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Assignment - 1

Define the following instruction

(1) STOP :- It is an imperative statement. It stop the execution of program. Opcode is 00.

(2) SUB :- It is an imperative statement. Its Opcode is 02. It substract the value with the register value.

(3) ADD :- It is an imperative statement. Its Opcode is 01. It add the value with the register value

(4) MULT :- It is an imperative statement. Its Opcode is 03. It multiply the value with the register value.

(5) MOVER :- It is an imperative statement. Its Opcode is 04. It is used to move the value from memory to register

(6) MOVEM :- It is an imperative statement. Its opcode is 05. It is used to move the value from register to Memory.

(7) COMP :- It is an imperative statement Its opcode is 06. It is used to compare and set the condition code.

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(8) BC :- It is an imperative statement. Its opcode is 07. It is used for the branch condition.

(9) READ :- It is an imperative Statement. Its opcode is 09. It is used to read a value

(10) PRINT :- It is an imperative statement. Its opcode is 10. It is used to print the contents of register.

(11) ORIGIN :- It is an Assembler directive statement This directive instruct the Assembler to put the address given by <address specification> in the location ~~counter~~ counter.

(12) EQV :- It is an Assembler directive statement. In EQV left side is label / symbol and right side is address.

(13) PURGE :- It is an Assembler directive statement It is used undefined the symbol names which are defined by the ORIGIN Statement.

(14) ASSUME :- It is an Assembler directive statement It tells the assembler that it can assume the address of the indicated

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segment to be present in <register>

(15) SEGMENT :- It is the memory used to store three components of a program i.e. Program code, data & stack.

(16) PROC :- It indicate that it is a procedure

Example CALCULATE PROC
Here CALCULATE is procedure.

(17) NEAR :- It indicate that wheather the call to the procedure is to be assembled as far call ~~be~~ i.e.. the procedure is called from the same segment.

(18) FAR :- It indicate that whether the call to the procedure is to be assembled as far call. i.e.. the procedure is called from the another segment.

(19) PUBLIC :- When a symbol is define as a public in a program that means it can be reffered by the another program units also.

(20) EXTERN :- When an assembly module wishing to use a symbol declare in another assembly module. The symbol

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Should be declare as extern.

(2) OFFSET :- It is a displacement from the base address of a segment.

* Explain the meanings.

(1) Base Register :-

-> The Base register is used for program relocation.

-> It holds the base address of data in RAM to be executed recently.

-> Example :- Let's say we have memory and in that we have store a program P1 from 100 to 199

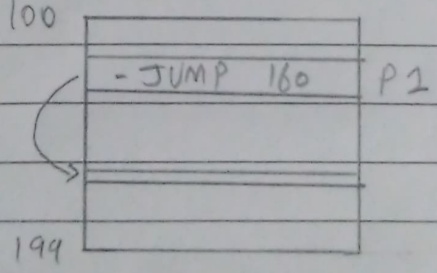

Diagram 1

-> So according to diagram 1 their is an instruction Jump 160 (using absolute address) so now control will be an address 160. Hex all works good.

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-> But now this Program is send to secondary memory for sometimes, then another program i.e. P2 will occupy address 100 to 199.

-> Then again program P1 comes to back to main memory than new address is allocated.

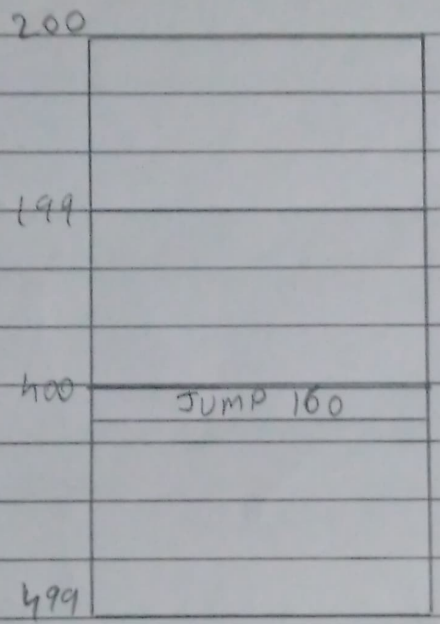

Diagram 2

-> So now the problem will occur as we have change the memory address of program P1 but it is having an instruction JUMP 160 so it create an illegal instruction so the program P2 memory is from 400 to 499.

-> so to solve this problem we have to add the displacement instead of giving absolute valve

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→ So the effective address
EA : Base register value to displacement

→ So their will be no Problem if address is change

(2) Index register :-

→ The index register have the source index of array and distination index. ie:- offset They are provided with auto increment and auto-decrement facility.

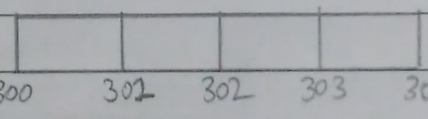
Example :- 

Diagram 1

Here in Diagram 1 the source index is 300. If we want to move at 303
Then,
Effective address = source index + offset
= 300 + 3
= 303
This way we can move to 303 address.

(3) Symbol table :-

→ An identifier used in the source program is called symbol. Thus names of variables function and procedure are symbols.

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→ Language Processor uses the symbol table to maintain the information about the symbols used in Source Program.

Symbol table perform following things:-

① Add the Symbol
② Add the location of symbol
③ Add the length of symbol
④ Delete the symbol entry
⑤ Access the symbol entry

SYMTAB

Symbol	Address	length
LOOP	202	1
NEXT	214	1

④ Literal Table:-

→ The use of literal table is to collect all literals used in a program. At any stage the current literal pool is the last pool in Littab on encountering an LTORG statement literals in the current pool are allocated addresses starting with the current value in LC.

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Littab

literal	address
= '5'	211
= '2'	212

⑤ Pool table :-

→ This table contains the literal number of the starting literal of each literal pool

Pool table

literal	no
#1	
#2	

⑥ OPtab :-

→ optab contains the fields mnemonic code, opcode and size of the operator. It also contain the class field. which tells us that the statement is imperative, Assembler directive or declaration statement.

→ If an imperative statement the mnemonic into field contains the pair else it contain the id of a routine to handle the declaration or directive statement.

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(1) Declaration statement :-

→ The syntax of declaration statement is as follows :-

[label] DS <constant>
[label] DC <value>

→ The DS statement resources area of memory and associate names with them.

→ The DC statement constructs a memory word containing constants.

Eg. A DS 200
ONE DC '1'

(2) Imperative Statements :-

→ As imperative statement indicates an action to be performed during the execution of the assembled program each imperative statement typically translate into one machine instruction

Eg. MOVER AREG, X

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(9) Assembler Directives :-

Assembler Directives instruct the assembler to perform certain action during the assembly program.

Eg. START.

This directive indicate that first word of machine should be placed in the memory word with address <constant>

START <constant>
START 200

* Difference between the following.

(1) Application Domain	Execution Domain
→ In this domain designer express their ideas.	→ In this domain the ideas expressi by designer are implemented.
→ The code of any program is written	→ On basis of code written output is generated.
→ In application domain algorithm and syntax is checked	→ In execution domain the run time problem are checked.

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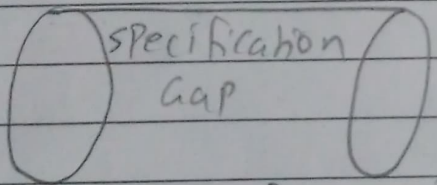
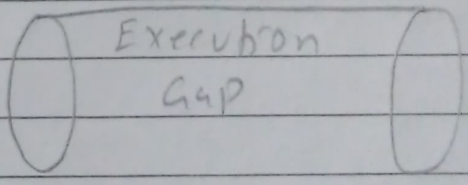
→ In application domain work of analysis phase is done.	→ In execution domain work of synthesis phase is done.
→ Eg. Printf("hello world"); Here we write the command and its symbol is checked	→ Eg. Hello world By processing the command output is generated by execution domain

② Specification Gap	Execution Gap
→ The gap between the application domain and the Programming domain is called specification gap	→ The gap between the Programming domain and execution domain is called execution gap.
→ 	→ 
→ Specification gap is the Semantic gap between two specification and same task.	→ Execution Gap is the gap between the semantic of Program written in different Programming language.
→ The specification gap is bridged by the software development tear	→ Execution gap is bridged by designer of PL processor, translator or interpreter.

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→ Eg. suppose a person who don't know programming language can use the application. but no able to de programming	→ Eg. Programmer write program in high level language and computer does not understand the high level language directly.

③ Source Program	Target program.
→ A program written in a PL is called source program.	→ Target program is an o/p generated after compiling the source program.
→ Source program is written in PL programmer	→ Target program is compiled and generated by the compiler
→ Source program contains English words according to the syntax of ~~the~~ PL.	→ Target program only contains Binary code.
→ Programmer can read the source program.	→ Machine can read the target program.
→ Source program is an input to compiler	→ Target program is the output to compiler.

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(4)

Compiler	Interpreter
→ Compiler converts the entire program	→ Interpreter translate code one line at a time.
→ It produce optimized code.	→ Code is not too much optimized
→ Analysis time is more.	→ program analysis time is less
→ Machine code is generated	→ No machine code is generated
→ There is a execution gap	→ There is no execution gap

(5)

language translator	Preprocessor
→ language translator is bridges an execution gap to the machine language of the computer system.	→ It is a language processor which bridges an execution gap but is not a language translator.
→ Assembler is an language translator whose source code is assembly language and convert it to machine language.	→ Preprocessor process high level language before language translator takes over.

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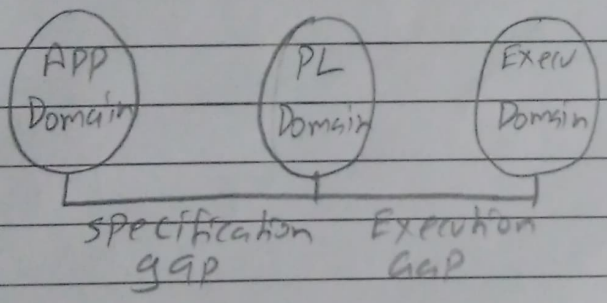
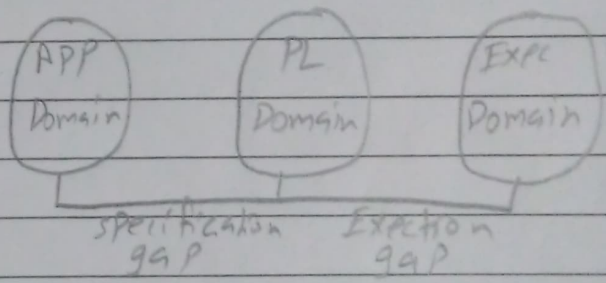
⑥ Problem oriented	Procedure oriented.
→ Problem oriented language are specific oriented language.	→ procedure oriented language are common oriented language.
→ Problem oriented language have large execution gap	→ Procedure oriented language have large specification gap
→ Execution gap is bridged by translator or interpreter	→ specification gap is bridge by an application designer
→ Eg. KOBOL, FORTAN	→ Eg. C, C++.
→ 	

⑦ lexical, Syntax & symentic rule

lexical :- It geverns lexical rules in the source language (eg identifier name is proper or not)

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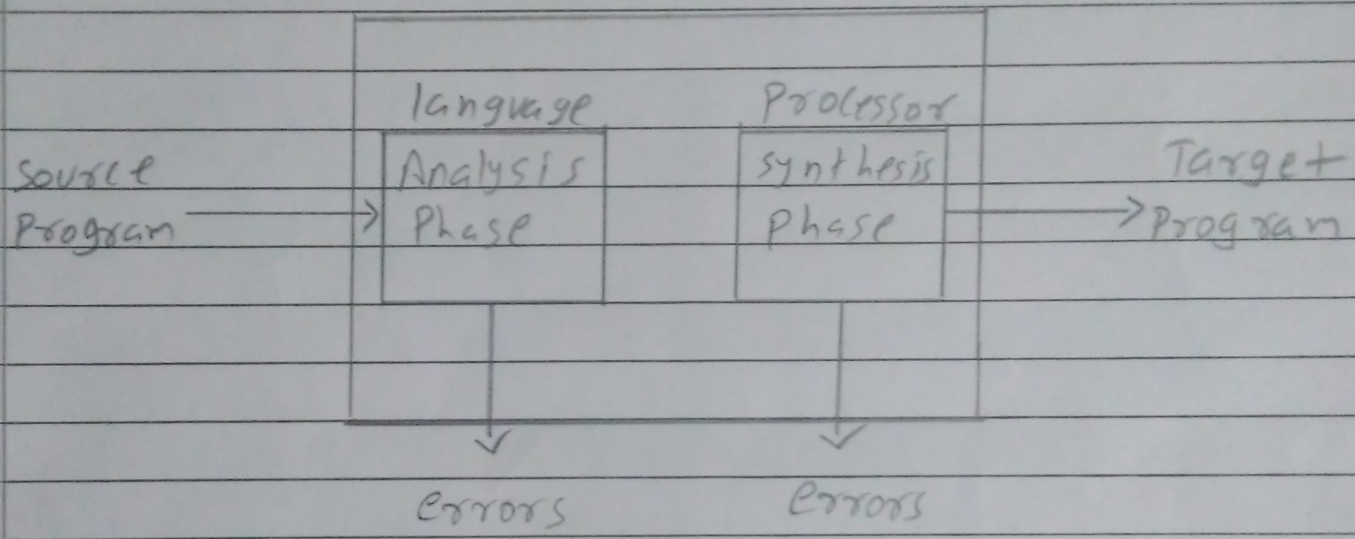
Syntax :- It checks validity of statement for syntax in the source language.

