GROUP - B

EXPERIMENT NO : 06

1. **Title:**
   Write a program using Lex specifications to implement lexical analysis phase of compiler to generate tokens of subset of 'Java' program

2. **Objectives :**
   - To understand LEX Concepts
   - To implement LEX Program
   - To study about Lex & Java
   - To know important about Lexical analyzer

3. **Problem Statement :**
   Write a program using Lex specifications to implement lexical analysis phase of compiler to generate tokens of subset of 'Java' program

4. **Outcomes:**

After completion of this assignment students will be able to:
   - Understand the concept of LEX Tool
   - Understand the lexical analysis part
   - It can be used for data mining concepts.

5. **Software Requirements:**
   - LEX Tool (flex)

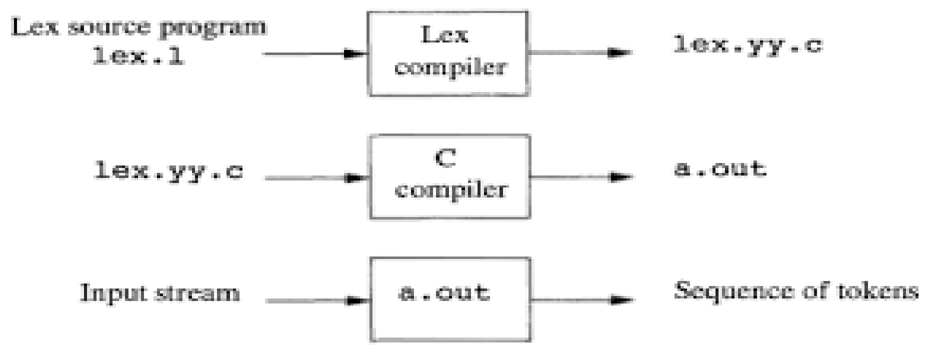
6. **Hardware Requirement:**
   - M/C Lenovo Think center M700 Ci3,6100,6th Gen. H81, 4GB RAM ,500GB HDD

7. **Theory Concepts:**

Lex stands for Lexical Analyzer. Lex is a tool for generating Scanners. Scanners are programs that recognize lexical patterns in text. These lexical patterns (or regular Expressions) are defined in a particular syntax. A matched regular expression may have an associated action. This action may also include returning a token. When Lex receives input in the form of a file or text, it takes input one character at a time and continues until a pattern is matched, then lex performs the associated action (Which may include returning a token). If, on the other hand, no regular expression can be matched, further processing stops and Lex displays an error message.

Lex and C are tightly coupled. A .lex file (Files in lex have the extension .lex) is passed through the lex utility, and produces output files in C. These file(s) are coupled to produce an executable version of the lexical analyzer.

Lex turns the user's expressions and actions into the host general –purpose language; the generated program is named yylex. The yylex program will recognize expressions in a stream (called input in this memo) and perform the specified actions for each expression as it is detected. See Figure 1.



Overview of Lex Tool

- **Regular Expression in Lex:-**

A Regular expression is a pattern description using a meta language. An expression is made up of symbols. Normal symbols are characters and numbers, but there are other symbols that have special meaning in Lex. The following two tables define some of the symbols used in Lex and give a few typical examples.

- **Defining regular expression in Lex:-**

Character	**Meaning**
A-Z, 0-9,a-z	Character and numbers that form of the pattern.
.	Matches any character except \n.
-	Used to denote range. Example: A-Z implies all characters from A to Z.
[]	A character class. Matches any character in the brackets. If character is ^ then it indicates a negation pattern. Example: [abc] matches either of a,b and c.
*	Matches zero or more occurences of the preceiding pattern.
+	Matches one or more occurences of the preceiding pattern.
?	Matches zero or one occurences of the preceiding pattern.
$	Matches end of line as the last character of the pattern.
{}	Indicates how many times a pattern can be present. Example: A {1, 3} implies one or three occurences of A may be present.
\	Used to escape meta characters. Also used to remove the special meaning of characters as defined in this table.
^	Negation
|	Logical OR between expressions.
"<some symbols>"	Literal meaning of characters. Meta characters hold.

