
- Example:
 $S \rightarrow \text{Start Symbol}$

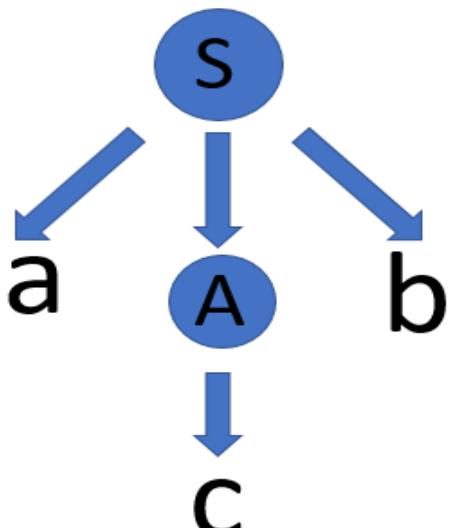


$\omega \rightarrow \text{String of terminal symbol}$

$S \rightarrow aAb$

$A \rightarrow cd/c \quad \boxed{\begin{array}{l} A \rightarrow cd \\ A \rightarrow c \end{array}}$

$\omega \rightarrow abc \quad \} - \text{Required string}$



3. b) Find the FIRST () and FOLLOW () for the following grammar.

- $S \rightarrow aIJh$
- $I \rightarrow IbSe / c$
- $J \rightarrow KLKr / \epsilon$
- $K \rightarrow d / \epsilon$
- $L \rightarrow p / \epsilon$

Ans 3. b)

- $S \rightarrow aIJh$
- $I \rightarrow cl'$
- $I' \rightarrow bSel' / \epsilon$
- $J \rightarrow KLKr / \epsilon$
- $K \rightarrow d / \epsilon$
- $L \rightarrow p / \epsilon$

To Eliminate Left Recursion

If $A \rightarrow A\alpha / \beta$

then

$A \rightarrow \beta A'$

$A' \rightarrow \alpha A'$

$\text{FIRST}(S) \rightarrow \{a\}$

$\text{FIRST}(I) \rightarrow \{c\}$

$\text{FIRST}(I') \rightarrow \{b, \epsilon\}$

$\text{FIRST}(J) \rightarrow \{d, p, r, \epsilon\}$

$\text{FIRST}(K) \rightarrow \{d, \epsilon\}$

$\text{FIRST}(L) \rightarrow \{p, \epsilon\}$

$\text{FOLLOW}(S) \rightarrow \{\$, e\}$

$\text{FOLLOW}(I) \rightarrow \{p, d, r, h\}$

$\text{FOLLOW}(I') \rightarrow \{p, d, r, h\}$

$\text{FOLLOW}(J) \rightarrow \{h\}$

$\text{FOLLOW}(K) \rightarrow \{p, d, r\}$

$\text{FOLLOW}(L) \rightarrow \{d, r\}$

	a	b	c	d	e	h	p	r	\$
S	$S \rightarrow aIJh$								
I			$I \rightarrow cl'$						
I'		$I' \rightarrow bSel'$		$I' \rightarrow \epsilon$	$I' \rightarrow \epsilon$	$I' \rightarrow \epsilon$			
J				$J \rightarrow KLKr$	$J \rightarrow \epsilon$	$J \rightarrow KLKr$	$J \rightarrow KLKr$		
K				$K \rightarrow d / \epsilon$			$K \rightarrow \epsilon$	$K \rightarrow \epsilon$	
L				$L \rightarrow \epsilon$			$L \rightarrow p$	$L \rightarrow \epsilon$	

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3. b) Find First() & Follow()

$S \rightarrow aIJh$

$I \rightarrow IbSe / c$

$J \rightarrow KLKr / \epsilon$

$K \rightarrow d / \epsilon$

$L \rightarrow p / \epsilon$

Sol Eliminate Left Recursion

If $A \rightarrow A\alpha / B$

then

$$A \rightarrow BA' \quad A' \rightarrow \alpha A' / \epsilon$$

So, $I \rightarrow IbSe/c$

$$I \rightarrow CI' \quad I' \rightarrow bSeI'/\epsilon$$

$$S \rightarrow aIJh$$

$$\cancel{I \rightarrow IbSe/c}$$

$$I \rightarrow CI'$$

$$I' \rightarrow bSeI'/\epsilon$$

$$J \rightarrow KLK\sigma/\epsilon$$

$$K \rightarrow d/\epsilon$$

$$L \rightarrow p/\epsilon$$

$$\begin{aligned} \text{FIRST}(L) &\rightarrow \text{FIRST}(p) \cup \text{FIRST}(\epsilon) \\ &\rightarrow \{p\} \cup \{\epsilon\} \end{aligned}$$

$$\text{FIRST}(L) \rightarrow \{p, \epsilon\}$$

$$\begin{aligned} \text{FIRST}(K) &\rightarrow \text{FIRST}(d) \cup \text{FIRST}(\epsilon) \\ &\rightarrow \{d\} \cup \{\epsilon\} \end{aligned}$$

$$\text{FIRST}(K) \rightarrow \{d, \epsilon\}$$

① - $\text{FIRST}(J) \rightarrow \text{FIRST}(KLKs) \cup \text{FIRST}(\epsilon)$

② - $\text{FIRST}(KLKs) \rightarrow \text{FIRST}(K) - \{\epsilon\} \cup \text{FIRST}(LKr)$