Symentic analysis : It checks the sementic rules in the source language.



⑧ Analysis Phase	Synthesis Phase
→ Analysis Phase use each Components of source Program to determine relevant information out of it.	Synthesis Phase generates/ computes target language statement which have same meaning as source language statement.
→ Analysis phase Consists of lexical, syntax and symentic analysis.	→ Synthesis Phase consists 2 activities. (i) Creating data structure in target Program

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	(ii) generation of target code.
→ Intermediate Representation is the o/p of Analysis Phase	→ Intermediate Representation (IR) is the I/P for Synthesis phase.
→ Analysis Phase is also known as Pass I.	→ Synthesis phase is also known as pass II

* Explain the following.

① - Single pass assembler
→ Scans entire source file only once.

→ Generally:-
(i) Deals with syntax
(ii) Constructs symbol table
(iii) Creates label list
(iv) Identifies the code segments, data Segment, stack segments etc.

→ cannot resolve forward reference of class symbol.

→ no object program is written hence no loader is required.

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-> Tends to be faster compared to two pass

-> only create tables with all symbols no address of symbol is calculated.

-> ~~None~~ More memory required compare to two pass assembler.

-> Intermediate code not generated.

- Two pass assember.
  -> Require two phases to scan source file

  -> Along with pass 1 pass two is also required which:-
    (i) generates actual opcode
    (ii) compute actual address of every label
    (iii) Assign code address for designing the information
    (iv) Translate operand name to appropriate register or memory.
    (v) Immediate value is translated binary strings.

-> Can resolve forward reference of data symbol

-> Loader is required as object code is generated

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-> Two pass assembler requires rescanning, hence slow compared to one pass assembler.

-> Address of symbols can be calculated.

-> less Memory required compare to single pass assembler

-> generation of intermediate code.

(2) Explain significance of location counter.

-> To implement memory allocation a data structure called location counter (LC) is introduced.

-> The location counter is always made to contain the address of the next memory word in the target program.

-> It is initialized to the constant specified in the START statement.

-> Whenever the analysis phase sees a label in a assembly statement, it enters the label and contents of LC in a new entry of the symbol table then the value to the location counter is increment and it goes to the next statement.

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→ It ensure that the LC points to the next memory word in the target program when Machine instruction have different length.

→ To update the contents of LC analysis Phase needs to know length of different instruction Eg.

symbol table

Symbol	address
AGAIN	104
N	113

Here address is inserted by the value stored in the location counter.

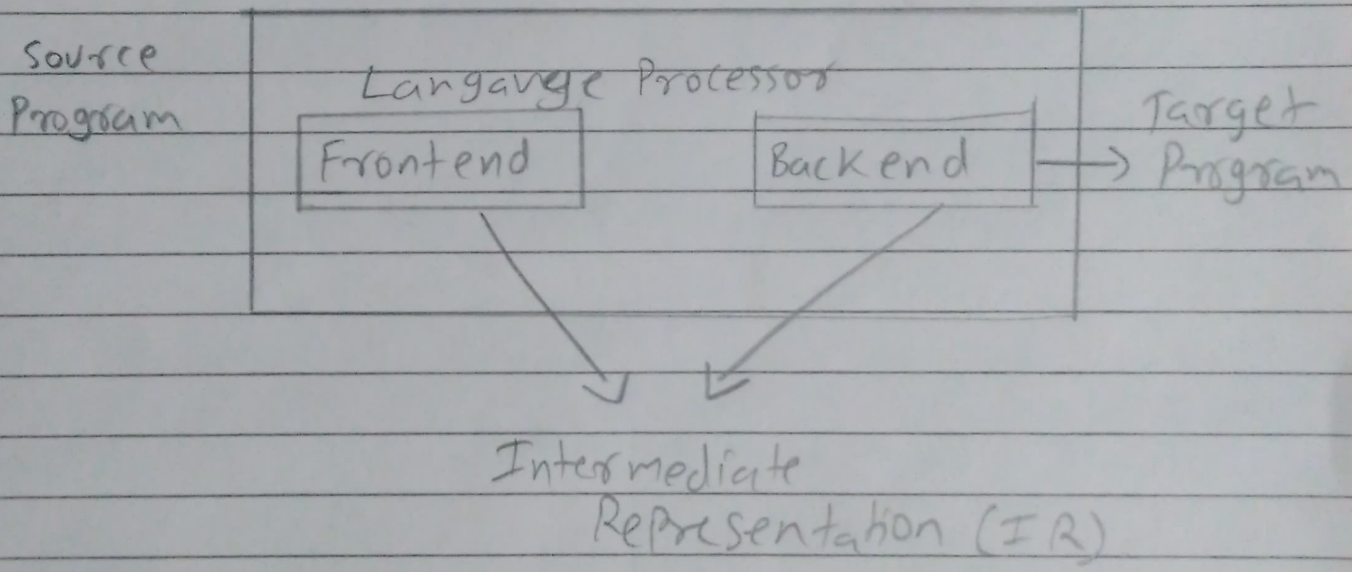
(3) Differentiate two variants for generation of intermediate code in two pass assemblers.

Variant 1	Variant 2
IS, DL, & AD all statement contain processed form.	OC & AD statements contain processed form while for IS statement, Operand field is processed only to identify literal reference.
Extra work in Pass 1	Extra work in Pass 2
simplifies tasks in Pass 1	simplifies task in Pass 2

Occupies more memory than Pass2	Memory utilization of two passes gets better balanced.

(4) What is intermediate representation in an Assembler.

→ An intermediate Representation is a Representation of a source program which reflects the effects of ~~s~~ source, but not all, analysis and synthesis ~~tasks~~ tasks performed during language processing.



Two Pass language processor

→ The first pass performs analysis of the source program and reflects its result in the intermediate Representation.

→ The second pass reads and analysis the IR.

instead of source program, to perform synthesis of the target program

→ This avoids repeated processing of the source program.

→ The first pass is concerned exclusively with source language issues. So it is called frontend of the language processor.

→ The second pass is concerned with program synthesis for a specific target language so it is called Backend of the language processor.

→ Properties of an IR:

Ease of use: IR should be easy to construct and analysis.

Processing efficiency: efficient algorithms must exist for constructing and analysing the IR.

Memory efficiency: It must be compact

(5) Explain the significance of segment register

→ Segmentation is the process in which the main memory of the computer is locally divided into

different segments and each segment has its own base address.

Need of segmentation :-

The BUS interface unit (BIU) contains four 16 bit special purpose registers called the segment registors

Types :-

(i) Code segment (CS) :- Code segment is used for addressing memory location in the code segment of the memory where the executable Program is store.

(ii) Extra segment (ES) :- Also refers to a segment in the memory which is another data segment in the memory.

(iii) Data segment (DS) :- Points to the data segment of the memory where the data is stored.

(iv) Stack segment (SS) :- It is used for addressing stack segment of the memory. The stack segment is that segment of memory which is used to store stack data.

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(8) Explain different registers of 8088 architecture.

→ The inter 8088 microprocessor supports 8 and 16 bit ~~cool~~ ~~crochet~~ arthemetic, and also provides special instruction for string manipulation.

Different Registers of 8088 architectures.
- Data registers AX, BX, CX and DX
- Index registers SI and DI.
- Stock pointer registered BP and SP.
- Segment registers Code, stack, Data and Extra.

Data Registers:

Each data register is 16 bits in size, selit into the upper and lower halves. Either half can be used for 8 bit arithmetic, where the two halves together constitute the data register for 16 bit arithmetic

Index Register :-

The index registers ST and DT are used to index the source and destination addresses in string manipulation instruction. They are provided with the auto-increment and auto-decrement facility.

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Stack Pointer register :

Two Stack Pointer register called SP and BP are ~~control~~ provided to address the stack SP points into the stack implicitly used by the architecture to store subroutines and interrupt return address. BP can be used by the programmer in any desired manner.

Segment registers :

The code stack and Data Segment registers are used to contain the start addresses of code, data and stack components. The Extra Segment register points to another memory area which can be used to store data.

(7) What is the meaning of segment overriding? Explain with example.

→ For arithmetic and now instructions the architecture uses the data segment by default.

→ To override this, an instruction can be preceded by a 1-byte segment override prefix with the following format:

001	seg	110

fix value.

When seg, represented in 2 bits, has the meaning.

seg	Segment register
00	ES
01	CS
00	SS
11	DS

Example : If the code segment is to be used instead of data segment, it can be rewritten as

```
ADD   AL, CS : 12H [SI]
```

The assembler would enlode This as,

Segment override			instruction							
001	01	110	00000	1	0	01	000	100		
									0001000	

Macros and Macro Prototype

Q1 Macro Prototype

→ A macro prototype statement declares the name of a macro and the names and kinds of its parameters.

The macro prototype statement has the following syntax:

<macro name> [<format parameter spe>[,...]]

Where <macro name> appears in the mnemonic field of an assembly statement and <format parameter> is of the form.

<parameter name> [<parameter kind>]

Q2 Macro Definition

A macro Definition is enclosed between a macro header statement and a macro end statement.

macro definitions are typically located at the start of a program, A macro definition consists of.

1. Macro prototype statements.
2. One or Model statements.
3. Macro Preprocessor statements

→ the macro prototype statement declares the name of a macro and the names and kinds of

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its parameters.

→ A model statement is a statement from which an assembly language statement may be generated during macro expansion.

→ A preprocessor statement is used to perform auxiliary functions during macro expansion.

EX.

```
MACRO
INCR  &MEM_VAL, &INC_VAL, &REG
MOVER &REG  &MEM_VAL
ADD   &REG  &INC_VAL
MOVEM &REG  &MEM_VAL
MEND.
```

Q3 Model statements.

→ A model statement is a statement from which assembly language statements may be generated during macro expansion.

→ The statements between MACRO and MEND directives define the model statement of the macro and can appear in the expanded code.

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Q4. PreProcessor statement.

A PreProcessor statement is used to perform auxiliary functions during macro expansion. AIF and AGO are PreProcessor statements.

Q5. Positional parameters.

→ For positional formal parameters, the spec. <Parameter name>, eg. &SAMPLE where SAMPLE is the name of a parameter.

→ In a call on a macro using positional parameters in an ordinary string.

→ The value of a positional formal parameter XY2 is determined by the rule of positional association as follows:

* find the ordinal of XY2 in the list of formal parameters in the macro prototype statements

* Find the actual parameter specification that occupies the same ordinal position in the list of actual parameters in the macro call statement. If it is an ordinary string ABC, the value of formal parameter XY2 would be ABC.

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Q6. Keyword Parameter

⇒ Keyword parameter are symbolic parameters that can be specified in any order when the macro is called.

→ The Parameter will be replaced within the macro body by the value specified when the macro is called. These parameter can be given a default value If no default value is specified and if the parameter is not given a value when the macro is called, then the parameter will be replaced by a null string.

⇒ Each keyword Parameter will have an equal sign (=) as the last character of the Parameter name.

Q7. Default Parameter

⇒ A default is a standard assumption in the absence of an explicit specification by the Programmer.

→ When the desired value is different from the default value, the desired value can be specified explicitly in a macro call. This

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specification overrides the default value of the parameter for the duration of the call

-> If a parameter has the same value in most calls on a macro, this value can be specified as its default value in the macro definitions itself.

