RAMAIAH UNIVERSITY
OF APPLIED SCIENCES

ASSIGNMENT

Course Code	19CSC305A
Course Name	Compilers
Programme	B. Tech.
Department	Computer Science and Engineering
Faculty	Faculty of Engineering & Technology

Name of the Student	Subhendu Maji
Reg. No	18ETCS002121
Semester/Year	5TH semester / 2018 batch
Course Leader/s	Ms. Suvidha

Declaration Sheet

Student Name	Subhendu Maji		
Reg. No	18ETCS002121		
Programme	B. Tech.	Semester/Year	5th sem / 2018 batch
Course Code	19CSC305A		
Course Title	Compilers		
Course Date		to	
Course Leader	Ms. Suvidha		

Declaration

The assignment submitted herewith is a result of my own investigations and that I have conformed to the guidelines against plagiarism as laid out in the Student Handbook. All sections of the text and results, which have been obtained from other sources, are fully referenced. I understand that cheating and plagiarism constitute a breach of University regulations and will be dealt with accordingly.

Signature of the Student		Date	
Submission date stamp (by Examination & Assessment Section)			

Signature of the Course Leader and date	Signature of the Reviewer and date

Assignment			
Register No.	18ETCS002121	Name of the Student	SUBHENDU MAJI

Sections		Marking Scheme	Marks		
			Max Marks	First Examiner Marks	Moderator
Part A1					
	A 1.1	Implementation in *Lex*	06		
	A 1.2	Results and Comments	04		
		Part-A 1 Max Marks	**10**		
	A 2.1	Implementation in *Lex*	10		
	A 2.2	Results and Comments	05		
		Part-A 2 Max Marks	**15**		
		Total Assignment Marks	**25**		

Course Marks Tabulation				
Component- CET B Assignment	**First Examiner**	**Remarks**	**Second Examiner**	**Remarks**
A.1				
A.2				
Marks (out of 25)				

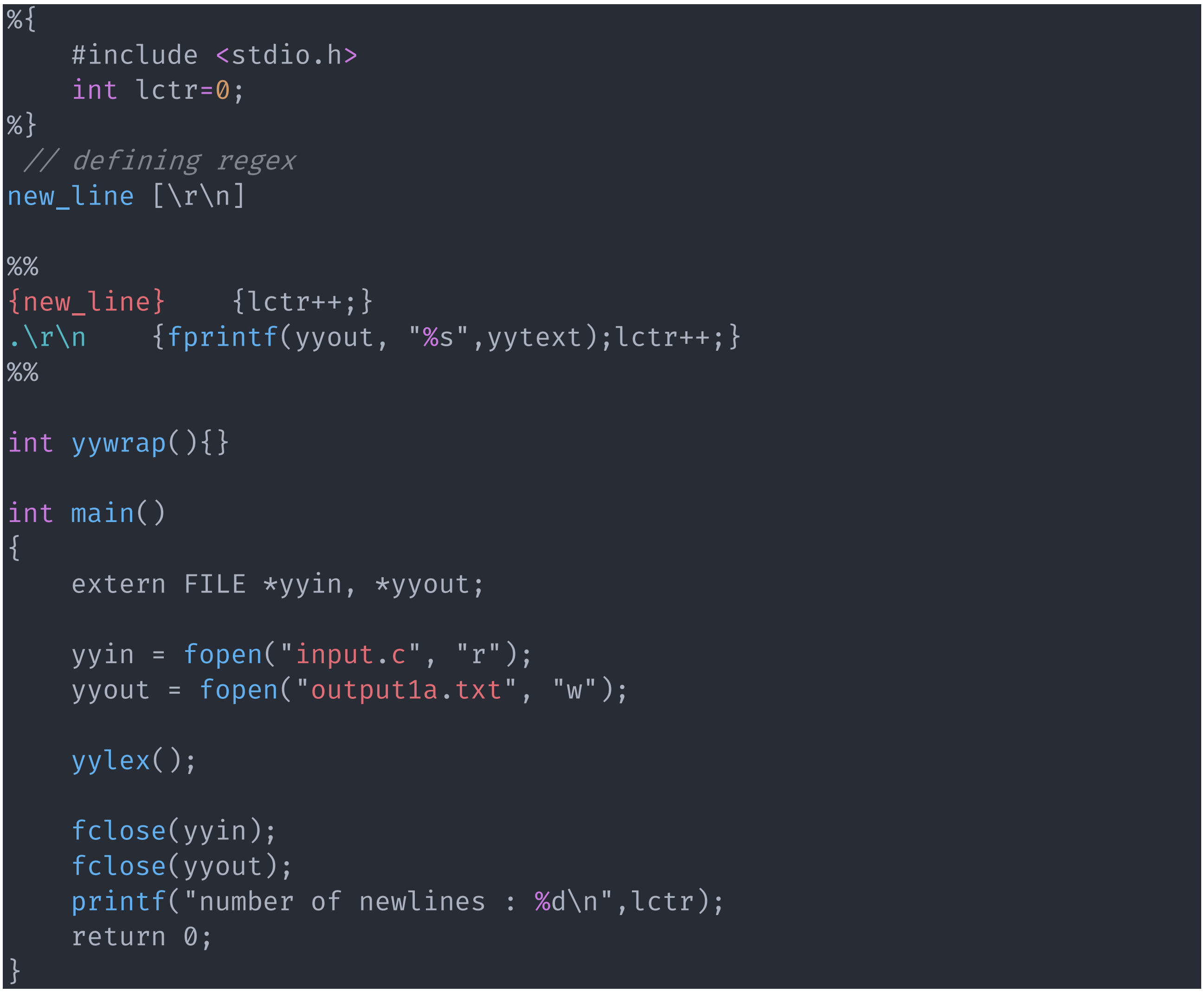
Signature of First Examiner **Signature of Moderator**

Solution to Question No. 1:

1.1 Implementation in Lex

1a. Multiple consecutive blank lines should be compressed and calculate number of lines at the end of given text.