③ - $\text{FIRST}(LKr) \rightarrow \text{FIRST}(L) - \{\epsilon\} \cup \text{FIRST}(Kr)$

$\text{FIRST}(Ks) \rightarrow \text{FIRST}(K) - \{\epsilon\} \cup \text{FIRST}(s)$

$\rightarrow \{d, \epsilon\} - \{\epsilon\} \cup \{s\}$

$\rightarrow \{d\} \cup \{s\}$

$\text{FIRST}(Ks) \rightarrow \{d, s\}$

↳ put in eq(3)

$\text{FIRST}(LKs) \rightarrow \{p, \epsilon\} - \{\epsilon\} \cup \{d, s\}$

$\rightarrow \{p\} \cup \{d, s\}$

$\text{FIRST}(LKs) \rightarrow \{p, d, s\}$

↳ put in eq(2)

$\text{FIRST}(KLKs) \rightarrow \{d, \epsilon\} - \{\epsilon\} \cup \{p, d, s\}$

$\rightarrow \{d\} \cup \{p, d, s\}$

$\text{FIRST}(KLKs) \rightarrow \{p, d, s\}$

↳ put in eq(1)

$\text{FIRST}(J) \rightarrow \{p, d, s\} \cup \{\epsilon\}$

$\text{FIRST}(J) \rightarrow \{p, d, s, \epsilon\}$

$\text{FIRST}(I') \rightarrow \text{FIRST}(bseI') \cup \text{FIRST}(\epsilon)$

$\rightarrow \{b\} \cup \{\epsilon\}$

$\text{FIRST}(I') \rightarrow \{b, \epsilon\}$

FIRST(I) \rightarrow FIRST(I')

FIRST(I) \rightarrow {c}

FIRST(S) \rightarrow FIRST(a I J b)

FIRST(S) \rightarrow {a}

FOLLOW(S) \rightarrow {\$} \cup \{e\}

FOLLOW(S) \rightarrow {\$, e}

FOLLOW(I) \rightarrow FIRST(J b)

\rightarrow FIRST(J) - {\$} \cup FIRST(b)

FOLLOW(I) \rightarrow {p, d, r, e} - {\$} \cup \{h\}

FOLLOW(I) \rightarrow {p, d, r, h}

FOLLOW(I') \rightarrow FOLLOW(I)

$\rightarrow \vdots$

FOLLOW(I') \rightarrow FOLLOW(I)

FOLLOW(I') \rightarrow {p, d, r, h}

FOLLOW(I) \rightarrow FIRST(h)

FOLLOW(I) \rightarrow {b}

FOLLOW(k) \rightarrow FIRST(L k r) \cup FIRST(K s)

\rightarrow {p, d, r} \cup {d, s}

FOLLOW(k) \rightarrow {p, d, r}

FOLLOW(l) \rightarrow FIRST(K s)

FOLLOW(l) \rightarrow {d, s}

	a	b	c	d	e	h	p	r	\$
S	$S \rightarrow aIJb$								
I				$I \rightarrow cI'$					
I'		$I' \rightarrow bSeI'$			$I' \rightarrow e$	$I' \rightarrow e$	$I' \rightarrow e$		
J					$J \rightarrow kLkS$	$J \rightarrow e$	$J \rightarrow kLkS$	$J \rightarrow kLkS$	
K					$K \rightarrow d, K \rightarrow e$		$K \rightarrow e$	$K \rightarrow e$	
L					$L \rightarrow G$		$L \rightarrow p$	$L \rightarrow G$	

4. a) Show whether given grammar is LL(1) or not.