Q8. Give two examples of nested macro calls

Ans ① MACRO
MAC X &Par1, &Par2
MOVER REG, &Par1
MACRO
MAC_Y &Par2, &REG=REG3
Add REG, &Par2
MOVEM REG, &Par2
MEND
PRINT &Par1
MEND

② MACRO
MAC_Y &Par2, REG=REG3
ADD REG, &Par2
MOVEM REG, &Par2
MEND
MACRO
MAC_X &Par, &Par2

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```
MOVER  REG2, Par1
MAC_Y  &Par2, REG1=REG3  //macro call
PRINT  &Par1
MEND.
```

Q9. Expansion Time variable

→ Expansion time variables, (EV's) are variables which can only be used during the expansion of macro calls

→ A local EV is created for use only during a particular macro call. A global EV exists across all macro calls situation in a program and can be used in any macro which has a declaration for it.

→ local and global EV's are created through declaration statements with the following syntax:

```
LCL <EV spec> [, <EV spec>]
GBL <EV spec> [, <EV, spec>...]
```

and <EV spec> has the syntax &<EV name> where <EV name> is an ordinary string.

→ Values of EV's can be manipulated through the Pre Processor Statement : SET A SET statement is written as.

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<EV spec> SET <SET - expression>

→ Where <EV specification> appears in the label field and SET in the mnemonic field A SET statement assign the value of <SET - expression> to the EV specified in <EV spec>.

Q10 Parameter Attributes.

Ans An attribute is written using the syntax <attribute name> <format Parameter spec> and represents information about the value of the formal Parameter. the type, length and size attributes have the names T, L and S.

Q11. AIF

An AIf statement has the syntax AIF (<expression>) <sequencing symbol> where <expression> is a relational expression involving ordinary strings, formal parameter and their attributes and expansion time variables.

If the relational expression evaluates to be true, expansion time control is transferred to the statement containing <sequencing symbol> in its label field.

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Q12 AGO

An AGO statement has the syntax:

AGO <sequencing symbol>

It unconditionally transfers expansion time control to the statement containing <sequencing symbol> in its label field.

Q13. ANOP

→ An ANOP statement has the syntax
<sequencing symbol> ANOP.

→ The significance of ANOP statement is to define sequencing symbol.

Q14. REPT

→ REPT statement has the syntax:
REPT <expression>

→ <expression> should evaluate to a numerical value during macro expansion. The statement between REPT and an ENDM statement would be processed for expansion <expression> number of times.

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Q15 IRP

The IRP statement.

IRP <Formal parameter>, <argument_list>

The formal parameter mentioned in the statement takes sucessive value from the argument list for each value, the statements between the IRP and ENDM statements are expanded once.

Q16. show combined working of macro and assembler.

Ans A macro processor is functionally independent of the assembler, and the output of the macro processor will be a part of the input into the assembler.

→ A macro processor, similar to any other assembler scans and processor statement]

→ often the use of a seperate macro processor for handeling macro instructions leads to less efficient program translator because many functions are duplicated by the assembler and macro processor.

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Q17 Macro Name table

Macro name table (MNT) has entries for all macro defined in a program.

→ Each MNT entry contains three pointers. MDTP, KPDTP and SSTP, which are pointers to MDT, KPDTAB and SSNTAB for the macro respectively.

→ MNT also contains Number of positional Parameters (#PP), number of keyword parameter (#KP) and number of EXPansion time variable (#EV).

Q18. Parameter name Table

→ Parameter Name table (PNTAB) contains all the parameter name used in macro.

→ It contains all keyword, default and positional parameter names.

Q19. EV Name Table

→ EV Name table contains all the expansion time variable names.

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→ expansion time variables are local variables and global variable which are declared in macro.

Q20 SS NAME TABLE

→ SS Name table (SSNTAB) contains the sequencing symbols.

Q21 keyword parameter Default Table

→ keyword parameter Default table (KPDTAB) Contains the name of keyword parameter and it's value.

Q22 Macro Definition Table

→ Macro Definition Table (MDT) entries are constructed while processing the model statements and preprocessing statements in the macro body.

Scanner & Parser.

Q1 Difference between scanner & Parser.

Ans

Scanning:

-> Scanning is the process of recognizing the lexical components in a source string.

-> The lexical features of a language can be specified using Type-3 or regular grammers. This facilitates automatic construction of efficient recognizers for the lexical features of the language.

-> Scanning uses two state FSA & DFA.

Parsing:

-> Parsing is used to check the validity of a source string and to determine its syntatic structure.

-> For an invalid string the parser issues diagnostic message reporting the cause and nature of errors in the string & for valid string it builds a parse tree to reflect the sequence of derivations or reductions performed during Parsing.

-> Parsing use two Parse method. Top-down, Bottom up

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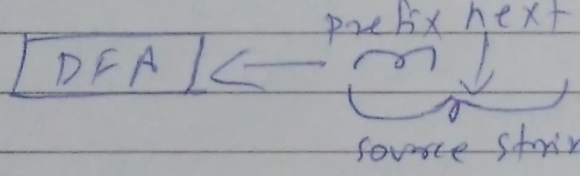
Q2 Define and give the usage of DFA.

Ans. -> It is a finite state automaton none of whose states has two or more transitions for the same source symbol. The DFA has the property that reaches a unique state for every source string input to it.

-> Transition in a DFA are deterministic.



-> At any point, the DFA recognized some prefix of of the source string, possibly the null string and would be poised to recognized the string pointed by the pointer next symbol.

-> The validity of a string is determined by giving it at the input of a DFA in its initial state.

-> The string is valid if and only if the DFA recognize every symbol in the string and find itself in a final state at the end of string.

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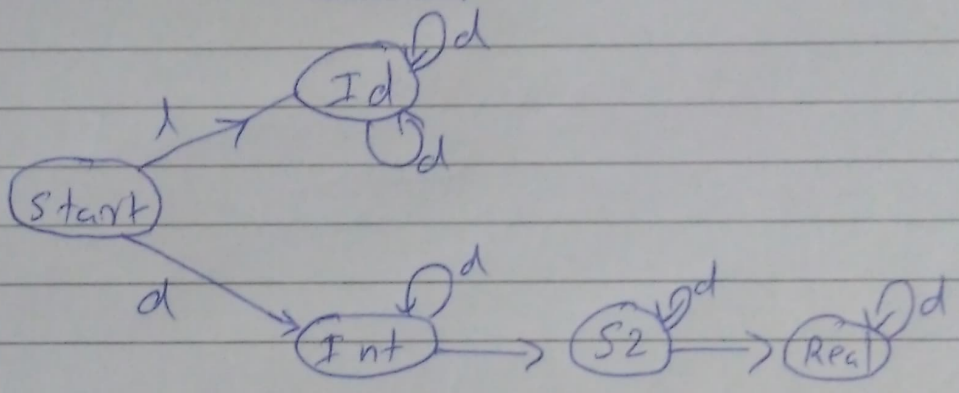
Example of Building DFA,

State	Next Symbol		
	l	d	.
start	Id	Int	
Id	Id	Id	
Int		Int	S_2
S_2		Real	
Real		Real	



A combined DFA for integers real number & identifiers.

→ Correct input could be like '1234.45' or 'asd12' etc.

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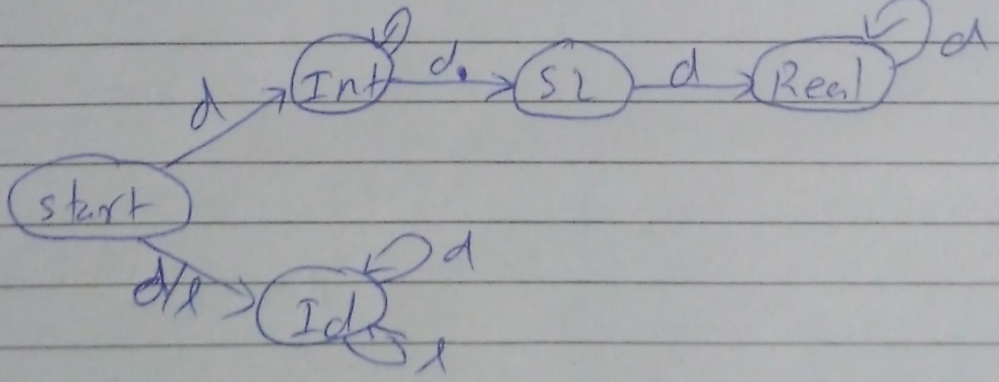
Q3 Take Example of any three valid string and ~~consist~~ constant DFA.

Ans. Valid String
12dsf
.23y
23.4

Start	Next Symbol		
	d	d	.
Start	Int	Id	S_2
Int	Int		S_2
Id	Id	Int	S_2
S_2	Real		
Real	Real		

* Graphical Representation



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Q4 Difference between top down parsing with backtracking and without back tracking

Ans

TOP-down Parsing with Backtracking	TOP-down Parsing without Backtracking
1. The leftmost non terminal in CSF is identified. So, then it matches the input string to its assigned grammer. If the check fails the predictions are discards and it goes on to the stage before the rejected prediction was made. This parse is called backtracking.	1. Here exclude the use of Backtracking which make the prediction very crucial. The grammer have to be modified so that it does not need left factoring since its RHS alternatives Produce unique terminal sym. Thus, parsing is no longer by trial - and error. It is also called Predictive Parser.
2. The Backtracking results in problem like, -> semantic actions cannot be performed while making a Prediction	2. When removed backtracking it resulted into several advantage -> Parsing became more efficient and also be possible to perform Semantic actions.
-> Precise error reporting is not possible	-> Precise error reporting during Parsing
-> Also it consumes time as it goes to previous stage	-> It does not consume time compared to top-down

Flying

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for rechecking	Parsing with Backtracking.
3. Grammer used here is $E = T + E/T$ $T = V * T/V$ $V = <id>$	3. Grammer used here is $E = T E''$ $E'' = +E/\varepsilon$ $T = VT''$ $T'' = *T/\varepsilon$ $V = <id>$

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Q5. Difference between top-down & bottom-up parser

Top-down	Bottom-up
1. Top down approach starts the parse tree from the top and move downwards for parsing other nodes	1. Bottom up approach starts evaluating the parse tree from the lowest level of the tree and move upwards for parsing the node.
2. Top down parsing attempts to find the left most derivation for a given string.	2. Bottom up parsing attempts too reduce the input string to first symbol of the grammer.
3. Top down parsing uses left most derivation	3. Bottom up parsing uses the right most derivation
4. Top down parsing searches for a production rule to be used to construct a string	4. Bottom up parsing searches for a production rule to be used to reduce a string to a get a starting symbol of grammer
5. In this parsing technique we start parsing from top to down in top-down manner.	5. In this parsing technique we start parsing from bottom to up in bottom-up manner.

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26 Define

(a) Grammer

A Grammer G of a language LG is a quadruple (Σ, SNT, S, P) where
Σ is the alphabet of LG, i.e. the set of terminal symbols.

SNT is the set of non terminal symbols
S is the disguished symbol
P is the set of products.

(b) terminal symbol

A symbol in the alphabet is known as a terminal symbol

(c) Non-terminal symbol

A Non terminal symbol is the name of syntax category of a language, e.g. noun, verb etc.

(d) Production Rule

A Production Rule, also called a rewriting rule is a rule of grammer.

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It has the form A → non terminal symbol → string of terminal and nonterminal symbols where the notation '→' stands for 'is defined as'.

eg: <Noun phrase> → <Article> <Noun>

(e) Reduction Rule:

It is the process of replacement of string or part of string by non terminal according to the production rule.

(f) Derivation Rule

Derivation is the replacement of non-terminal symbol in accordance with the given production rule.

(g) CSF

CSF stands for current sequential form Let CSF be of the form βAα, such that β is a string of Ts and A is the leftmost NT in CSF. Exit with success if CSF = α

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(h) SSM

SSM stands for Source string maker.

SSM points to the first unmatched symbol in the source string.

(i) Prediction

This mechanism systematically selects the RHS alternatives of a production during prediction making. It must ensure that any string in LG can be derived from S.

(j) Abstract syntax tree

An abstract syntax tree represents the structure of a source string in a more economical manner.

The word 'abstract' implies that it is a representation designed by a compiler designer for his own purpose.

(k) left to left Parsing

An L(1) parser is a table driven parser for left to left Parsing

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The first L indicates input is scanned from left to right. The second L means it uses left most derivation for input string.

(L) Left to Right Parsing

Left to right parsing follows reverse of right most derivation

In left to right parsing input is scanned from left to right and uses rightmost derivation for input string.

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Q7 Explain the following parsing with grammer algorithm and example.

Ans (a) Top down parser with backtracking

Grammer → E = T + E / T
T = V * T / V
V = <id>

source string → a + b * c $\xrightarrow{\text{to}}$ <id> + <id> * <id>
The pridiction making mechanism selects the RHS alternative of a production in a left-to-right manner.

1. E
2. T + E
3. V * T + E
4. <id> * T + E
5. V + E
6. <id> + E
7. <id> + T + E
8. <id> + V * T + E
9. <id> + <id> * T + E
10. <id> + T
11. <id> + V * T
12. <id> + <id> * T
13. <id> + <id> * V * T
14. <id> + <id> * <id> * T
15. <id> + <id> * <id> * V
16. <id> + <id> * <id> //

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(b) Top- down Parser without Backtracking

Grammer : $E = TE''$
$E'' = +E / \epsilon$
$T = VT''$
$T'' = *T / \epsilon$
$V = \langle id \rangle$

Source string -> a * b + c ⟶ <id> * <id> + <id>

1. E
2. TE''
3. $VT''E''$
4. $\langle id \rangle T'' E''$
5. $\langle id \rangle * TE''$
6. $\langle id \rangle * VT'' E''$
7. $\langle id \rangle * \langle id \rangle T'' E''$
8. $\langle id \rangle * \langle id \rangle E''$
9. $\langle id \rangle * \langle id \rangle + E$
10. $\langle id \rangle * \langle id \rangle + TE''$
11. $\langle id \rangle * \langle id \rangle + VT'' E''$
12. $\langle id \rangle * \langle id \rangle + \langle id \rangle T'' E''$
13. $\langle id \rangle * \langle id \rangle + \langle id \rangle E''$
14. $\langle id \rangle * \langle id \rangle + \langle id \rangle$ //