Token	Regular Expression
NEW_LINE	: \r\n

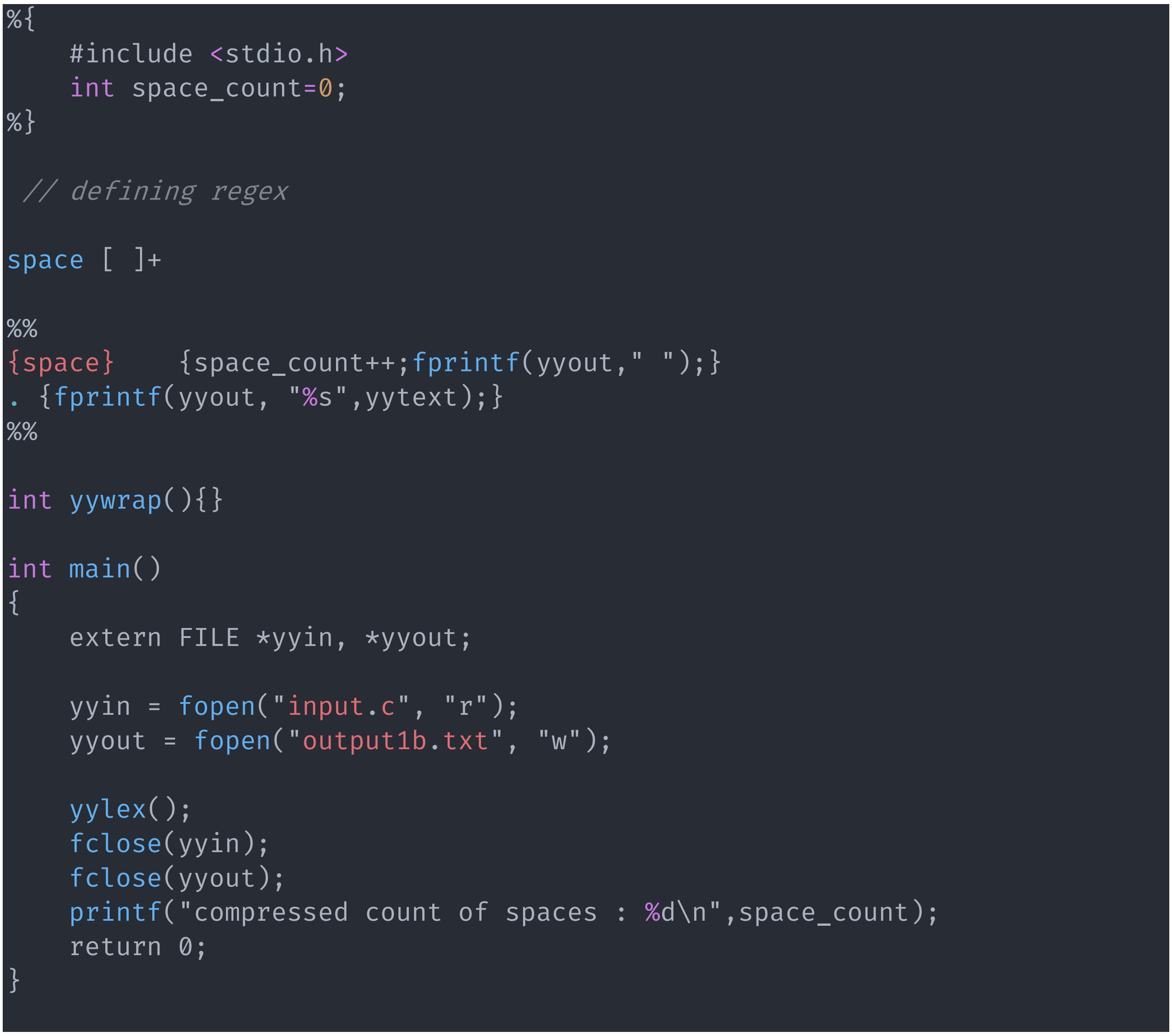


```
%{
    #include <stdio.h>
    int lctr=0;
%}
 // defining regex
new_line [\r\n]

%%
{new_line}    {lctr++;}
.\r\n    {fprintf(yyout, "%s",yytext);lctr++;}
%%

int yywrap(){}

int main()
{
    extern FILE *yyin, *yyout;

    yyin = fopen("input.c", "r");
    yyout = fopen("output1a.txt", "w");

    yylex();

    fclose(yyin);
    fclose(yyout);
    printf("number of newlines : %d\n",lctr);
    return 0;
}
```

Figure 1 Lex program of 1a.l

1.b Multiple consecutive spaces should be compressed and calculate number of blank space at the end of given text.