- $S \rightarrow AaAb/BbBa$
- $A \rightarrow \epsilon$
- $B \rightarrow \epsilon$

Ans 4. a) Condition for LL(1) - $\therefore \text{FIRST}(\alpha) \cap \text{FIRST}(\beta) = \{\Phi\}$

$\text{FIRST}(AaAb) \rightarrow \text{FIRST}(A) - \{\epsilon\} \cup \text{FIRST}(aAb)$

$\text{FIRST}(BbBa) \rightarrow \text{FIRST}(b) - \{\epsilon\} \cup \text{FIRST}(bBa)$

$\text{FIRST}(AaAb) \cap \text{FIRST}(BbBa) = \{\Phi\}$

\therefore The given grammar is LL(1)

$\text{FIRST}(A) \rightarrow \{\epsilon\}$

$\text{FIRST}(B) \rightarrow \{\epsilon\}$

$\text{FIRST}(S) \rightarrow \text{FIRST}(AaAb) \cup \text{FIRST}(BbBa)$

$\rightarrow \{a\} \cup \{b\}$

$\rightarrow \{a,b\}$

$\text{FOLLOW}(S) \rightarrow \{\$\}$

$\text{FOLLOW}(A) \rightarrow \text{FIRST}(aAb) \mid \text{FIRST}(b)$

$\rightarrow \{a\} \mid \{b\}$

$\rightarrow \{a,b\}$

$\text{FOLLOW}(B) \rightarrow \text{FIRST}(Bba) \mid \text{FIRST}(a)$

$\rightarrow \{b\} \mid \{a\}$

$\rightarrow \{b,a\}$

Predictive Parsing Table:

	a	b	\$
S	$S \rightarrow AaAb$	$S \rightarrow BbBa$	
A	$A \rightarrow \epsilon$	$A \rightarrow \epsilon$	
B	$B \rightarrow \epsilon$	$B \rightarrow \epsilon$	

4. a) Check LL(1) or not
 $S \rightarrow AaAb / BbBa$

$A \rightarrow \epsilon$

$B \rightarrow \epsilon$

Condition for LL(1)

$S \rightarrow \alpha / \beta$

$\text{FIRST}(\alpha) \cap \text{FIRST}(\beta) = \{\Phi\}$

\therefore Grammar is LL(1)

Here,

$$S \rightarrow AaAb \quad / \quad BbBa$$

$$\begin{aligned} \text{FIRST}(AaAb) &\rightarrow \text{FIRST}(A) - \{\epsilon\} \cup \text{FIRST}(Ab) \\ &\rightarrow \{\epsilon\} - \{\epsilon\} \cup \{a\} \\ &\rightarrow \{a\} \end{aligned}$$

$$\begin{aligned} \text{FIRST}(BbBa) &\rightarrow \text{FIRST}(B) - \{\epsilon\} \cup \text{FIRST}(bBa) \\ &\rightarrow \{\epsilon\} - \{\epsilon\} \cup \{b\} \\ &\rightarrow \{b\} \end{aligned}$$

$$\text{FIRST}(AaAb) \cap \text{FIRST}(BbBa) = \{a\} \cap \{b\} = \{\phi\}$$

\therefore given Grammar is LL(1)

$$\text{FIRST}(A) \rightarrow \{\epsilon\}$$

$$\text{FIRST}(B) \rightarrow \{\epsilon\}$$

$$\begin{aligned} \text{FIRST}(S) &\rightarrow \text{FIRST}(AaAb) \cup \text{FIRST}(BbBa) \\ &\rightarrow \{a\} \cup \{b\} \end{aligned}$$

$$\text{FIRST}(S) \rightarrow \{a, b\}$$

$$\text{FOLLOW}(S) \rightarrow \{\$\}$$

$$\begin{aligned} \text{FOLLOW}(A) &\rightarrow \text{FIRST}(aAb) \cup \text{FIRST}(b) \\ &\rightarrow \{a, b\} \end{aligned}$$

$$\begin{aligned} \text{FOLLOW}(B) &\rightarrow \text{FIRST}(bBa) \cup \text{FIRST}(a) \\ &\rightarrow \{b, a\} \end{aligned}$$

Predictive Parsing Table

	a	b	\$
S	$S \rightarrow AaAb$	$S \rightarrow BbBa$	
A	$A \rightarrow E$	$A \rightarrow E$	
B	$B \rightarrow G$	$B \rightarrow G$	

4. b) Explain why Top-Down Parser is called left most derivative Parser.

Ans 4. b)

The reason that top-down parsing follows the left-most derivation for an input string ω and not the right-most derivation is that **the input string ω is scanned by the parser from left to right, one symbol/token at a time.**

5. a) Find the reduced grammar equivalent to CFG

- $G \{ S A B C \} \{ a b d \} S P$ where P contains = (, , , , ,)
- $S \rightarrow AC / SB$
- $A \rightarrow bASC / a$
- $B \rightarrow aSB / bbC$
- $C \rightarrow Bc / ad$

5. b) Consider the following Grammar

- $E \rightarrow TA$
- $A \rightarrow +TA/\epsilon$
- $T \rightarrow FB$
- $B \rightarrow *FB/\epsilon$
- $F \rightarrow (E)/id$