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28 LL 1 Parser

-> An LL(1) parser is a table driven parser for left-to-left parsing. The '1' in LL(1) indicates that the grammer uses a look-ahead of one source symbol that is the prediction to be made is determined by the next source symbol.

-> Example:

Grammer:

$E = TE'$
$E' = +TE' / \varepsilon$
$T = VT'$
$T' = *VT' / \varepsilon$
$V = \langle id \rangle$

Source string : $\vdash \langle id \rangle * \langle id \rangle + \langle id \rangle \dashv$

Parser Table:

Non terminal	Source Symbol			
	$\langle id \rangle$	+	*	$\dashv$
E	$E = TE'$			
E'		$E = +TE'$		$E' = \varepsilon$
T	$T = VT'$			
T'		$T = \varepsilon$	$T = *VT'$	$T' = \varepsilon$
V	$V = \langle id \rangle$			

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LL Parsing

Current sentential form	Symbol	Prediction
⊢E⊣	<id>	E = TE'
⊢TE'⊣	<id>	T = VT'
⊢VT'E'⊣	*	V = <id>
⊢<id>T'E'⊣	*	T' = *VT'
⊢<id>*VT'E'⊣	<id>	V = <id>
⊢<id>*<id>T'E'⊣	+	T' = ε
⊢<id>*<id>E'⊣	+	E' = +TE'
⊢<id>*<id>+TE'⊣	<id>	T = VT'
⊢<id>*<id>+VT'E'⊣	<id>	V = <id>
⊢<id>*<id>+<id>T'E'⊣	⊣	T' = ε
⊢<id>*<id>+<id>E'⊣	⊣	E' = ε
⊢<id>*<id>+<id>⊣	-	

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Q9. Recursive Decent Parser.

Ans → A Recursive decent parser is a variant of TOP down parsing without backtracking

→ It uses a set of recursive procedures to perform Parsing

→ To implement recursive decent parsing, a left grammer is modified to make repeated occurence of strings more implicit.

→ Salient advantages of recursive desent parsing are its simplicity and generally

→ It can be implemented in any language supporting recursive procedures.

E.g.

Recursive descent parser.

String to be Parsed → P + q * r

Call Proc_E

Step 1 → Call Proc_T (a);
in that call Proc_V (a)
in that next symbol is id
so build a tree node → (P)

Step 5 → Return to step 5
next symbol is not '*'

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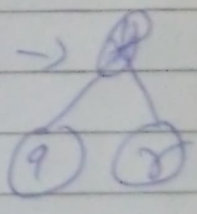
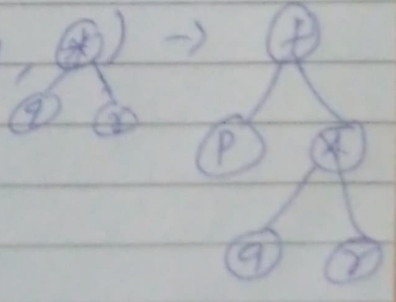
Step 4:- so return to step ①
next symbol is '+'
so match ('+')
Call Proc_T (b);
Call Proc_V (b)
next symbol is id
so build a tree node → ⑨

Step 5 return to step 5
then next symbol is '*'
so match ('*')
and call proc_V (a)
→ create tree node — ⑧

Step 7:- return to step ②
and build the tree ('*', a, b) → 

Step 3:- Now return to step 3
and tree build ('+', a, *) → 

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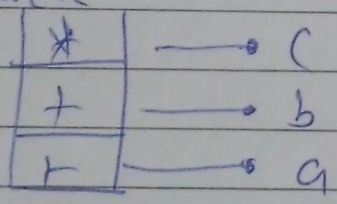
Q10 Operator Precedence parser

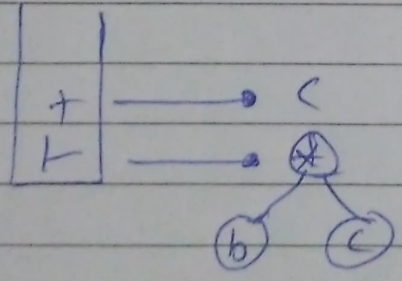
Ans Precedence between operator a & b appearing in a sentential form aPb where P is a null string is termed as operator precedence.

Example : The parsing string is
a + b * c

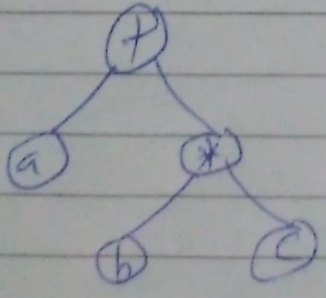
Stack

①


So the operator precedence of * is higher so it will POP out.

②


Last remaining operator will POP out.

③


Loader & Linker.

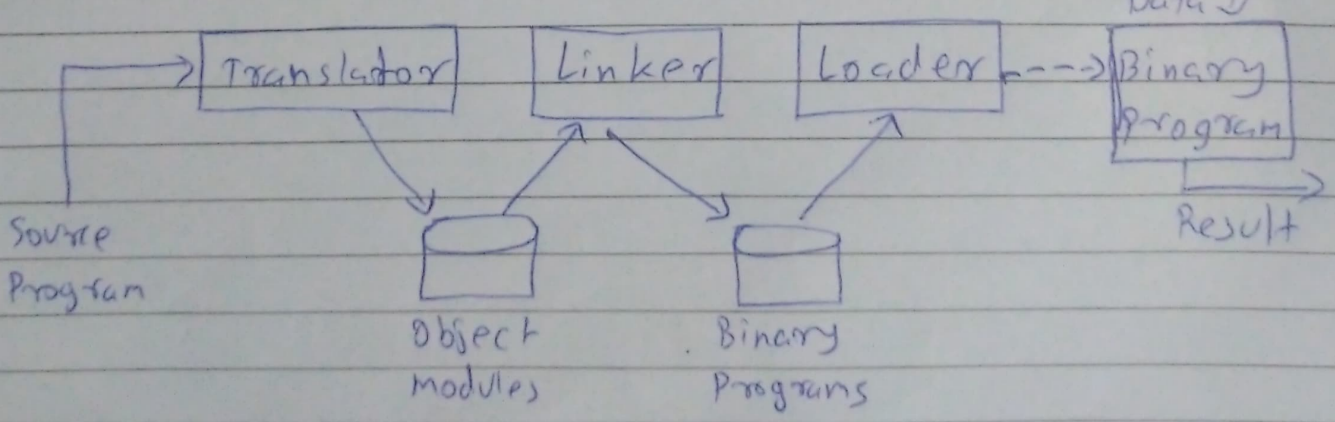
① Define Translated, linked and load time addresses.

Ans When a program is compiled, a translator is given an origin specification, this is called the translated origin of the program.

The translator uses the value of the translated origin to perform memory allocation for the symbols declared in Program.

The execution start address or simply the start address of a program is the address of the instruction from which its execution must begin.

The start address specified by the translator is the translated start address of the Program.



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- The origin of a program may have to be changed by the linker or loader for any of two reasons

- First, the same set of translated addresses may have been used in different object modules constituting a program so memory allocations to such programs would conflict unless their origins are changed.

The change of origin leads to changes in the execution start address and in the addresses assigned to symbols.

1. Translation time address:
   Address assigned by the Translator.

2. linked address:
   Address assigned by the linker.

3. Load time address:
   Address assigned by the Loader.

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Q2 Define

(a) Program Relocation :- It is a process of modifying the address used in the address sensitive instructions such that the program can execute correctly from the designated area of memory.

- Linker performs relocation if
  Liked origin ≠ Translated origin

- Loader performs relocation if
  Load origin ≠ Linked origin.

- In general Linker always performs relocation whereas some loaders do not.

- Absolute loaders do not perform relocation, then
  - load origin = Linked origin.
  - Thus, load origin and Linked origin are used interchangeable.

(b) Address sensitive instruction or ARI :-
Its a set of instructions that perform relocation in Program.

- steps: - Calculate Relocation Factor
  - Add it to Translation Time Address

for every instruction which is member of IRR.

- e.g. relocation factor = 900 - 500 = 400

- IRR contains translation address 500 & 538

Address is changed to 500 + 400 = 900 and 538 + 400 = 938.

(c) Relocation Factor :- Let the translated program P be t_origin P and l_origin P respectively.

- Consider a symbol symb in P. Let its translation time address be t_symb and its link time address l_symb.

- The relocation factor is :-
relocation_factor = L_origin P - t_origin P

- The relocation factor can be positive, negative & zero.

(d) Public definition :- The Entry statement lists the public definitions of a program unit.

(e) External Reference :- The EXTRN statement lists the symbol to which external references are made in the program unit.

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Q> Difference between Non-relocatable, Relocatable and self-Relocatable Module.

Ans. Non-relocatable : A program is one that cannot be executed in any memory area other than the area starting on its translated origin.

Relocatable :- A program that can be processed to relocate it to a desired area of memory. The difference is the availability of information concerning the address sensitive instructions.

Self-Relocatable :- A program that can Perform a relocation of its own address sensitive instructions. A self Relocatable module can be executed in any area of memory.

Qn. Define : Work Area.

-> Work Area : An area of memory where the loader simply loads the binary program for the purpose of execution.

address-in-work area = address of work area + translated address - t_origin

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Qs. Explain object module format of MS DOS linker.

Ans An object module is a sequence of object records.

- There are 14 Types of object records, in which they contain 5 kind of info:
  (i) Binary image
  (ii) External reference
  (iii) Public definition
  (iv) Debugging information
  (v) Miscellaneous information

- object Records of Intel 8088
  each object record contains variable length information and may refer to the contents of previous object records.

- Each name in an object record is represented in the following format

| length (1 byte) | Name. |

THEADR records:

| 80H | length | I-module name | check-sum |

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- The module name in THEADR record is typically derived by the Translator from the source file name.

- The name is used by the linker to report errors.

- An assembly programmer can specify the module name in the Name directive.

LNAMES record:

96H	length	name-list	Check-sum

- The LNAMES record lists the names for use by SEGDEF records.

SEGDEF record.

98H	length	attributes	segment	name	Checksum

- A SEGDEF record designates a segment name using an index into this list.
- The attributes field of a SEGDEF record indicates whether the segment is relocatable or absolute, whether it can be combined with other segments, as also the alignment requirement of its base address

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EXTDEF and PUBDEF record.

8CH	length	ext-reference	check sum

90H	length	base	name	offset	check-sum

- The EXTDEF record contains a list of external reference used by the programs of this modules.

- The PUBDEF records contains a list of public names declared in a segment of the object modules.

LEDATA record :-

A0H	length	segment	data offset	data	check

- An LEDATA record contains the binary image of the code generated by the language translator

FIXUPP record

9CH	length	locat	fix	frame	target	offset	check

- A fixupp record contains information for one or more relocation and linking fixups to be performed.

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MODEND record :-

80H	length	type (1)	start addr (S)	check sum

- The MODEND record signifies the end of the module with the type field indicating whether it is the main program

Q6. Explain basic object module Format.

Ans The object module of a program contains all information necessary to relocate and link the program with other program.

- The object module of a program P contains of 4 components.

(1) Header :- The header contains translated origin size and execution start address of P.

(2) Program :- This component contains the machine language Program corresponding to P.

(3). Relocation table : (RelocTAB) This table describe IRR. Each RELOCTAB entry contains a single field.

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(5) Linking table : This table contains information concerning the public definitions and external reference in P.

eg.

Statement	address	code
START 500		
ENTRY TOTAL		
EXTRN MAX, ALPHA		
READ A	500	+09 0 540
LOOP	501	
:		
MOVER AREG, ALPHA	518	+04 1 0000
BC ANY, MAX	519	+06 6 0000
:		
BC LT, LOOP	538	
STOP	539	
A DS 1	540	
TOTAL DS 1	541	
END		

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Q7 FIXUPP codes and fix data field codes.

Ans The local field contains a numeric code called loc code to indicate the type of a fixup.

Loc code	Meaning
0	Low order byte fix
1	offset fix
2	segment fix
3	Pointer fix

- local also contains the offset of the fixup location in the previous LEDATA record.

- The fix data field indicates the manner in which the target data and target offset fields are to be interpreted.

code	Contents of target data & offset fields
0	segments index and displacement
2	external index and target displacement
4	segment index (offset field not used)
6	external index. (offset field not used)

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Q8 Take 3 assembly language Programs and explain the execution of MSDOS Linker.

Ans Linker performs relocation and linking of all named object modules to produce a binary program with the specified load origin.

- Linker execution terminates when all external references have been resolved or when. The unresolved external reference cannot be found in any of the library files.

- linker uses a two-pass strategy.

- In the first pass, the object modules are processed to collect info concerning segments and public definitions.

- The second pass performs relocation and linking

- First pass: In the first pass Linker only process. The object records for building 'NTAB'.

- Second pass: In the second pass, Linker builds NAMELIST, SEGDEF and EXTDEF.

Q1 Difference between static and dynamic memory allocation.

Ans

static	dynamic
① In this memory is allocated to a variable before the execution of a program begins.	① The memory bindings are established and destroyed during the execution of a program.
② No memory allocation and deallocation action are performed during the execution of a program.	② memory is allocated and deallocation during the execution of program.
③ Variables remain permantly allocated, allocation of variable exists even if the program unit in which it is defined is not active	③ The variable get allocated only if the program unit gets active.
④ eg: FORTRAN	④ Eg. PL/I, Pascal, Ada etc.

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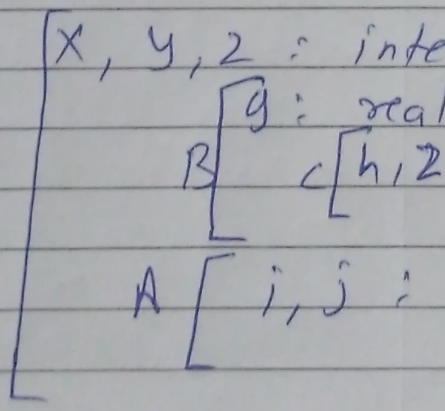
Q2 Explain Scope Rules with example.

Ans. → For data declaration it is possible to use same name in many docks of program.

→ This would establish many bindings of the form (name, var) for different values of a variable.

→ scope rules determines which of these bindings is effective at a specific place in the program.

→ eg.:
Consider the block structured program. The variables accessible within the various block are as follow:-



→ Variable ZA is not accessible inside Block C since C contains a declaration using the name > Thus >A and >C are two distinct variables. This would be true

even if they had identical attributes. i.e. even if 2 of c may declared to be an integer.

Q3) Explain Memory allocation in Recursion.

-> Recursion procedure (or functions) are characterised by the fact that many invocations of a procedure (o exist during the execution of a program.

-> A copy of the local variables of the procedure must be allocated for each invocation.

-> This does not pose any problem when a stack model of memory allocation is used because an activation record is created for every invocation of a procedure or function.