Token	**Regular Expression**
SPACES	: [ ]+

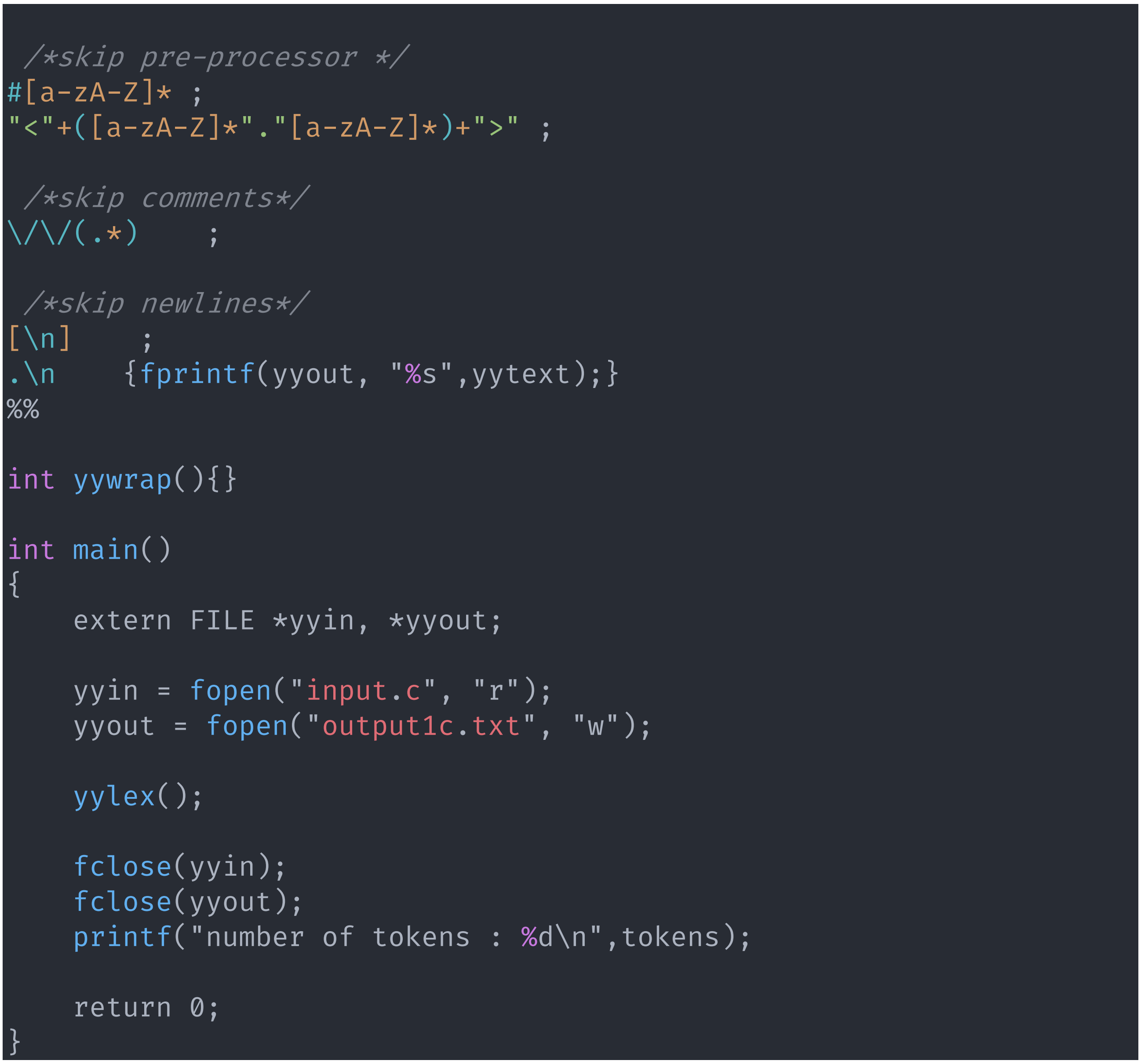


```
%{
    #include <stdio.h>
    int space_count=0;
%}

 // defining regex

space [ ]+

%%
{space}    {space_count++;fprintf(yyout," ");}
. {fprintf(yyout, "%s",yytext);}
%%

int yywrap(){}

int main()
{
    extern FILE *yyin, *yyout;

    yyin = fopen("input.c", "r");
    yyout = fopen("output1b.txt", "w");

    yylex();
    fclose(yyin);
    fclose(yyout);
    printf("compressed count of spaces : %d\n",space_count);
    return 0;
}
```

Figure 2 Lex Program of 1b.l

1c. Space before and after punctuation and after opening and closing parentheses and also calculting no. of tokens.

```
%{
    #include <stdio.h>
    int tokens = 0;
%}


%%

 /* remove white spaces*/
[ ]+    {fprintf(yyout," ");}

 /*count identifiers and keywords*/
[a-zA-Z_][a-zA-Z0-9_]*   {tokens++;fprintf(yyout,"%s",yytext);}


 /*count operators*/
"<="|"=="|"="|"++"|"-
"|"*"|"+"|"&"|">"|"<"|"|"|"/"|"%"    {tokens++;fprintf(yyout,"%s",y
ytext);}

 /*count and adding space before and after puncutations*/
[,;:]    {tokens++;fprintf(yyout," %s ",yytext);}
[,;:][\n]    {tokens++;fprintf(yyout," %s",yytext);}

 /*count and adding space after opening brackets */
[({\[]    {tokens++;fprintf(yyout,"%s ",yytext);}
[({\[][\n]    {tokens++;fprintf(yyout,"%s ",yytext);}

 /*count and adding space before closing brackets*/
[)}\]]    {tokens++;fprintf(yyout," %s",yytext);}
[)}\]][\n]    {tokens++;fprintf(yyout," %s",yytext);}

 /*count float literal*/
[0-9]*"."[0-9]+    {tokens++;fprintf(yyout,"%s",yytext);}

 /*count int literal*/
[0-9]+   {tokens++;fprintf(yyout,"%s",yytext);}

 /*count string literal*/
\"(\\.|[^"\\])*\"    {tokens++;fprintf(yyout,"%s",yytext);}

 /*count character literal*/
\'(\\.|[^'\\])*\'    {tokens++;fprintf(yyout,"%s",yytext);}
```

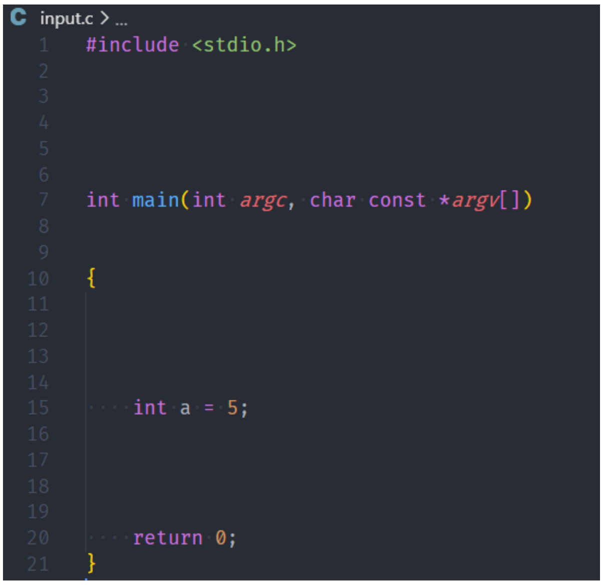


```
 /*skip pre-processor */
#[a-zA-Z]* ;
"<"+([a-zA-Z]*"."[a-zA-Z]*)+">" ;

 /*skip comments*/
\/\/(.*)    ;

 /*skip newlines*/
[\n]    ;
.\n    {fprintf(yyout, "%s",yytext);}
%%

int yywrap(){}

int main()
{
    extern FILE *yyin, *yyout;

    yyin = fopen("input.c", "r");
    yyout = fopen("output1c.txt", "w");

    yylex();

    fclose(yyin);
    fclose(yyout);
    printf("number of tokens : %d\n",tokens);

    return 0;
}
```