Find FIRST() and FOLLOW() for each and every non terminal

Ans 5. b)

$$\text{FIRST}(E) \rightarrow \{ (, id \}$$

$$\text{FIRST}(A) \rightarrow \{ +, \epsilon \}$$

$$\text{FIRST}(T) \rightarrow \{ (, id \}$$

$$\text{FIRST}(B) \rightarrow \{ *, \epsilon \}$$

$$\text{FIRST}(F) \rightarrow \{ (, id \}$$

$$\text{FOLLOW}(E) \rightarrow \{ \$,) \}$$

$$\text{FOLLOW}(A) \rightarrow \{ \$,) \}$$

$$\text{FOLLOW}(T) \rightarrow \{ +, \$,) \}$$

$$\text{FOLLOW}(B) \rightarrow \{ +, \$,) \}$$

$$\text{FOLLOW}(F) \rightarrow \{ *, +, \$,) \}$$

Q. 5b Find FIRST() & FOLLOW()

$$E \rightarrow TA$$

$$A \rightarrow +TA / \epsilon$$

$$T \rightarrow FB$$

$$B \rightarrow *FB / \epsilon$$

$$F \rightarrow (E) / id$$

Sol $\text{FIRST}(F) \rightarrow \text{FIRST}((E)) \cup \text{FIRST}(id)$
 $\rightarrow \{ (, id \}$

$$\text{FIRST}(B) \rightarrow \text{FIRST}(*FB) \cup \text{FIRST}(\epsilon)$$

 $\rightarrow \{ *, \epsilon \}$

$$\text{FIRST}(T) \rightarrow \text{FIRST}(FB)$$

 $\rightarrow \text{FIRST}(F)$
 $\rightarrow \{ (, id \}$

$$\text{FIRST}(A) \rightarrow \text{FIRST}(+TA) \cup \text{FIRST}(E)$$

$$\rightarrow \{+, E\}$$

$$\text{FIRST}(E) \rightarrow \text{FIRST}(TA)$$

$$\rightarrow \text{FIRST}(T)$$

$$\rightarrow \{C, id\}$$

$$\text{FOLLOW}(E) \rightarrow \{\$,)\}$$

$$\text{FOLLOW}(A) \rightarrow \text{FOLLOW}(E)$$

$$\rightarrow \{\$,)\}$$

$$\text{FOLLOW}(T) \rightarrow \text{FIRST}(A) - \{E\} \cup \text{FOLLOW}(E)$$

$$\cup \text{FIRST}(A) - \{E\} \cup \text{FOLLOW}(A)$$

$$\rightarrow \{+, E\} - \{E\} \cup \{\$,)\} \cup \{+, E\} - \{E\}$$

$$\cup \{\$,)\}$$

$$\rightarrow \{+\} \cup \{\$,)\} \cup \{+\} \cup \{\$,)\}$$

$$\text{FOLLOW}(T) \rightarrow \{+, \$,)\}$$

$$\text{FOLLOW}(B) \rightarrow \text{FOLLOW}(T) \cup \text{FOLLOW}(B)$$

$$\rightarrow \text{FOLLOW}(T)$$

$$\rightarrow \{+, \$,)\}$$

$$\text{FOLLOW}(F) \rightarrow \text{FIRST}(B) - \{E\} \cup \text{FOLLOW}(T)$$

$$\cup \text{FIRST}(B) - \{E\} \cup \text{FOLLOW}(B)$$

$$\rightarrow \{\ast, E\} - \{E\} \cup \{+, \$,)\}$$

$$\cup \{\ast, E\} - \{E\} \cup \{+, \$,)\}$$

$$\rightarrow \{\ast\} \cup \{+, \$,)\}$$

$$\text{FOLLOW}(F) \rightarrow \{\ast, +, \$,)\}$$

	+	*	()	<	id	\$
E			E → TA			E → TA	
A	A → +TA		(A → E		A → E	
T			T → FB			T → FB	
B	B → E	B → *FB		B → E		B → E	
F			F → (E)			F → id	

6. a) Compare SLR ,CLR and LALR Parser

Ans 6. a)

SLR Parser	LALR Parser	CLR Parser
It is very easy and cheap to implement.	It is also easy and cheap to implement.	It is expensive and difficult to implement.
SLR Parser is the smallest in size.	LALR and SLR have the same size. As they have a smaller number of states.	CLR Parser is the largest. As the number of states is very large.
Error detection is not immediate in SLR.	Error detection is not immediate in LALR.	Error detection can be done immediately in CLR Parser.
SLR fails to produce a parsing table for a certain class of grammars.	It is intermediate in power between SLR and CLR i.e., $SLR \leq LALR \leq CLR$.	It is very powerful and works on a large class of grammar.
It requires less time and space complexity.	It requires more time and space complexity.	It also requires more time and space complexity.

6. b) Consider the following grammar:

- $S \rightarrow aSbS / bSaS / \epsilon$

a) Show that this grammar is ambiguous by constructing two different leftmost derivation for the sentence abab.