/	Look ahead matches the preceding pattern only if followed by the succeeding expression. Example: A0/1 matches A0 only if A01 is the input.
()	Groups a series of regular expressions.

- **Examples of regular expressions**

Regular expression	**Meaning**
Joke[rs]	Matches either jokes or joker
A {1,2}shis+	Matches Aashis, Ashis, Aashi, Ashi.
(A[b-e])+	Matches zero or one occurrences of A followed by any character from b to e.

Tokens in Lex are declared like variable names in C.Every token has an associated expression.(Examples of tokens and expression are given in the following table). Using the examples in our tables, we'll build a word-counting program. Our first task will be to show how tokens are declared.

- **Examples of token declaration**

Token	**Associated expression**	**Meaning**
Number	([0-9])+	1 or more occurences of a digit
Chars	[A-Za-z]	Any character
Blank	""	A blank space
Word	(chars)+	1 or more occurences of chars
Variable	(chars)+(number)*(chars)*(number)*	

➢ **Programming in Lex:-**

Programming in Lex can be divided into three steps:

1. Specify the pattern-associated actions in a form that Lex can understand.
2. Run Lex over this file to generate C code for the scanner.
3. Compile and link the C code to produce the executable scanner.

Note: If the scanner is part of a parser developed using Yacc, only steps 1 and 2 should be performed.

A Lex program is divided into three sections: the first section has global C and Lex declaration, the second section has the patterns (coded in C), and the third section has supplement C functions. Main (), for example, would typically be founding the third section. These sections are delimited by %%.so, to get back to the word to the word-counting Lex program; let's look at the composition of the various program sections.

Table 1: Special Characters	
Pattern	**Matches**
`.`	any character except newline
`\.`	literal `.`
`\n`	newline
`\t`	tab
`^`	beginning of line
`$`	end of line

Table 2: Operators	
Pattern	**Matches**
`?`	zero or one copy of the preceding expression
`*`	zero or more copies of the preceding expression
`+`	one or more copies of the preceding expression
`a|b`	`a` or `b` (alternating)
`(ab)+`	one or more copies of `ab` (grouping)
`abc`	`abc`
`abc*`	`ab abc abcc abccc ...`
`"abc*"`	literal `abc*`
`abc+`	`abc abcc abccc abcccc ...`
`a(bc)+`	`abc abcbc abcbcbc ...`
`a(bc)?`	`a abc`

Table 3: Character Class	
Pattern	**Matches**
`[abc]`	one of: `a b c`
`[a-z]`	any letter a through z
`[a\-z]`	one of: `a - z`
`[-az]`	one of: `- a z`
`[A-Za-z0-9]+`	one or more alphanumeric characters
`[ \t\n]+`	whitespace
`[^ab]`	anything except: `a b`
`[a^b]`	one of: `a ^ b`
[a|b]	one of: **a | b**

Regular expressions are used for pattern matching. A character class defines a single character and normal operators lose their meaning. Two operators supported in a character class are the hyphen ("-") and circumflex ("^"). When used between two characters the hyphen represents a range of characters. The circumflex, when used as the first character, negates the expression. If two patterns match the same string the longest match wins. In case both matches are the same length, then the first pattern listed is used.

```
... definitions ...

%%
.
.. rules ...

%%

... subroutines ...
```

Input to Lex is divided into three sections with **%%** dividing the sections. This is best illustrated by example. The first example is the shortest possible lex file:

```
%%
```

Input is copied to output one character at a time. The first **%%** is always required as there must always be a rules section. However if we don't specify any rules then the default action is to match everything and copy it to output. Defaults for input and output are **stdin** and **stdout**, respectively. Here is the same example with defaults explicitly coded:

```
    %%
/* match everything except newline */
.   ECHO;
/* match newline */
\n  ECHO;

%%

int yywrap(void) {
return 1;
}

int main(void) {
yylex();
return 0;
}
```

Two patterns have been specified in the rules section. Each pattern must begin in column one. This is followed by *whitespace* (space, tab or newline) and an optional action associated with the pattern. The action may be a single Cstatement, or multiple C statements, enclosed in braces. Anything not starting in column one is copied verbatim to the generated C file. We may take advantage of this behavior to specify comments in our lex file. In this example there are two patterns, "**.**" and "**\n**", with an **ECHO** action associated for each pattern. Several macros and variables are predefined by lex. **ECHO** is a macro that writes code matched by the pattern. This is the default action for any unmatched strings. Typically, **ECHO** is defined as:

```
#define ECHO fwrite(yytext, yyleng, 1, yyout)
```