Figure 3 lex program of 1c.l

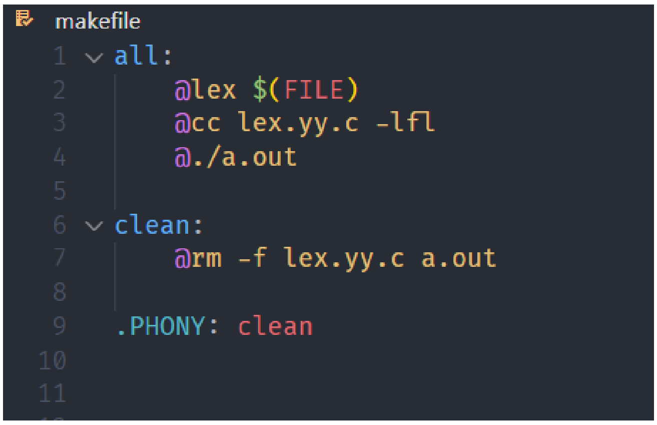
1.2 Results and Comments

Note: I am using the same `input.c` file for all the three lex program.



```c
#include <stdio.h>





int main(int argc, char const *argv[])


{




    int a = 5;




    return 0;
}
```

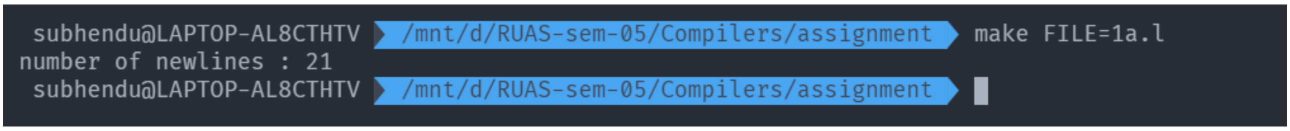
Figure 4 Input file



```make
all:
	@lex $(FILE)
	@cc lex.yy.c -lfl
	@./a.out

clean:
	@rm -f lex.yy.c a.out

.PHONY: clean


```

Figure 5 makefile

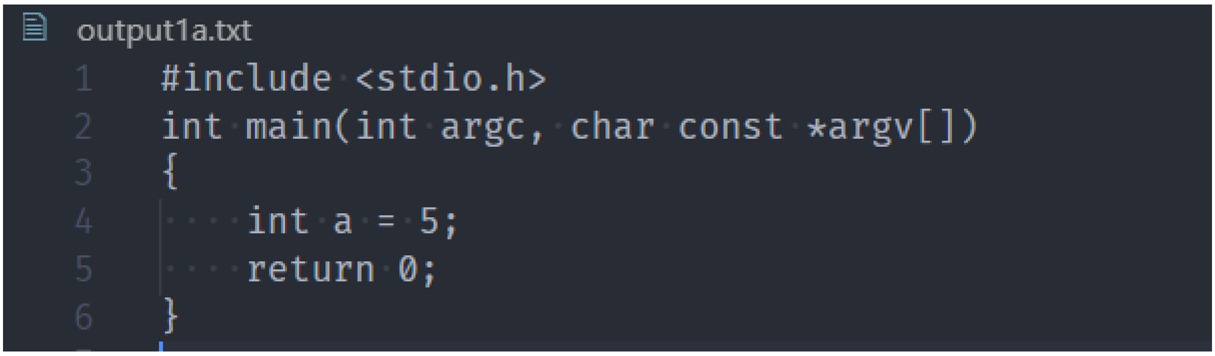
1a. Executing lex program to compress multiple consecutive blank lines and calculate number of lines at the end of given text.



```
 subhendu@LAPTOP-AL8CTHTV  /mnt/d/RUAS-sem-05/Compilers/assignment  make FILE=1a.l
number of newlines : 21
 subhendu@LAPTOP-AL8CTHTV  /mnt/d/RUAS-sem-05/Compilers/assignment 
```

Figure 6 executing 1a.l

Output file after execution:



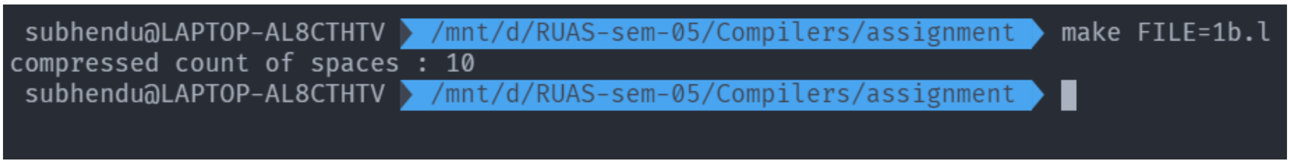
output1a.txt

```
#include <stdio.h>
int main(int argc, char const *argv[])
{
    int a = 5;
    return 0;
}
```

Figure 7 output file after execution

As we can see in above figure (Fig 7), multiple lines are compressed and stored in `output1a.txt` file.

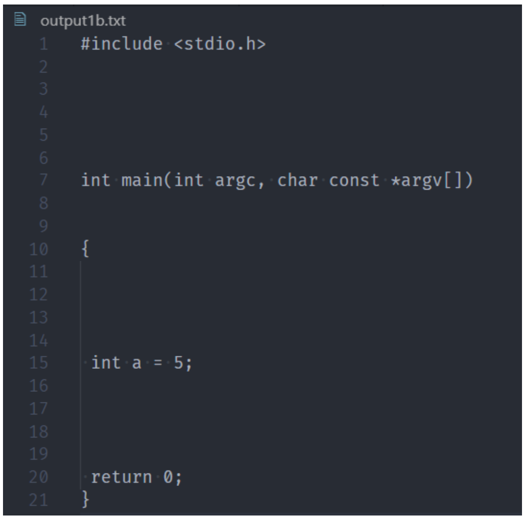
1b. Executing lex program to compress multiple consecutive spaces and calculate number of spaces at the end of given text.



```
 subhendu@LAPTOP-AL8CTHTV  /mnt/d/RUAS-sem-05/Compilers/assignment  make FILE=1b.l
compressed count of spaces : 10
 subhendu@LAPTOP-AL8CTHTV  /mnt/d/RUAS-sem-05/Compilers/assignment  
```

Figure 8 execution of 1b.l

Output file after execution:



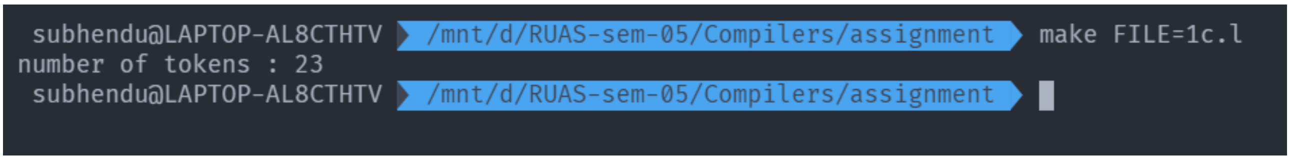
output1b.txt

```
#include <stdio.h>





int main(int argc, char const *argv[])


{




 int a = 5;




 return 0;
}
```

Figure 9 output file after execution

As we can see in above figure (Fig 9), multiple spaces are compressed and stored in `output1b.txt` file.