Same Online Answer: <https://www.collegenote.net/pastpapers/4270/question/>

Similar Question on Youtube: https://youtu.be/K_aMajzrKF4

Q. 6b CAT I - QB

$$S \rightarrow aSbS / bSaS / \epsilon$$

a) Show that it is ambiguous by const
2 diff leftmost derivations for sentence
"abab"

sol

$$w = abab$$

Derivation 1 :

S	
$aSbS$	$\xrightarrow{S \rightarrow aSbS}$
$abSaSbS$	$\xrightarrow{S \rightarrow bSaS}$
$ababSbS$	$\xrightarrow{S \rightarrow \epsilon}$
$ababS$	$\xrightarrow{S \rightarrow \epsilon}$
$abab$	$\xrightarrow{S \rightarrow \epsilon}$

Derivation 2 :

S	
$aSbS$	$\xrightarrow{S \rightarrow aSbS}$
abS	$\xrightarrow{S \rightarrow \epsilon}$
$abSaSbS$	$\xrightarrow{S \rightarrow aSbS}$
$ababS$	$\xrightarrow{S \rightarrow \epsilon}$
$abab$	$\xrightarrow{S \rightarrow \epsilon}$

7. a) Consider the following grammar

- $S \rightarrow ABC$
- $A \rightarrow a/\epsilon$
- $B \rightarrow r/\epsilon$
- $C \rightarrow b/\epsilon$

Construct parsing table with LL Parser

Ans 7. a)

$$\text{FIRST}(A) \rightarrow \text{FIRST}(a) \cup \text{FIRST}(\epsilon)$$

$$\begin{aligned} &\rightarrow \{a\} \cup \{\epsilon\} \\ &\rightarrow \{a, \epsilon\} \end{aligned}$$

$$\text{FIRST}(B) \rightarrow \text{FIRST}(r) \cup \text{FIRST}(\epsilon)$$

$$\begin{aligned} &\rightarrow \{r\} \cup \{\epsilon\} \\ &\rightarrow \{r, \epsilon\} \end{aligned}$$

$$\text{FIRST}(C) \rightarrow \text{FIRST}(b) \cup \text{FIRST}(\epsilon)$$

$$\begin{aligned} &\rightarrow \{b\} \cup \{\epsilon\} \\ &\rightarrow \{b, \epsilon\} \end{aligned}$$

$$\text{FIRST}(S) \rightarrow \text{FIRST}(ABC)$$

$$\begin{aligned} &\rightarrow \text{FIRST}(A) - \{\epsilon\} \cup \text{FIRST}(BC) \\ &\rightarrow \{a, \epsilon\} - \{\epsilon\} \cup \{r, \epsilon\} - \{\epsilon\} \cup \{b, \epsilon\} \\ &\rightarrow \{a\} \cup \{r\} \cup \{b, \epsilon\} \\ &\rightarrow \{a\} \cup \{r, b, \epsilon\} \\ &\rightarrow \{a, r, b, \epsilon\} \end{aligned}$$

$$\text{FOLLOW}(S) \rightarrow \{\$\}$$

$$\text{FOLLOW}(A) \rightarrow \text{FIRST}(BC) - \{\epsilon\} \cup \text{FOLLOW}(S)$$

$$\begin{aligned} &\rightarrow \{r, b, \epsilon\} - \{\epsilon\} \cup \{\$\} \\ &\rightarrow \{r, b, \$\} \end{aligned}$$

$$\text{FOLLOW}(B) \rightarrow \text{FIRST}(C) - \{\epsilon\} \cup \text{FOLLOW}(S)$$

$$\begin{aligned} &\rightarrow \{b, \epsilon\} - \{\epsilon\} \cup \{\$\} \\ &\rightarrow \{b, \$\} \end{aligned}$$

$$\text{FOLLOW}(C) \rightarrow \{\$\}$$

Parsing Table				
	a	b	r	\$
S	$S \rightarrow ABC$	$S \rightarrow ABC$	$S \rightarrow ABC$	$S \rightarrow ABC$
A	$A \rightarrow a$	$A \rightarrow \epsilon$	$A \rightarrow \epsilon$	$A \rightarrow \epsilon$
B		$B \rightarrow \epsilon$	$B \rightarrow r$	$B \rightarrow \epsilon$
C		$C \rightarrow b$		$C \rightarrow \epsilon$

7 a) $S \rightarrow ABC$

$$A \rightarrow a/\epsilon$$

$$B \rightarrow r/\epsilon$$

$$C \rightarrow b/\epsilon$$

sol $\text{FIRST}(C) \rightarrow \text{FIRST}(b) \cup \text{FIRST}(\epsilon)$
 $\rightarrow \{b, \epsilon\}$