```
Program Sample (input, output);
var
    a, b : integer;
    function fib(n) : integer;
    var
        x : integer
    begin
        if n >2 then
            x := fib(n-1) + fib(n-2);
```

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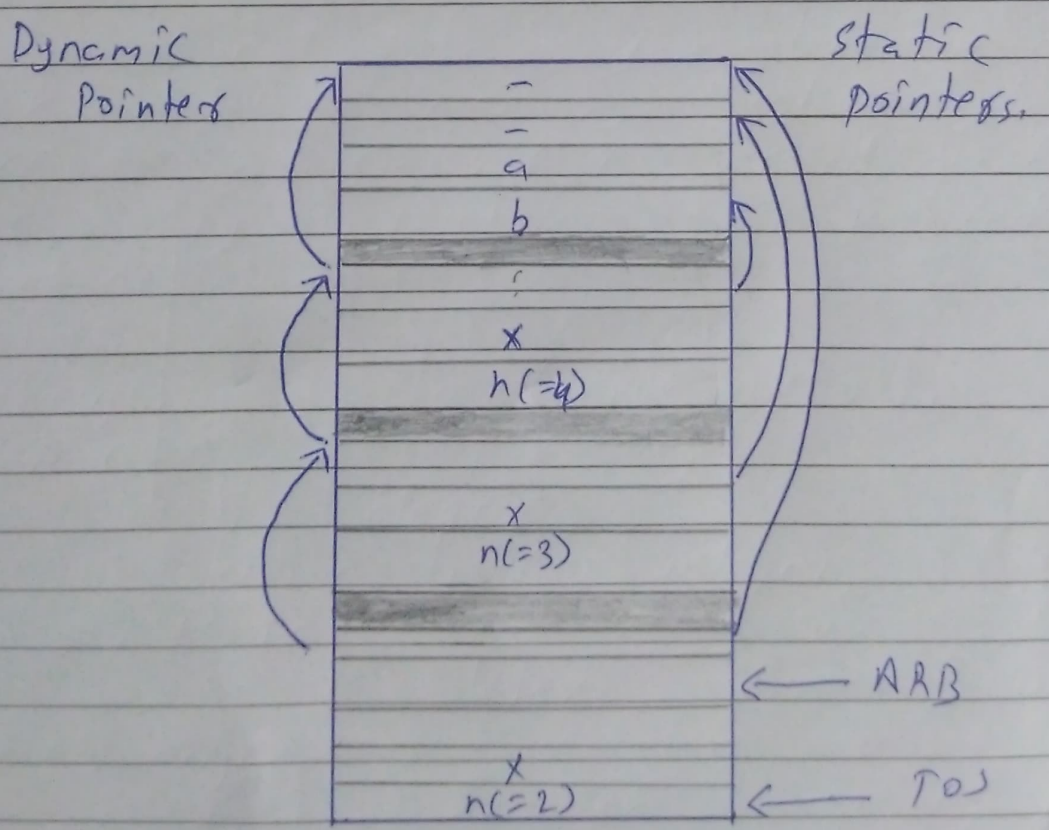
```
    else
        x = 1;
    return (x);
end fib;
begin
    fib(4);
end.
```

-> For the call feb(4) the function makes recursive calls.

-> Pictorial representation of recursive call in fibonnacci Series Program



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Q4 Define Dope vector with example.

Ans -> If array dimension bounds are not known during compilation the dope vector has to exist during program execution.

-> The number of dimension of an array determines the format and size of its DV.

-> The Dope vector is allocated in the AR of a block and dDV, its displacement in AR. is noted in the symbol table entry of the array.

-> The array is allocated dynamically by repeating step for the array.

-> It start address values of lj, uj and range j are entered in the DV

-> The generated code uses dDV to access the contents of DV to check the validity of subscripts and compute the address of an array element.

Q5. Define with example:-

(i) Operand descripter:-

It has following fields:-

① Attributes :- Contains the subfield type length and miscellaneous information.

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② Addressability :- specifies where the operands is located and how it can be accessed. It has 2 sub fields
① Addressability code.
② Address.

→ An operand descriptor is built for every operand participating in an expression.

→ An operand descriptor is built for an id when the id is reduced during parsing

→ A partial result pri is the result of evaluting same operater opj. A descriptor is built for Pri immediately after code is generated for operator opj.

→ for simplicity, assume that all operand descriptors are stored in an array called operand-descriptor.

eg:-

```
MOVER AREG, A
MULT AREG, B
```

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(ii) Register Descripter :-

⇒ A register descripter has two field.

① status :-
Contains the code free or occupied to indicate register status.

② Operand descripter # :-
If status = occupied this field contains the descripter # for the operand contained in the register

⇒ Register descriptors are stored in an array called Register_descripter.

⇒ one register descriptor exists for each CPU register.

eg :-
The register descripter for AREG after generating code for a+b

| Occupied | #3 |

This indicates that register AREG contains the operand description by descripter #3

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Q6 Write the steps for Assembly lang code Generation from an expression specified in high level language.

→ Expression :- x + y * p + q

steps :-

Step no	Parsing action	code generation
1	<id>x → F^1	Build descriptor #1
2	$F^1 \rightarrow T^1$	–
3.	<id>y → F^2	Build descriptor #2
4.	$T^1 + F^2 \rightarrow T^3$	Generate MOVER AREG
5.	$T^3 \rightarrow E^3$	–
6.	<id>p → F^4	Build descriptor #4
7.	$F^4 \rightarrow T^4$	–
8.	<id>q → F^5	Build descriptor #5

9.	$T^4 * F^5 \rightarrow T^6$	Generate MOVEM AREG TEMP 1
		MOVER AREG, P
		ADD AREG, Q
		Build descriptor #6

10.	$E^3 + T^6 \rightarrow E^7$	Generate MULT AREG, TEMP 1

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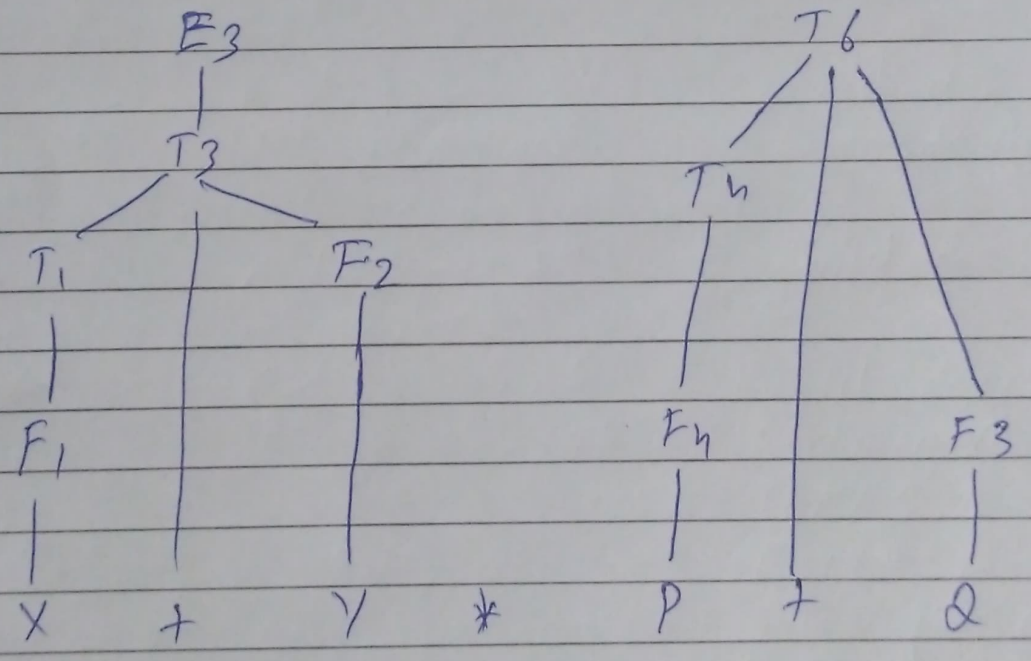
→ Operand descriptors :-

1	(int, 2)	M, addr(x)
2	(int, 2)	M, addr(y)
3	(int, 2)	M, addr(temp[i])
4	(int, 1)	M, addr(p)
5	(int, 1)	M, addr(q)
6	(int, 1)	R, addr(REG)

=>



=> Register descriptor

occ	6

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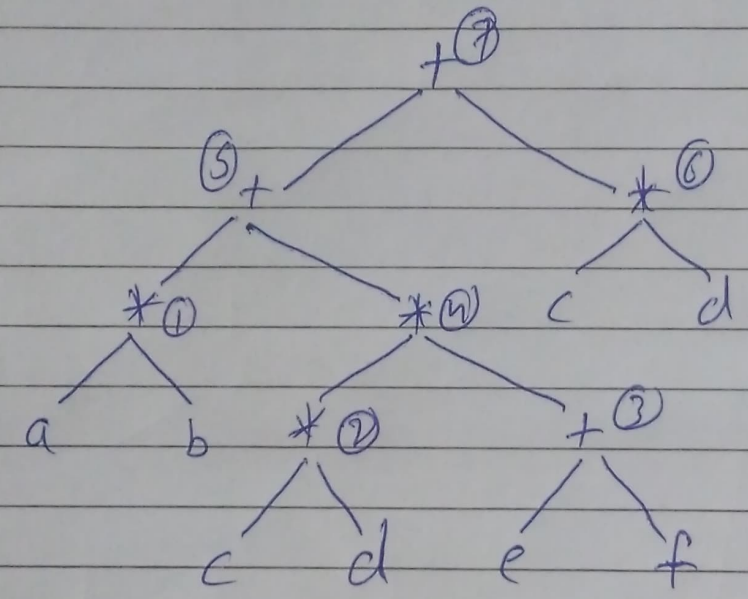
Q7 With an example, Explain the alternative of assembly language code generation for expression

Ans $x * y + P * Q (R + S) + Q * Q$




```
MOVER  AREG, X
MULT   AREG, Y
MOVEM  AREG, TEMP_1
MOVER  AREG, P
MULT   AREG, Q
MOVEM  AREG, TEMP_2
MOVER  AREG, R
MOVER  AREG, S
MULT   AREG, TEMP_2
ADD    AREG, TEMP_3
MOVER  AREG, P,
```