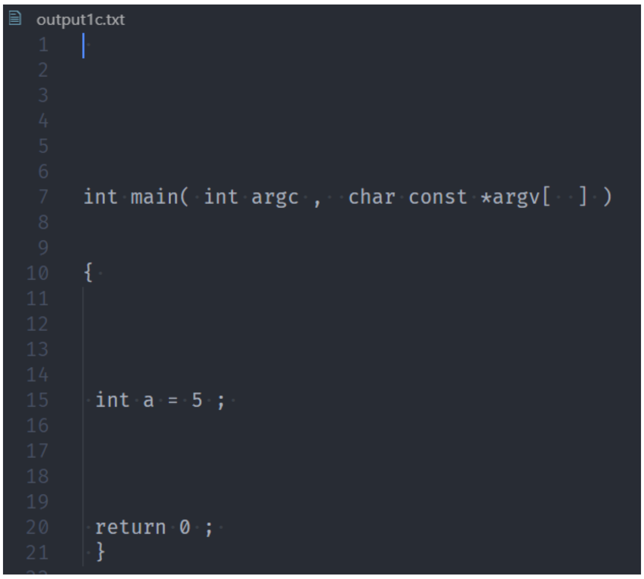
1c. Space before and after punctuation and after opening and closing parentheses and also calculting no. of tokens.



```
 subhendu@LAPTOP-AL8CTHTV  /mnt/d/RUAS-sem-05/Compilers/assignment  make FILE=1c.l
number of tokens : 23
 subhendu@LAPTOP-AL8CTHTV  /mnt/d/RUAS-sem-05/Compilers/assignment 
```

Figure 10 execution of 1c.l

Output file after execution:



```






int main( int argc ,  char const *argv[  ] )


{ 




 int a = 5 ; 




 return 0 ; 
 }
```

Figure 11 output file after execution

As we can see in above figure (Fig 11), Space before and after punctuation and after opening and closing parentheses is added and stored in `output1c.txt` file

Question No. 2

Solution to Question No. 2:

2.1 Implementation in Lex

The indivisible unit of a program is called a token. A compiler breaks the program into the smallest possible units and proceeds to the various stages of the compilation. Such units are tokens. As seen here, tokens are the units in which compilers act on. Typically, in a language like C, there are the following tokens: Identifiers, Keywords, Constants, Strings, Operators and Special Symbols.

Regular Expression

The regular expressions that are used to match and produce the various token are straight forward. For the keyword token, the regular expressions are the keywords themselves.

Token	**Regular Expression**
`KEYWORD`	`auto|double|int|struct|break|else|long|switch|case|typedef|char|extern|return|continue|for|signed|void|do|if|static|while|default|goto|sizeof|const|float|short`

For the identifier token, any set of alphanumeric characters that start with an alphabet is assumed to be an identifier. Thus, the regular expression for this would be:

Token	**Regular Expression**
`IDENTIFIER`	`: [a-zA-Z]+[a-zA-Z0-9]*`

For the integer number token, the regular expression would be to match an optional negative sign, followed by any set of digits. For the floating-point number token on the other hand, there are two cases to be handled. One is the case where the number is defined in terms of regular digits and a decimal point, the other, when the number is defined using scientific notation. Thus, the regular expressions are:

Token	**Regular Expression**
`INT_NUM`	`: -?[0-9]+`
`FLOAT_NUM`	`: -?([0-9]+\.[0-9]+)([eE][-+]?[0-9]+)?`
`STRING_LITERAL`	`: \"[^\"]*\"`
`CHAR_LITERAL`	`: \'[^\']*\'`

The tokens for the special symbols and operators are matched using the characters themselves, with the characters escaped when necessary.