$\text{FIRST}(B) \rightarrow \text{FIRST}(r) \cup \text{FIRST}(\epsilon)$
 $\rightarrow \{r, \epsilon\}$

$$\begin{aligned}\text{FIRST}(A) &\rightarrow \text{FIRST}(a) \cup \text{FIRST}(\epsilon) \\ &\rightarrow \{a, \epsilon\}\end{aligned}$$

$$\begin{aligned}\text{FIRST}(S) &\rightarrow \text{FIRST}(ABC) \\ &\rightarrow \text{FIRST}(A) - \{\epsilon\} \cup \text{FIRST}(B) - \{\epsilon\} \\ &\quad \cup \text{FIRST}(C) \\ &\rightarrow \{a, \epsilon\} - \{\epsilon\} \cup \{r, \epsilon\} - \{\epsilon\} \cup \{b, \epsilon\} \\ &\rightarrow \{a, r, b, \epsilon\}\end{aligned}$$

$$\text{FOLLOW}(S) \rightarrow \{\$\}$$

$$\begin{aligned}\text{FOLLOW}(A) &\rightarrow \text{FIRST}(BC) - \{\epsilon\} \cup \text{FOLLOW}(S) \\ &\rightarrow \{r, b\} \cup \{\$\} \\ &\rightarrow \{r, b, \$\}\end{aligned}$$

$$\begin{aligned}\text{FOLLOW}(B) &\rightarrow \text{FIRST}(C) - \{\epsilon\} \cup \text{FOLLOW}(S) \\ &\rightarrow \{b, \epsilon\} - \{\epsilon\} \cup \{\$\}\end{aligned}$$

$$\text{FOLLOW}(C) \rightarrow \{b, \$\}$$

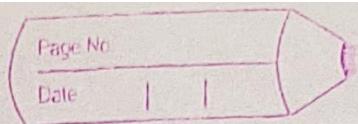
$$\begin{aligned}\text{FOLLOW}(C) &\rightarrow \text{FOLLOW}(S) \\ &\rightarrow \{\$\}\end{aligned}$$

	a	b	r	\$	
S	$S \rightarrow ABC$	$S \rightarrow ABC$	$S \rightarrow ABC$	$S \rightarrow ABC$	
A	$A \rightarrow a$	$A \rightarrow \epsilon$	$A \rightarrow \epsilon$	$A \rightarrow \epsilon$	
B	$B \rightarrow \epsilon$	$B \rightarrow r$	$B \rightarrow \epsilon$	$B \rightarrow \epsilon$	
C	$C \rightarrow b$		$C \rightarrow \epsilon$	$C \rightarrow \epsilon$	

7. b) Consider the following grammar

- $E \rightarrow CC$
- $C \rightarrow cC$
- $C \rightarrow d$

Construct LR(0) Parser.



LR(0)

Q7.b) CAT1 QB

$$E \rightarrow CC - \textcircled{1}$$

$$\text{FIRST}(E) \rightarrow \{c, d\}$$

$$C \rightarrow cC - \textcircled{2}$$

$$C \rightarrow d - \textcircled{3}$$

$$\text{FIRST}(C) \rightarrow \{c, d\}$$

Sol Step 1: Argumented Grammar

$$S \rightarrow E$$

$$E \rightarrow CC$$

$$C \rightarrow cC$$

$$C \rightarrow d$$

$$\text{Follow}(E) \rightarrow \{\$\}$$

$$\text{Follow}(C) \rightarrow \{c, d, \$\}$$

Step 2: Closure ($S \rightarrow \cdot E$)

$$= \left\{ \begin{array}{l} S \rightarrow \cdot E \\ E \rightarrow \cdot CC \\ C \rightarrow \cdot cC \\ C \rightarrow \cdot d \end{array} \right\} \text{ IO}$$

Step 3

$$\text{goto}(I_0, E) = \{ S \rightarrow E \cdot \} \quad I_1$$

$$\text{goto}(I_0, C) = \left\{ \begin{array}{l} E \rightarrow C \cdot C \\ C \rightarrow \cdot CC \\ C \rightarrow \cdot d \end{array} \right\} \quad I_2$$

$$\text{goto}(I_0, c) = \left\{ \begin{array}{l} C \rightarrow c \cdot C \\ C \rightarrow \cdot cc \\ C \rightarrow \cdot d \end{array} \right\} \quad I_3$$

$$\text{goto}(I_0, d) = \{ C \rightarrow d \cdot \} \quad I_4$$

$$\text{goto}(I_1, E) \rightarrow \emptyset$$

$$\text{goto}(I_1, C) \rightarrow \emptyset$$

$$\text{goto}(I_1, c) \rightarrow \emptyset$$

$$\text{goto}(I_1, d) \rightarrow \emptyset$$

$$\text{goto}(I_2, E) = \emptyset$$

$$\text{goto}(I_2, C) = \{ E \rightarrow CC \cdot \} \quad I_5$$

$$\text{goto}(I_2, c) = \left\{ \begin{array}{l} C \rightarrow c \cdot C \\ C \rightarrow \cdot CC \\ C \rightarrow \cdot d \end{array} \right\} \quad I_3$$