```
MULT AREG Q
ADD AREG, TEMP_3
```

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Q8 How postfix string can be used for generating the intermediate code for expression

Ans → In the postfix notation each operator appears immediately after its last operand.

→ Thus a binary operator OPi appears after its second operand. If any of its operand is itself an expression involving an operator OPj, OPj must appear before OPi.

eg :- +a+b*c+d*e↑f—|
source string

postfix string :- +abc*+def↑*++|

→ The postfix string is a popular intermediate code in non-optimizing compiler due to ease of generation and use.

→ The code generation from the postfix string using a stack of operand descripter.

→ Operand descripter are pushed on the stack as operand appear in string

→ When an operator with arity k appears in

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the string & descriptors are popped off the stack.

→ A descripter for the partial result generated by the operator is now pushed on the stack.

→ Conversion of infix to postfix is modified operands appearing in the source string are copied into the postfix string straight away.

→ The TOS operator is popped into the postfix string of TOS operator ≥ current operator.

29. How triples and quadraples can be used for generating the intermediate code for expression.

Ans → Triples: - A triples is a representation of an elementary operation in the form of a pseudo machine instruction.

Format :-

| Operator | operand 1 | operand 2 |

→ Each operand of a triple is either a variable / constant or the result of some

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evaluation represented by another triple.

→ Conversion of infix string into triples can be achieved by a slight modification

e.g.
infix string :- ↑ a + b * c + d * e ↑ f ↑

⇒ Quadruples :-

→ A Quadruples represents an elementary evaluation in the following format :-

Operator	operands	operand2	Result Name

Q10. List the steps taken by the compiler at function & procedure calls.

Ans While implementing a function call the compiler must the following :-

① Actual parameter are accessible in the called function

② The called function is able to produce side effect according to the rules of the PL.

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(3) Control is transffered to and is returned from the called function.

(4) The function value is returned to the calling Program.

(5) All other aspects of execution of a calling programs are unaffected by the function calls.

- Compiler used a set of feature to implement function
  - (i) Parameter list
  - (ii) calling conventions
  - (iii) Save area.

Q11 Different function calls.

Ans Different types of function calls are :-
(i) Call by Value :- In this mechanism Value of actual Parameter are passed to the called function.

(ii) Call by Value-Result :- In this mechanism the value of formal parameters is copied back into actual Parameter

(iii) Call by reference :- In this the address

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of actual parameter is passed to the called function

(iv) Call by Name :- In this also the same mechanism is follow of the call by reference.

-> Here also change in formal Parameter affect the value of actual parameter.

System Software Practicals

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Class : MCA – 3

Subject : System Software

---

1. **Assembler**

```
import java.util.StringTokenizer;

public class assembler
{
    static String[][] symbolTable=new String[10][2] ;//this is symbol table
    static String[][] litTable=new String[10][2] ;//this is literal table
    static int[] poolTable= new int[10];//this is literal table
    static int locationCounter =0;
    static int poolTabPtr = 0;//pooltable pointer
    static int litTabPtr = 0;//literaltable pointer
    static int symbolTabPtr=0;

   public static void main(String[] args)
   {
        poolTable[0]=1;
        String statements = "START 200\nREAD A\nREAD B\nMOVER AREG,A\nADD AREG
,B\nMOVEM AREG,RESULT\nPRINT A\nPRINT B\nPRINT RESULT\nA DS 0\nB DS 1\nRESULT
DS 0\nEND";

        String delimiters = "[, \n\t]"; //comma,space,new line, tab are delimi
ters
        String[] tokens = statements.split(delimiters, 0);

        String code;
        String regNO;
        int size=0;
        int i=0;
```

```
        for(i=0;i<tokens.length;i++)
        {
            int index=0;
            String token = tokens[i];
            String result = mnemonic(token,"type");//to find type
            code = mnemonic(token,"code");//to find code

            if(result.equals("AD"))
            {

                if(token.equals("START"))
                {
                    locationCounter = Integer.parseInt(tokens[i+1]);//to go to
 next token
                    System.out.println("LC= "+locationCounter);
                    i++;
                }
                else if(token.equals("EQU"))
                {
                    index = get_symbol_index(tokens[i+1]);//for finding addres
s of loop
                    System.out.println("IC=(AD,"+code+") (S,"+index+1+")");
                    String address = symbolTable[index][1];
                    index = get_symbol_index(tokens[i-
1]);//for finding address of equ
                    symbolTable[index][1] = address;
                    i++;

                }
                else if(token.equals("ORIGIN"))
                {
                    index = get_symbol_index(tokens[i+1]);//for finding addres
s of loop
                    int address = Integer.parseInt(symbolTable[index][1]);

                     if((tokens[i+2].substring(0)).equals("+"))
                        locationCounter = address + Integer.parseInt(tokens[i+
2].substring(1,(tokens[i+2].length()-1)));
                    if((tokens[i+2].substring(0)).equals("-"))
                        locationCounter = address - Integer.parseInt(tokens[i+
2].substring(1,(tokens[i+2].length()-1)));

                    i+=2;
                  System.out.println("IC=(AD,"+code+") (C,"+locationCounter+")
");
                }
                else if(token.equals("LTORG") || (token.equals("END") && i < t
okens.length))
```

```
                {

                    for(index = poolTable[poolTabPtr]-
1;index<litTabPtr;index++)
                    {
                        litTable[index][1] = String.valueOf(locationCounter);
                        System.out.println("IC=(AD,"+litTable[index][0]+") (C,
"+locationCounter+")");
                        locationCounter++;
                    }

                    poolTabPtr++;
                    poolTable[poolTabPtr] = litTabPtr+1;

                }


            }
            else if(result == "" && !isliteral(token))//for label
            {
                index=get_symbol_index(token);

                if(mnemonic(tokens[i+1],"type").equals("IS"))
                {
                    if(index== -1)  //labal is not inserted in symolTable
                    {
                        symbolTable[symbolTabPtr][0] = token;
                        symbolTable[symbolTabPtr][1] = String.valueOf(location
Counter);//to insert lc in symbol table
                        symbolTabPtr++;
                    }
                    else
                    {
                        symbolTable[index][1]=String.valueOf(locationCounter);
                    }
                }
            }
            else if(result.equals("IS"))
            {

                regNO= mnemonic(tokens[i+1],"code");//to find register number
eg.1 for AREG
                locationCounter++;
                String operand = tokens[i+2];
                if(token.equals("STOP"))    //if stop condition
                    System.out.println("IC=(IS,00)");

                else
```

```
                {
                    if(!isliteral(operand))
                    {
                        if(get_symbol_index(operand) == -
1)     //if symbol is not in symtab
                        {
                            symbolTable[symbolTabPtr][0] = operand;
                            symbolTabPtr++;
                            System.out.println("IC=(IS,"+code+") ("+regNO+") (
S, "+symbolTabPtr+")");
                        }
                        else    //if symbol is present in symTab
                        {
                            index = get_symbol_index(operand)+1;
                            System.out.println("IC=(IS,"+code+") ("+regNO+") (
S, "+index+")");
                        }

                    }

                    else//if operand is litral
                    {
                        String this_litral=operand.substring(2,(operand.length
()-1));
                        litTable[litTabPtr][0]=String.valueOf(this_litral);

                        litTabPtr++;
                        System.out.println("IC=(IS,"+code+") ("+regNO+") (L, "
+litTabPtr+")");
                    }
                    i+=2;
                }
            }
            else if(result.equals("DL"))
            {

                index = get_symbol_index(tokens[i-1]);
                code = mnemonic(token,"code");
                size = Integer.parseInt(tokens[i+1]);
                symbolTable[index][1]=String.valueOf(locationCounter);
                System.out.println("IC=(DL,"+code+") (C, "+(index+1)+")");
                locationCounter+=size;

                i++;
            }

        }
        System.out.println("\n------------->Literal Table");
```

```
        for(int index=0;index<litTabPtr;index++)
        {
           System.out.println(litTable[index][0]+ ":"+litTable[index][1]);
        }
        System.out.println("\n------------->Symbol Table");
        for(int index=1;index<symbolTabPtr-
1;index++) //for testing values of symbol table
        {
            System.out.println(symbolTable[index][0] + " - " + symbolTable[ind
ex][1]);
        }
            System.out.println("\n------------->Pool Table");
            for(int index=0;index<=poolTabPtr;index++)
            {
                System.out.println(poolTable[index]);
            }
    }

    public static String mnemonic(String token,String want)
    {
        String[][] codes = {{"00","STOP","IS"},{"01","ADD","IS"},{"02","SUB","
IS"},{"03","MULT","IS"},{"04","MOVER","IS"},{"05","MOVEM","IS"},
                            {"06","COMP","IS"},{"07","BC","IS"},{"08","DIV","IS"},
{"09","READ","IS"},{"10","PRINT","IS"},
                            {"01","DC","DL"},{"02","DS","DL"},{"01","START","AD"},
{"02","END","AD"},{"03","ORIGIN","AD"},{"04","EQU","AD"},
                        {"05","LTORG","AD"},{"1","AREG","REG"},{"2","BREG","REG"},
{"3","CREG","REG"},{"4","DREG","REG"},
                        {"1","LT","FLAG"},{"2","LE","FLAG"},{"3","EQ","FLAG"},{"4"
,"GT","FLAG"},{"5","GE","FLAG"},
                        {"6","ANY","FLAG"}};
        for(String[] code : codes)  //to return type or code of token
        {
            if(token.equals(code[1]))
            {
                if(want.equals("type"))
                    return code[2];
                if(want.equals("code"))
                    return code[0];
            }
        }
        return "";
    }
    //to find literals
    public static boolean isliteral(String token)
    {
        if(token.startsWith("=") || token.startsWith("\'"))
        {
```

```
            return true;
        }
        return false;
    }

    //tocheck already exist
    public static int get_symbol_index(String token)
    {
         int index;
         for(index=0;index<symbolTabPtr;index++)
         {
             if(symbolTable[index][0].equals(token))
             {
                 return index;
             }
         }


        return -1;
    }
}
```

Output :

PS D:\MCA\MCA SEM 3\SS> java .\SS_Assembler.java

LC= 200

IC=(IS,09) () (S, 1)

IC=(IS,04) (1) (S, 3)

IC=(IS,01) (1) (S, 2)

IC=(IS,05) (1) (S, 4)

IC=(IS,10) () (S, 5)

IC=(IS,10) () (S, 3)

IC=(DL,02) (C, 3)

IC=(DL,02) (C, 2)

IC=(DL,02) (C, 4)

---------->Literal Table

---------->Symbol Table

B - 206

A - 206

RESULT - 207

---------->Pool Table

1

1

2. Macro Preprosessor

```java
import java.io.IOException;
import java.util.ArrayList;
import java.util.List;
import java.io.BufferedReader;
import java.io.FileReader;
import java.util.StringTokenizer;


public class Macro {

    public static void main(String[] args) throws IOException {

        List<String> input = new ArrayList<>();

        input.add("\tMACRO");
        input.add("\tCLEARMEM &X, &N, &REG=AREG");
        input.add("\tLCL &M");
        input.add("\t&M SET 0");
        input.add("\tMOVER &REG, ='0'");
        input.add(".MORE MOVEM &REG, &X + &M");
        input.add("\t&M SET &M+1");
        input.add("\tAIF (&M NE &N) .MORE");
        input.add("\tMEND");
        input.add("\tMMEND");

        System.out.println("Starting Preprocessing...");

        PreProcessor pr = new PreProcessor(input);

        pr.showCode();
        pr.analyze();
        pr.showTables();

        System.out.println("Ending Preprocessing...");
    }
}

class PreProcessor {
    private List<String> code;

    private List<String> pntab;
    private List<String> evntab;
    private List<String> ssntab;
    private List<MacroData> mnt;
    private List<String[]> kpdtab;
```

```java
    private List<Integer[]> sstab;
    private List<String> mdt;

    private int pntab_ptr;
    private int evntab_ptr;
    private int ssntab_ptr;
    private int mnt_ptr;
    private int kpdtab_ptr;
    private int sstab_ptr;
    private int mdt_ptr;

    public PreProcessor(String filename) throws IOException {
        initialize();
        loadCode(filename);
    }

    public PreProcessor(List<String> code) {
        initialize();
        this.code = code;
    }

    private static List<String> tokenize(String line) {
        StringTokenizer st = new StringTokenizer(line, ", \t()");
        List<String> tokenized = new ArrayList<>();

        while (st.hasMoreTokens()) {
            tokenized.add(st.nextToken());
        }

        return tokenized;
    }

    private static String getParameterType(String parameter) {
        return parameter.indexOf('=') == -1 ? "PP" : "KP";
    }

    private static boolean isSequencingSymbol(String token) {
        return token.charAt(0) == '.';
    }

    private void initialize() {
        pntab = new ArrayList<>();
        evntab = new ArrayList<>();
        ssntab = new ArrayList<>();
        mnt = new ArrayList<>();
        kpdtab = new ArrayList<>();
        sstab = new ArrayList<>();
        mdt = new ArrayList<>();
```

```
        pntab_ptr = evntab_ptr = ssntab_ptr = mnt_ptr =
                kpdtab_ptr = sstab_ptr = mdt_ptr = 0;
    }

    private String getIC(String data) {
        String ic = "(%s,%s)";
        int index = -1;
        int start = data.charAt(0) == '&' || data.charAt(0) == '.' ? 1 : 0;
        data = data.substring(start).toUpperCase();

        for(int i = 0; i < evntab_ptr && index == -1; i++) {
            if(evntab.get(i).toUpperCase().equals(data)) index = i;
        }
        if(index != -1) return String.format(ic, "E", ("" + index));

        for(int i = 0; i < pntab_ptr && index == -1; i++) {
            if(pntab.get(i).toUpperCase().equals(data)) index = i;
        }
        if(index != -1) return String.format(ic, "P", ("" + index));

        for(int i = 0; i < ssntab_ptr && index == -1; i++) {
            if(ssntab.get(i).toUpperCase().equals(data)) index = i;
        }
        if(index != -1) return String.format(ic, "S", ("" + index));

        return null;
    }

    private static String removeSequencingSymbol(String line) {
        line = line.trim();
        if(line.charAt(0) == '.') {
            int indexOfSpace = line.indexOf(' ');
            line = line.substring(indexOfSpace + 1);
        }
        return line;
    }

    private String getLineIC(String line) {
        String lineIC = removeSequencingSymbol(line);
        List<String> tokenized = tokenize(lineIC);

        for(int i = 0; i < tokenized.size(); i++) {
            String ic = getIC(tokenized.get(i));

            if(ic != null) {
                lineIC = lineIC.replaceAll(tokenized.get(i), ic);
            }
```