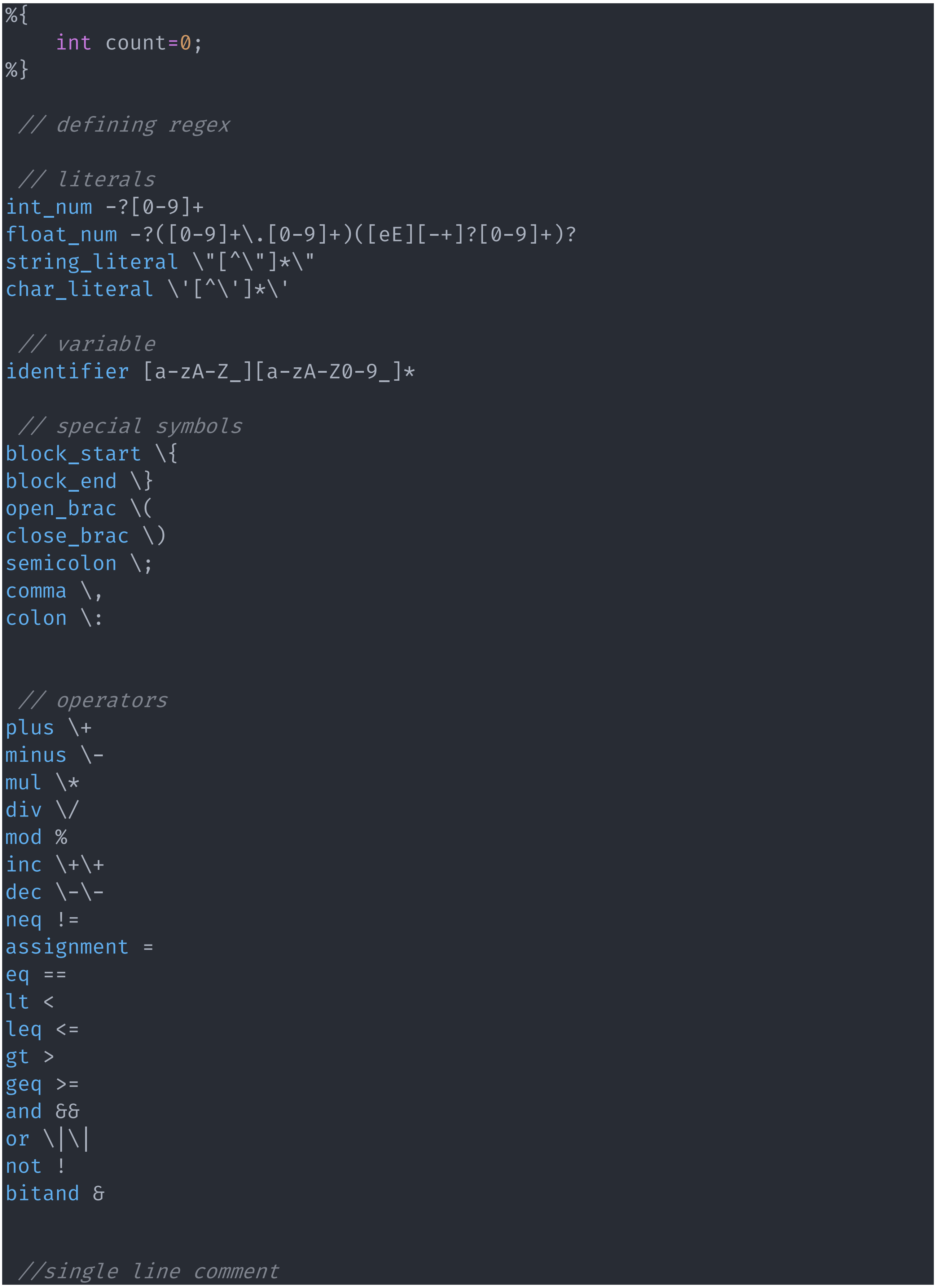
<table>
<tr><th>Token</th><th>Regular Expression</th></tr>
<tr><td>BLOCK_START</td><td>: \{</td></tr>
<tr><td>BLOCK_END</td><td>: \}</td></tr>
<tr><td>OPEN_BRAC</td><td>: \(</td></tr>
<tr><td>CLOSE_BRAC</td><td>: \)</td></tr>
<tr><td>SEMICOLON</td><td>: \;</td></tr>
<tr><td>COMMA</td><td>: \,</td></tr>
<tr><td>COLON</td><td>: \:</td></tr>
<tr><td></td><td></td></tr>
<tr><td>PLUS</td><td>: \+</td></tr>
<tr><td>MINUS</td><td>: \-</td></tr>
<tr><td>MUL</td><td>: *</td></tr>
<tr><td>DIV</td><td>: \/</td></tr>
<tr><td>MOD</td><td>: %</td></tr>
<tr><td>INC</td><td>: \+\+</td></tr>
<tr><td>DEC</td><td>: \-\-</td></tr>
<tr><td>ASSIGNMENT</td><td>: =</td></tr>
<tr><td>EQ</td><td>: ==</td></tr>
<tr><td>LT</td><td>: &lt;</td></tr>
<tr><td>LEQ</td><td>: &lt;=</td></tr>
<tr><td>GT</td><td>: &gt;</td></tr>
<tr><td>GEQ</td><td>: &gt;=</td></tr>
<tr><td>AND</td><td>: &amp;&amp;</td></tr>
<tr><td>OR</td><td>: \|\|</td></tr>
<tr><td>NOT</td><td>: !</td></tr>
</table>

The regex to ignore any single line comment.

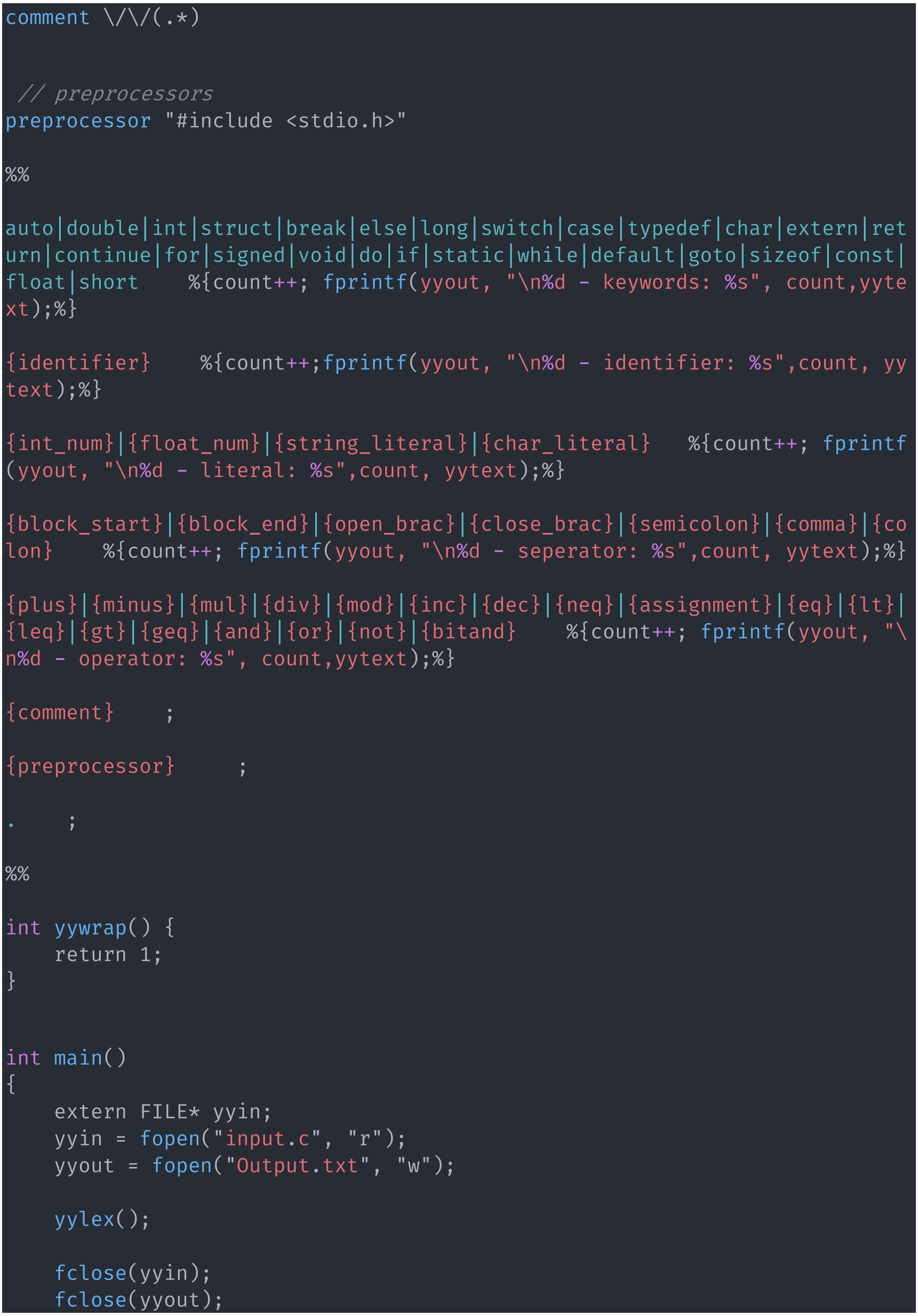
Token	**Regular Expression**
COMMENT	: \/\/(.*)