$$\text{goto}(I_2, d) = \{ C \rightarrow d \cdot \} \quad I_4$$

$$\text{goto}(I_3, E) = \emptyset$$

$$\text{goto}(I_3, C) = \{ C \rightarrow CC \cdot \} \quad I_6$$

$$\text{goto}(I_3, c) = \left\{ \begin{array}{l} C \rightarrow c \cdot C \\ C \rightarrow \cdot CC \\ C \rightarrow \cdot d \end{array} \right\} \quad I_3$$

$$\text{goto}(I_3, d) = \{ C \rightarrow d \cdot \} \quad I_4$$

$\text{goto}(I_4, E) = \emptyset$
 $\text{goto}(I_4, C) = \emptyset$
 $\text{goto}(I_4, c) = \emptyset$
 $\text{goto}(I_4, d) = \emptyset$

$\text{goto}(I_5, E) = \emptyset$
 $\text{goto}(I_5, C) = \emptyset$
 $\text{goto}(I_5, c) = \emptyset$
 $\text{goto}(I_5, d) = \emptyset$

$\text{goto}(I_6, E) = \emptyset$
 $\text{goto}(I_6, C) = \emptyset$
 $\text{goto}(I_6, c) = \emptyset$
 $\text{goto}(I_6, d) = \emptyset$

	Action Table			Go to Table	
	c	d	\$	E	C
I0	S3	S4		1	2
I1			Accept		
I2	S3	S4			5
I3	S3	S4			6
I4	R3	R3	R3		
I5			R1		
I6	R2	R2	R2		

8. a) Show Quadruple Triple and Indirect triples for the following expression.

$$-(a+b)*(c+d)+(a+b+c)$$

Ans 8. a)

i. Quadruple Representation

Location	Operator	Operand 1	Operand 2	Result
(1)	+	a	b	t1
(2)	+	c	d	t2
(3)	*	t1	t2	t3
(4)	+	t1	c	t4
(5)	+	t3	t4	t5
(6)	-	t5		

ii. Triple Representation

Location	Operator	Operand 1	Operand 2
(1)	+	a	b
(2)	+	c	d
(3)	*	(1)	(2)
(4)	+	(1)	c
(5)	+	(3)	(4)
(6)	-	(5)	

iii. Indirect Triple Representation

Location
(1)
(2)
(3)
(4)
(5)
(6)

8-a) $-(a+b)*(c+d)+(a+b+c)$

sol $-(\underline{a+b}) * (\underline{c+d}) + (\underline{a+b+c})$

$$\begin{array}{ccc} \underline{t_1} & \underline{t_2} & + t_1 \\ | & | & + | \\ t_3 & & - t_4 \end{array}$$

$$\begin{array}{c} | \\ t_5 \end{array}$$

$$t_6$$

i) Quadruple

Location	Operator	Operand 1	Operand 2	Result
(1)	+	a	b	t1
(2)	+	c	d	t2
(3)	-	t1		t3
(4)	+	t1	c	t4
(5)	*	t3	t2	t5
(6)	+	t5	t4	t6

ii) Triple

Location	operator	operand 1	operand 2
(1)	+	a	b
(2)	+ r	c	d
(3)	+ -	(1)	
(4)	+	(1)	c
(5)	*	(3)	(2)
(6)	+	(5)	(4)

iii) Indirect triple

Location
(1)
(2)
(3)
(4)
(5)
(6)

8. b) Find the TAC for following code:- if ($B > D$) And $A < C$ then $P = a + 1$ else $Q = b + 1$;

8.b) $\text{if } (B > D) \text{ And } A < C \text{ then } P = a + 1 \text{ else } Q = b + 1 ;$