```
        }
        return lineIC;
    }

    private void loadCode(String filename) throws IOException {
        BufferedReader reader = new BufferedReader(new FileReader(filename));
        code = new ArrayList<>();

        String line;

        while ((line = reader.readLine()) != null) {
            code.add(line);
        }

        if (reader != null) reader.close();
    }

    public void showCode() {
        for (int i = 0; i < code.size(); i++) {
            System.out.println(code.get(i));
        }
    }

    public void showTables() {
        System.out.println("\n------- TABLES -------\n");

        System.out.println("-------------------- MNT --------------------");
        System.out.println("MACRONAME\t#PP\t#KP\t#EV\tMDTP\tKPDTP\tSSTP");
        System.out.println("-------------------------------------------");
        for (int i = 0; i < mnt_ptr; i++) {
            MacroData md = mnt.get(i);
            System.out.println(md.name + "\t" + md.pp + "\t" + md.kp + "\t" +
md.ev + "\t" + md.mdtp + "\t\t" + md.kpdtp + "\t\t" + md.sstp);
        }
        System.out.println("-------------------------------------------");


        System.out.println("\n----- PNTAB -----");
        System.out.println("Index\tName");
        System.out.println("-----------------");
        for (int i = 0; i < pntab_ptr; i++) {
            System.out.println(i + "\t\t" + pntab.get(i));
        }
        System.out.println("-----------------");

        System.out.println("\n----- EVNTAB -----");
        System.out.println("Index\tName");
        System.out.println("------------------");
        for (int i = 0; i < evntab_ptr; i++) {
```

```
            System.out.println(i + "\t\t" + evntab.get(i));
        }
        System.out.println("------------------");

        System.out.println("\n----- SSNTAB -----");
        System.out.println("Index\tName");
        System.out.println("------------------");
        for (int i = 0; i < ssntab_ptr; i++) {
            System.out.println(i + "\t\t" + ssntab.get(i));
        }
        System.out.println("------------------");

        System.out.println("\n---------- SSTAB ----------");
        System.out.println("Index\tValue\tValue");
        System.out.println("--------------------------");
        for (int i = 0; i < sstab_ptr; i++) {
            System.out.println(i + "\t\t" + sstab.get(i)[0] + "\t\t" +sstab.ge
t(i)[1]);
        }
        System.out.println("--------------------------");

        System.out.println("\n-------- KPDTAB --------");
        System.out.println("Index\tName\tDefault");
        System.out.println("------------------------");
        for (int i = 0; i < kpdtab_ptr; i++) {
            System.out.println(i + "\t\t" + kpdtab.get(i)[0] + "\t\t" + kpdtab
.get(i)[1]);
        }
        System.out.println("------------------------");

        System.out.println("\n------------------------- MDT ----------------
---------");
        System.out.println("Index\tIC");
        System.out.println("----------------------------------------------
-------");
        for (int i = 0; i < mdt_ptr; i++) {
            System.out.println(i + "\t\t" + mdt.get(i));
        }
        System.out.println("----------------------------------------------
-------");
    }

    public void analyze() {

        List<String> tokenized;
        MacroData md = new MacroData();

        String prototype = code.get(1);
```

```
        tokenized = tokenize(prototype);

        md.name = tokenized.get(0);
        md.kpdtp = kpdtab_ptr;

        for (int i = 1; i < tokenized.size(); i++) {
            String parameter = tokenized.get(i);
            if (getParameterType(parameter).equals("PP")) {
                System.out.println(parameter + " is PP");
                pntab.add(parameter.substring(1));
                pntab_ptr++;
                md.pp++;
            } else {
                System.out.println(parameter + " is KP");
                int index = parameter.indexOf('=');
                String parameterName = parameter.substring(1, index);
                String defaultValue = parameter.substring(index + 1);
                String[] kpdtab_entry = {parameterName, defaultValue};

                kpdtab.add(kpdtab_entry);
                pntab.add(parameterName);

                kpdtab_ptr++;
                pntab_ptr++;
                md.kp++;
            }
        }

        md.mdtp = mdt_ptr;
        md.ev = 0;
        md.sstp = sstab_ptr;

        for (int i = 2; i < code.size(); i++) {
            String currentLine = code.get(i);
            tokenized = tokenize(currentLine);

            if(tokenized.size() < 1) continue;

            boolean hasSequencingSymbol = isSequencingSymbol(tokenized.get(0))
;


            if(hasSequencingSymbol) {
                ssntab.add(tokenized.get(0).substring(1));
                int index = ssntab_ptr++;

                Integer[] data = {index, mdt_ptr};
                sstab.add(data);
            }
```

```
            System.out.println("CurrentLine: " + currentLine);
            if (tokenized.get(0).toUpperCase().equals("LCL")) {
                int start = tokenized.get(1).charAt(0) == '&' ? 1 : 0;
                String variable = tokenized.get(1).substring(start);
                evntab.add(variable);
                evntab_ptr++;
                md.ev++;

                String lineIC = getLineIC(currentLine);
                System.out.print(lineIC);
                mdt.add(lineIC);
                mdt_ptr++;
            }
            else if(tokenized.size() > 1 && tokenized.get(1).toUpperCase().equ
als("SET")) {
                String lineIC = getLineIC(currentLine);
                System.out.println("IC-> "+lineIC);
                mdt.add(lineIC);
                mdt_ptr++;
            }
            else if(tokenized.get(0).toUpperCase().equals("AIF") || tokenized.
get(0).toUpperCase().equals("AGO")) {
                String sequencingSymbol = tokenized.get(tokenized.size() - 1).
substring(1);

                int index = ssntab.indexOf(sequencingSymbol);

                if(index == -1) {
                    ssntab.add(sequencingSymbol);
                    index = ssntab_ptr++;
                }

                String lineIC = getLineIC(currentLine);
                System.out.println(lineIC);
                mdt.add(lineIC);
                mdt_ptr++;
            }
            else if (tokenized.get(0).toUpperCase().equals("MEND")) {
                if(ssntab_ptr == 0) md.sstp = 0;
                else sstab_ptr = sstab_ptr + ssntab_ptr;
                break;
            }
            else {
                String lineIC = getLineIC(currentLine);
                System.out.print(lineIC);
                mdt.add(lineIC);
                mdt_ptr++;
```

```
            }
        }

        mnt.add(md);
        mnt_ptr++;
    }

}

class MacroData {
    String name;
    int pp, kp, ev, mdtp, kpdtp, sstp;

    MacroData() {
        name = "";
        pp = kp = ev = mdtp = kpdtp = sstp = 0;
    }
}
```

Output :

PS D:\MCA\MCA SEM 3\SS> java .\Macro.java
Starting Preprocessing...
MACRO
CLEARMEM &X, &N, &REG=AREG
LCL &M
&M SET 0
MOVER &REG, ='0'
.MORE MOVEM &REG, &X + &M
&M SET &M+1
AIF (&M NE &N) .MORE
MEND
MMEND
&X is PP
&N is PP
&REG=AREG is KP
CurrentLine: LCL &M
LCL (E,0)CurrentLine: &M SET 0
IC-> (E,0) SET 0
CurrentLine: MOVER &REG, ='0'

MOVER (P,2), ='0'CurrentLine: .MORE MOVEM &REG, &X + &M
MOVEM (P,2), (P,0) + (E,0)CurrentLine: &M SET &M+1
IC-> (E,0) SET (E,0)+1
CurrentLine: AIF (&M NE &N) .MORE
AIF ((E,0) NE (P,1)) (S,0)
CurrentLine: MEND

------- TABLES -------

------------------- MNT -------------------

MACRONAME	#PP	#KP	#EV	MDTP	KPDTP	SSTP
CLEARMEM	2	1	1	0	0	0

----- PNTAB -----

Index	Name
0	X
1	N
2	REG

----- EVNTAB -----

Index	Name
0	M

----- SSNTAB -----

Index	Name
0	MORE

---------- SSTAB ----------

Index	Value	Value
0	0	3

-------- KPDTAB --------

Index	Name	Default
0	REG	AREG

---------- MDT ----------

Index	IC
0	LCL (E,0)
1	(E,0) SET 0
2	MOVER (P,2), ='0'
3	MOVEM (P,2), (P,0) + (E,0)
4	(E,0) SET (E,0)+1
5	AIF ((E,0) NE (P,1)) (S,0)

Ending Preprocessing...

3. Top Down Without Backtracking

```
public class TopDown {
    public static void main(String[] args) {
        System.out.println("TopDownWithoutBackTrack");
        TopDownWithoutBackTrack a = new TopDownWithoutBackTrack();

        String parsed = a.parse("a + b * c * d + e");

        System.out.println("Parsed: " + parsed);

        // System.out.println(a.replaceAt(1, "TE''", "+E", 3));
    }
}

class TopDownWithoutBackTrack {
    private static final String EPSILON = "";

    private static String replaceAt(int index, String subject, String replacem
ent, int size) {
        return subject.substring(0, index) + replacement + subject.substring(i
ndex + size);
    }

    public String parse(String equation) {
        System.out.println("Steps: ");

        String parsed = "E";
        int indexInEquation = 0, index = 0, count = 0;
        equation = equation.replaceAll(" ", "");

        while (index < parsed.length()) {
            count++;
            System.out.println(String.format("%2d", count) + ": " + parsed);

            if (parsed.charAt(index) == 'E') {
                // E''
                if (index < parsed.length() - 2 && parsed.charAt(index + 1) ==
 '\''
                        && parsed.charAt(index + 2) == '\'') {
                    if (indexInEquation < equation.length() && equation.charAt
(indexInEquation) == '+') {
                        parsed = replaceAt(index, parsed, "+E", 3);
                        indexInEquation++;
                    } else
                        parsed = replaceAt(index, parsed, EPSILON, 3);
                }
```

```
                // E
                else {
                    parsed = replaceAt(index, parsed, "TE'", 1);
                }
            } else if (parsed.charAt(index) == 'T') {
                // T'
                if (index < parsed.length() - 2 && parsed.charAt(index + 1) ==
 '\''
                        && parsed.charAt(index + 2) == '\'') {
                    if (indexInEquation < equation.length() && equation.charAt
(indexInEquation) == '*') {
                        parsed = replaceAt(index, parsed, "*T", 3);
                        indexInEquation++;
                    } else
                        parsed = replaceAt(index, parsed, EPSILON, 3);
                }
                // T
                else {
                    parsed = replaceAt(index, parsed, "VT'", 1);
                }
            } else if (parsed.charAt(index) == 'V') {
                parsed = replaceAt(index, parsed, "<id>", 1);
                indexInEquation++;
                index += 4;
            } else
                index++;
        }
        System.out.println(String.format("%2d", ++count) + ": " + parsed);
        System.out.println("Completed in " + count + " steps.");
        return parsed;
    }
}


class TreeNode {
    private char expression;
    private TreeNode leftNode, rightNode;

    public TreeNode() {
    }

    public TreeNode(char expression, TreeNode leftNode, TreeNode rightNode) {
        this.expression = expression;
        this.leftNode = leftNode;
        this.rightNode = rightNode;
    }

    public void postOrderTraversal() {
        if (this.leftNode != null)
```

```
            leftNode.postOrderTraversal();

        if (this.rightNode != null)
            rightNode.postOrderTraversal();

        System.out.print(this.expression);
    }
}
```

Output :

PS D:\MCA\MCA SEM 3\SS\Parsers> java .\TopDown.java

TopDownWithoutBackTrack

Steps:

1: E

2: TE''

3: VT''E''

4: <id>T''E''

5: <id>E''

6: <id>+E

7: <id>+E

8: <id>+TE''

9: <id>+VT''E''

10: <id>+<id>T''E''

11: <id>+<id>*TE''

12: <id>+<id>*TE''

13: <id>+<id>*VT''E''

14: <id>+<id>*<id>T''E''

15: <id>+<id>*<id>*TE''

16: <id>+<id>*<id>*TE''

17: <id>+<id>*<id>*VT''E''

18: <id>+<id>*<id>*<id>T''E''

19: <id>+<id>*<id>*<id>E''

20: <id>+<id>*<id>*<id>+E

21: <id>+<id>*<id>*<id>+E

22: <id>+<id>*<id>*<id>+TE''

23: <id>+<id>*<id>*<id>+VT''E''

24: <id>+<id>*<id>*<id>+<id>T''E''

25: <id>+<id>*<id>*<id>+<id>E''

26: <id>+<id>*<id>*<id>+<id>

Completed in 26 steps.

Parsed: <id>+<id>*<id>*<id>+<id>

4 . Recursive Decent Parser