Variable **yytext** is a pointer to the matched string (NULL-terminated) and **yyleng** is the length of the matched string. Variable **yyout** is the output file and defaults to **stdout**. Function **yywrap** is called by lex when input is exhausted. Return 1 if you are done or 0 if more processing is required. Every C program requires a **main** function. In this case we simply call **yylex** that is the main entry-point for lex . Some implementations of lex include copies of **main** and**yywrap** in a library thus eliminating the need to code them explicitly. This is why our first example, the shortest lexprogram, functioned properly.

Table 4: Lex Predefined Variables

Name	Function
int yylex(void)	call to invoke lexer, returns token
char *yytext	pointer to matched string
yyleng	length of matched string
yylval	value associated with token
int yywrap(void)	wrapup, return 1 if done, 0 if not done
FILE *yyout	output file
FILE *yyin	input file
INITIAL	initial start condition
BEGIN condition	switch start condition
ECHO	write matched string

Here is a program that does nothing at all. All input is matched but no action is associated with any pattern so there will be no output.

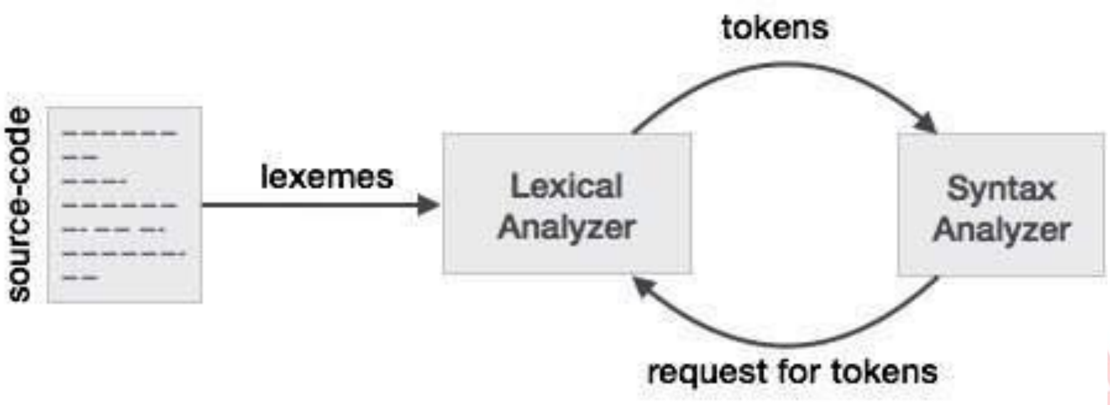
```
%%
.
\n
```

The following example prepends line numbers to each line in a file. Some implementations of lex predefine and calculate **yylineno**. The input file for lex is **yyin** and defaults to **stdin**.

```
%{
   int yylineno;
%}
%%
^(.*)\n    printf("%4d\t%s", ++yylineno, yytext);
%%
int main(int argc, char *argv[]) {
   yyin = fopen(argv[1], "r");
   yylex();
```

```
        fclose(yyin);
    }
```

8. Design (architecture) :



9. Algorithms(procedure) :

Note: you should write algorithm & procedure as per program/concepts

10. Flowchart :

Note: you should draw flowchart as per algorithm/procedure

11. Conclusion:

Thus, I have studied lexical analyzer and implemented an application for lexical analyzer to perform scan the program and generates token of subset of java.

References :

A	**P**	**C/W**	**Sign**
(3)	**(4)**	**(3)**	

A – Attendance, P – Performance , C/W – Completion & Writing

Oral Questions: [Write short answer]

1. What is Lex.
2. What is Compiler and phases of compiler.
3. What is Lex specification.
4. What is the difference between Lex and YACC.
5. What is Regular Expression.
6. How to run a Lex program.
7. What is yytext, yyin, yyout.
8. What is yywrap().
9. What is yylex().
10. token, lexemes, pattern?