The following is the implementation of the previously mentioned tokens and regular expressions as a lex program.

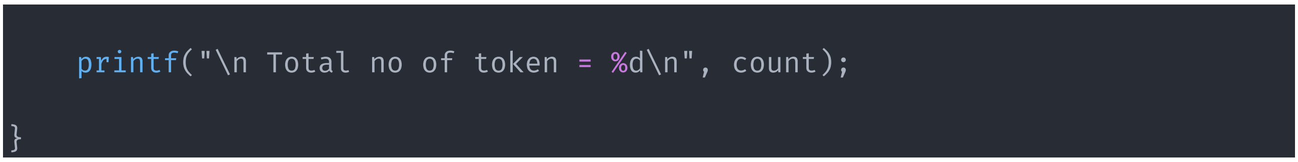
Program:



```
%{
    int count=0;
%}

 // defining regex

 // literals
int_num -?[0-9]+
float_num -?([0-9]+\.[0-9]+)([eE][-+]?[0-9]+)?
string_literal \"[^\"]*\"
char_literal \'[^\']*\'

 // variable
identifier [a-zA-Z_][a-zA-Z0-9_]*

 // special symbols
block_start \{
block_end \}
open_brac \(
close_brac \)
semicolon \;
comma \,
colon \:


 // operators
plus \+
minus \-
mul \*
div \/
mod %
inc \+\+
dec \-\-
neq !=
assignment =
eq ==
lt <
leq <=
gt >
geq >=
and &&
or \|\|
not !
bitand &


 //single line comment
```



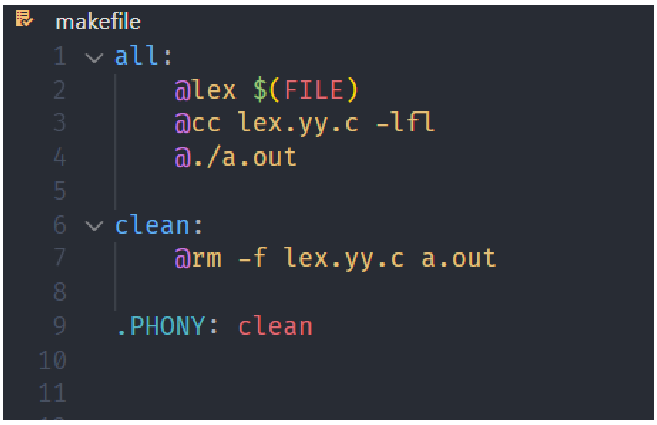
```
comment \/\/(.*)


 // preprocessors
preprocessor "#include <stdio.h>"

%%

auto|double|int|struct|break|else|long|switch|case|typedef|char|extern|return|continue|for|signed|void|do|if|static|while|default|goto|sizeof|const|float|short    %{count++; fprintf(yyout, "\n%d - keywords: %s", count,yytext);%}

{identifier}    %{count++;fprintf(yyout, "\n%d - identifier: %s",count, yytext);%}

{int_num}|{float_num}|{string_literal}|{char_literal}   %{count++; fprintf(yyout, "\n%d - literal: %s",count, yytext);%}

{block_start}|{block_end}|{open_brac}|{close_brac}|{semicolon}|{comma}|{colon}    %{count++; fprintf(yyout, "\n%d - seperator: %s",count, yytext);%}

{plus}|{minus}|{mul}|{div}|{mod}|{inc}|{dec}|{neq}|{assignment}|{eq}|{lt}|{leq}|{gt}|{geq}|{and}|{or}|{not}|{bitand}    %{count++; fprintf(yyout, "\n%d - operator: %s", count,yytext);%}

{comment}    ;

{preprocessor}     ;

.    ;

%%

int yywrap() {
    return 1;
}


int main()
{
    extern FILE* yyin;
    yyin = fopen("input.c", "r");
    yyout = fopen("Output.txt", "w");

    yylex();

    fclose(yyin);
    fclose(yyout);
```



```
    printf("\n Total no of token = %d\n", count);
}
```