Set

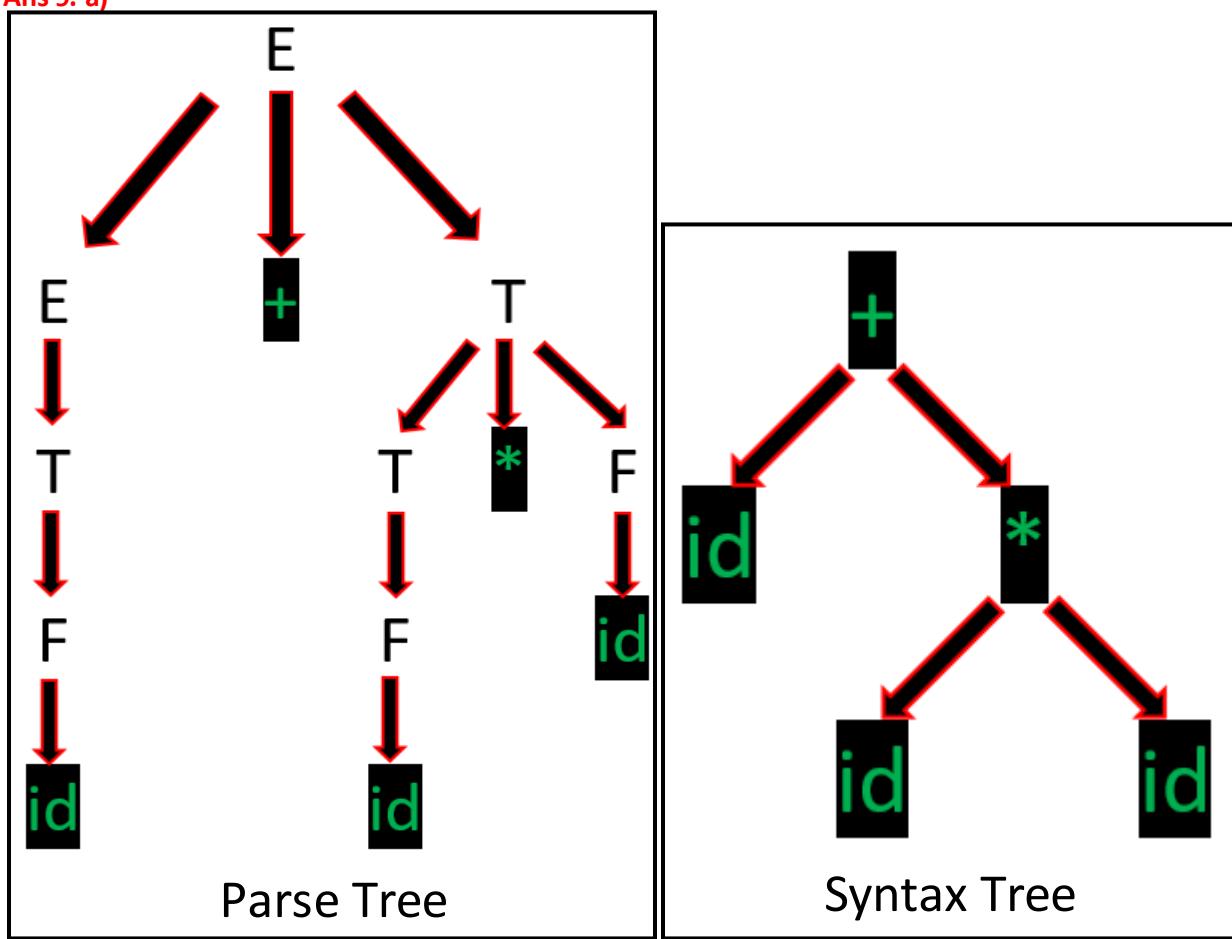
- 1.) $t_1 = B > D$
- 2.) $t_2 = A < C$
- 3.) $t_3 = t_1 \text{ and } t_2$
- 4.) If t_3 goto 7
- 5.) goto 10
- 6.) $t_4 = a + 1$
- 7.) $P = t_4$
- 8.) goto —
- 9.) $t_5 = b + 1$
- 10.) $Q = t_5$
- 11.) goto —

9. a) For the given grammar:

- $E \rightarrow E + T / T$
- $T \rightarrow T * F / F$
- $F \rightarrow (E) / \text{id}$

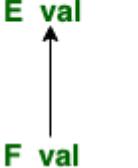
Construct parse tree and syntax tree for string
 $w = \text{id} + \text{id} * \text{id}$

Ans 9. a)



9. b) Differentiate between Synthesized Attributes and Inherited Attributes.

Ans 9. a)

S.NO	Synthesized Attributes	Inherited Attributes
1.	An attribute is said to be Synthesized attribute if its parse tree node value is determined by the attribute value at child nodes.	An attribute is said to be Inherited attribute if its parse tree node value is determined by the attribute value at parent and/or siblings' node.
2.	The production must have non-terminal as its head.	The production must have non-terminal as a symbol in its body.
3.	A synthesized attribute at node n is defined only in terms of attribute values at the children of n itself.	An Inherited attribute at node n is defined only in terms of attribute values of n's parent, n itself, and n's siblings.
4.	It can be evaluated during a single bottom-up traversal of parse tree.	It can be evaluated during a single top-down and sideways traversal of parse tree.
5.	Synthesized attributes can be contained by both the terminals or non-terminals.	Inherited attributes can't be contained by both, it is only contained by non-terminals.
6.	Synthesized attribute is used by both S-attributed SDT and L-attributed SDT.	Inherited attribute is used by only L-attributed SDT.
7.	EX:- $E.val \rightarrow F.val$ 	EX:- $E.val = F.val$ 