```
import java.util.Scanner;

public class RD {
    public static Scanner scanner = new Scanner(System.in);

    public static void main(String[] args) {
        System.out.print("Enter the Expression: ");
        String expression = scanner.nextLine();
        RecursiveDescentParser recursiveDescentParsing = new RecursiveDescentP
arser(expression);
        TreeNode rootNode;

        rootNode = recursiveDescentParsing.proc_E();

        if (rootNode != null) {
            rootNode.postOrderTraversal();
        }
    }
}

class RecursiveDescentParser {
    private String expressionString;
    private int indexInEquation = 0;

    public RecursiveDescentParser(String expressionString) {
        this.expressionString = expressionString;
        this.indexInEquation = 0;
    }

    public TreeNode proc_E() {
        TreeNode leftNode = null, rightNode = null;
        leftNode = proc_T();

        while (indexInEquation < expressionString.length() && expressionString
.charAt(indexInEquation) == '+') {
            this.indexInEquation++;
            rightNode = proc_T();

            if (rightNode == null)
                return null;

            leftNode = new TreeNode('+', leftNode, rightNode);
        }
        return leftNode;
    }
```

```
    public TreeNode proc_T() {
        TreeNode leftNode = null, rightNode = null;
        leftNode = proc_V();

        while (indexInEquation < expressionString.length() && expressionString
.charAt(indexInEquation) == '*') {
            this.indexInEquation++;
            rightNode = proc_V();

            if (rightNode == null)
                return null;

            leftNode = new TreeNode('*', leftNode, rightNode);
        }
        return leftNode;
    }

    public TreeNode proc_V() {
        if (indexInEquation < expressionString.length() && expressionString.ch
arAt(indexInEquation) != '*'
                && expressionString.charAt(indexInEquation) != '+')
            return new TreeNode(expressionString.charAt(indexInEquation++), nu
ll, null);

        else {
            System.out.println("\nInvalid Expression!");
            return null;
        }
    }
}

class TreeNode {
    private char expression;
    private TreeNode leftNode, rightNode;

    public TreeNode() {
    }

    public TreeNode(char expression, TreeNode leftNode, TreeNode rightNode) {
        this.expression = expression;
        this.leftNode = leftNode;
        this.rightNode = rightNode;
    }

    public void postOrderTraversal() {
        if (this.leftNode != null)
            leftNode.postOrderTraversal();
```

```
        if (this.rightNode != null)
            rightNode.postOrderTraversal();

        System.out.print(this.expression);
    }
}
```

Output:

PS D:\MCA\MCA SEM 3\SS\Parsers> java .\RD.java

Enter the Expression: x+x*x

xxx*+

5 . Operator Precedence Parser

```
import java.util.Stack;

public class OP {
    public static void main(String[] args) {
        String equation = "x + x * x";
        OperatorPrecedenceParser a = new OperatorPrecedenceParser();
        OperatorPrecedenceParser.TreeNode tree = a.parse(equation);

        System.out.println("Equation: " + equation);
        System.out.print("InOrder Traversal: ");
        OperatorPrecedenceParser.inOrder(tree);

        System.out.print("\nPostOrder Traversal: ");
        OperatorPrecedenceParser.postOrder(tree);
        System.out.println();

    }
}

class OperatorPrecedenceParser {
    public static class TreeNode {
        char data;
        TreeNode left, right;

        TreeNode(char value) {
            data = value;
            left = right = null;
        }
    }

    private static short getPriority(char op) {
        switch (op) {
            case '+':
            case '-':
                return 1;

            case '/':
            case '*':
                return 2;

            default:
                return 0;
        }
    }
```

```
    private static boolean isOperator(char ch) {
        return (ch == '+' || ch == '-' || ch == '*' || ch == '/');
    }

    private static boolean isOperand(char ch) {
        return ((ch >= 'A' && ch <= 'Z') || (ch >= 'a' && ch <= 'z'));
    }

    private static boolean isOpeningBracket(char ch) {
        return (ch == '(' || ch == '{' || ch == '[');
    }

    private static boolean isClosingBracket(char ch) {
        return (ch == ')' || ch == '}' || ch == ']');
    }

    private static char getPair(char bracket) {
        switch (bracket) {
            case '(':
                return ')';
            case '{':
                return '}';
            case '[':
                return ']';
            case ')':
                return '(';
            case '}':
                return '{';
            case ']':
                return '[';
            default:
                return (char) 0;
        }
    }

    private static String toPostFix(String equation) {
        Stack<Character> operators = new Stack<>();
        String postfix = "";
        for (int i = 0; i < equation.length(); i++) {
            char ch = equation.charAt(i);

            if (isOpeningBracket(ch))
                operators.push(ch);
            else if (isClosingBracket(ch)) {
                char op = operators.pop();
                char openingPair = getPair(ch);

                while (op != openingPair) {
```

```
                    postfix += op;
                    op = operators.pop();
                }
            } else if (isOperator(ch)) {
                short previousPriority = operators.isEmpty() ? 0 : getPriority
(operators.peek());
                short currentPriority = getPriority(ch);

                while (previousPriority != 0 && previousPriority >= currentPri
ority) {
                    postfix += operators.pop();
                    previousPriority = operators.isEmpty() ? 0 : getPriority(o
perators.peek());
                }

                operators.push(ch);
            } else if (isOperand(ch))
                postfix += ch;
        }

        while (!operators.isEmpty())
            postfix += operators.pop();

        return postfix;
    }

    private static TreeNode getExpressionTree(String equation) {
        Stack<TreeNode> stack = new Stack<>();
        for (int i = 0; i < equation.length(); i++) {
            char ch = equation.charAt(i);

            if (isOperator(ch)) {
                TreeNode operand2 = stack.pop();
                TreeNode operand1 = stack.pop();
                TreeNode parentNode = new TreeNode(ch);
                parentNode.left = operand1;
                parentNode.right = operand2;

                stack.push(parentNode);
            } else if (isOperand(ch))
                stack.push(new TreeNode(ch));
        }

        return stack.pop();
    }

    public static void inOrder(TreeNode root) {
        if (root == null)
```

```
            return;

        inOrder(root.left);
        System.out.print(root.data);
        inOrder(root.right);
    }

    public static void postOrder(TreeNode root) {
        if (root == null)
            return;

        postOrder(root.left);
        postOrder(root.right);
        System.out.print(root.data);
    }

    public TreeNode parse(String equation) {
        return getExpressionTree(toPostFix(equation));
    }
}
```

Output:

PS D:\MCA\MCA SEM 3\SS\Parsers> java .\OP.java

Equation: x + x * x

InOrder Traversal: x+x*x

PostOrder Traversal: xxx*+

6. LL1 Parser

```
public class LL1 {
    public static void main(String[] args) {
        System.out.println("LL1Parser");
        LL1Parser a = new LL1Parser();

        String parsed = a.parse("a * b + c");

        System.out.println("Parsed: " + parsed);

        // System.out.println(a.replaceAt(1, "TE'", "+E", 3));
    }
}

class LL1Parser {
    private static final String EPSILON = "";

    private static String replaceAt(int index, String subject, String replacem
ent, int size) {
        return subject.substring(0, index) + replacement + subject.substring(i
ndex + size);
    }

    public String parse(String equation) {
        System.out.println("Steps: ");

        String parsed = "E";
        int indexInEquation = 0, index = 0, count = 0;
        equation = equation.replaceAll(" ", "");

        while (index < parsed.length()) {
            count++;
            System.out.println(String.format("%2d", count) + ". " + parsed);
            if (parsed.charAt(index) == 'E') {
                // E'
                if (index < parsed.length() - 1 && parsed.charAt(index + 1) ==
 '\'') {
                    if (indexInEquation < equation.length() && equation.charAt
(indexInEquation) == '+') {
                        parsed = replaceAt(index, parsed, "+TE'", 2);
                        indexInEquation++;
                    } else
                        parsed = replaceAt(index, parsed, EPSILON, 2);
                }
                // E
                else {
                    parsed = replaceAt(index, parsed, "TE'", 1);
```

```
                }
            } else if (parsed.charAt(index) == 'T') {
                // T'
                if (index < parsed.length() - 1 && parsed.charAt(index + 1) ==
 '\'') {
                    if (indexInEquation < equation.length() && equation.charAt
(indexInEquation) == '*') {
                        parsed = replaceAt(index, parsed, "*VT'", 2);
                        indexInEquation++;
                    } else
                        parsed = replaceAt(index, parsed, EPSILON, 2);
                }
                // T
                else {
                    parsed = replaceAt(index, parsed, "VT'", 1);
                }
            } else if (parsed.charAt(index) == 'V') {
                parsed = replaceAt(index, parsed, "<id>", 1);
                indexInEquation++;
                index += 4;
            } else
                index++;
        }
        System.out.println(String.format("%2d", ++count) + ". " + parsed);
        System.out.println("Completed in " + count + " steps.");
        return parsed;
    }
}
```

Output :

PS D:\MCA\MCA SEM 3\SS\Parsers > java .\LL1.java

LL1Parser

Steps:

1. **E**
2. **TE'**
3. **VT'E'**
4. **<id>T'E'**
5. **<id>*VT'E'**
6. **<id>*VT'E'**
7. **<id>*<id>T'E'**
8. **<id>*<id>E'**
9. **<id>*<id>+TE'**

10. <id>*<id>+TE'
11. <id>*<id>+VT'E'
12. <id>*<id>+<id>T'E'
13. <id>*<id>+<id>E'
14. <id>*<id>+<id>
Completed in 14 steps.
Parsed: <id>*<id>+<id>

7. Scanner

```
import java.util.Arrays;
import java.util.List;
import java.util.ArrayList;

public class ScannerDemo {
    public static void main(String[] args) {
        String[] valids = { "aaabbbcccddd", "aaabcddd", "abcd", "aaaaabbbbddddd
", "abd" };
        MyScanner sc = new MyScanner(valids);
        boolean check6 = sc.check("cccddd");
        System.out.println("aaaacccddd is " + (check6 ? " valid" : " not valid
."));
        System.out.println();
    }
}

class State {
    char symbol;
    List<Character> nextStates;

    State(char state) {
        this.symbol = state;
        nextStates = new ArrayList<>();
    }

    boolean hasNextState(char state) {
        return this.nextStates.stream().anyMatch(ch -> ch == state);
    }

    @Override
    public String toString() {
        String state = "State: " + (symbol == (int) 0 ? "start" : symbol) + ",
 Next States: ";

        for (char ch : nextStates)
            state += ch + ", ";

        return state.substring(0, state.length() - 2);
    }
}

class MyScanner {
    State start;
    List<State> states;
```

```
    public MyScanner() {
        this.initialize();
        this.createDFA();
        this.displayStates();
    }

    public MyScanner(String[] valids) {
        this.initialize(valids);
        this.displayStates();
    }

    private void initialize() {
        start = new State((char) 0);
        State[] list = new State[] { new State('a'), new State('b'), new State
('c'), new State('d') };
        states = Arrays.asList(list);
    }

    private void initialize(String[] valids) {
        this.states = new ArrayList<>();
        this.start = new State((char) 0);

        for (String valid : valids) {
            State current = this.start;

            for (int i = 0; i < valid.length(); i++) {
                char ch = valid.charAt(i);

                if (this.getState(ch) == null)
                    this.states.add(new State(ch));

                if (!current.hasNextState(ch))
                    current.nextStates.add(ch);

                current = this.getState(ch);
            }
        }

    }

    private State getState(char value) {

        return this.states.stream().filter(state -
> state.symbol == value).findAny().orElse(null);
    }


    private void createDFA() {
        start.nextStates.add('a');
```

```
        State a = this.getState('a');
        a.nextStates.add('a');
        a.nextStates.add('b');

        State b = this.getState('b');
        b.nextStates.add('b');
        b.nextStates.add('c');
        b.nextStates.add('d');

        State c = this.getState('c');
        c.nextStates.add('c');
        c.nextStates.add('d');

        State d = this.getState('d');
        d.nextStates.add('d');
    }

    private void displayStates() {
        System.out.println(start);


        this.states.forEach(System.out::println);
    }


    public boolean check(String expression) {

        State current = start;

        for (int i = 0; i < expression.length(); i++) {
            char symbol = expression.charAt(i);

            if (current.hasNextState(symbol)) {
                System.out
                        .println((current.symbol == (int) 0 ? "start" : curren
t.symbol) + " has next state " + symbol);
                current = this.getState(symbol);
            }
            else
                return false;
        }
        return true;
    }
}
```

Output :

```
PS D:\MCA\MCA SEM 3\SS\scanner> java .\ScannerDemo.java
State: start, Next States: a
State: a, Next States: a, b
State: b, Next States: b, c, d
State: c, Next States: c, d
State: d, Next States: d
aaaacccddd is  not valid.
```