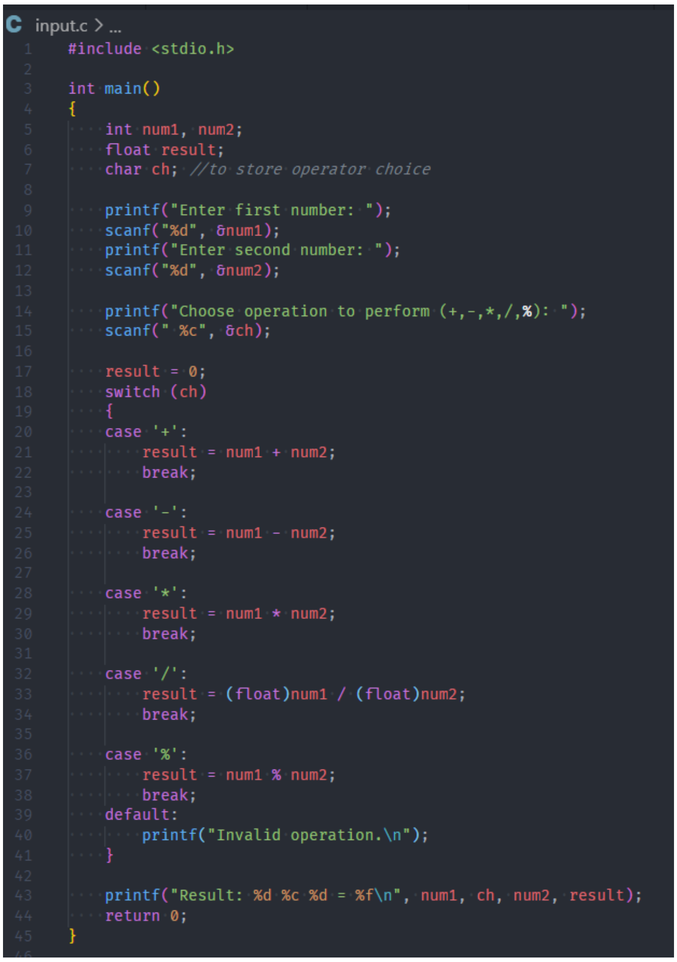
Figure 12 Lex program source Code

2.2 Results and Comments



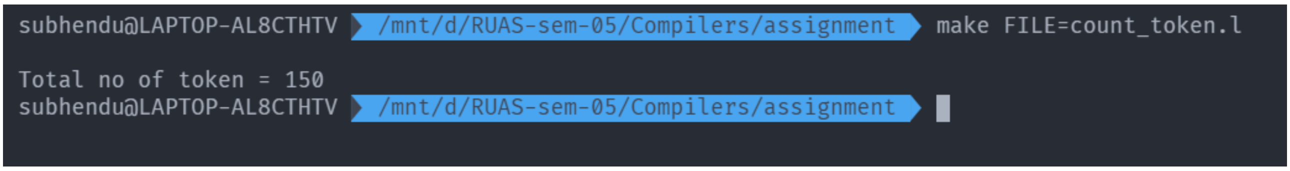
```
all:
	@lex $(FILE)
	@cc lex.yy.c -lfl
	@./a.out

clean:
	@rm -f lex.yy.c a.out

.PHONY: clean
```

Figure 13 makefile



```c
#include <stdio.h>

int main()
{
    int num1, num2;
    float result;
    char ch; //to store operator choice

    printf("Enter first number: ");
    scanf("%d", &num1);
    printf("Enter second number: ");
    scanf("%d", &num2);

    printf("Choose operation to perform (+,-,*,/,%): ");
    scanf(" %c", &ch);

    result = 0;
    switch (ch)
    {
    case '+':
        result = num1 + num2;
        break;

    case '-':
        result = num1 - num2;
        break;

    case '*':
        result = num1 * num2;
        break;

    case '/':
        result = (float)num1 / (float)num2;
        break;

    case '%':
        result = num1 % num2;
        break;
    default:
        printf("Invalid operation.\n");
    }

    printf("Result: %d %c %d = %f\n", num1, ch, num2, result);
    return 0;
}
```

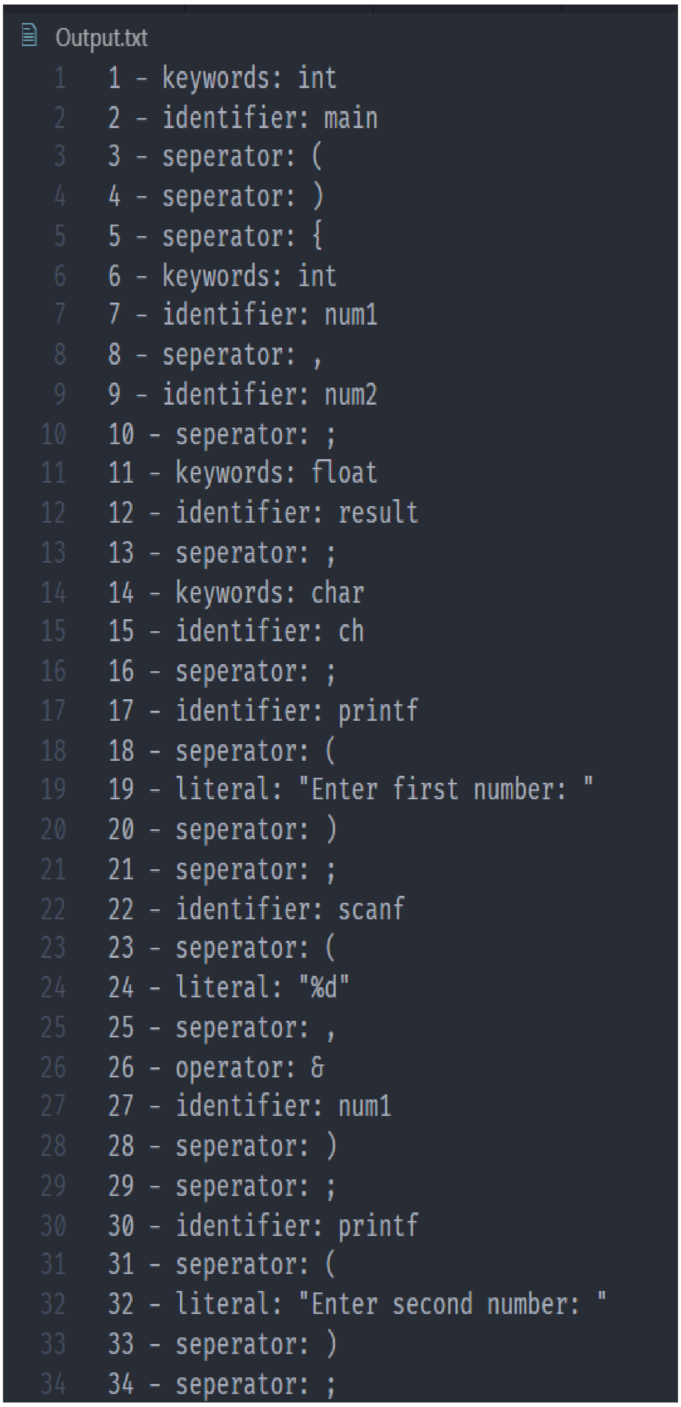
Figure 14 given input file in question



```
subhendu@LAPTOP-AL8CTHTV  /mnt/d/RUAS-sem-05/Compilers/assignment  make FILE=count_token.l

Total no of token = 150
subhendu@LAPTOP-AL8CTHTV  /mnt/d/RUAS-sem-05/Compilers/assignment  
```

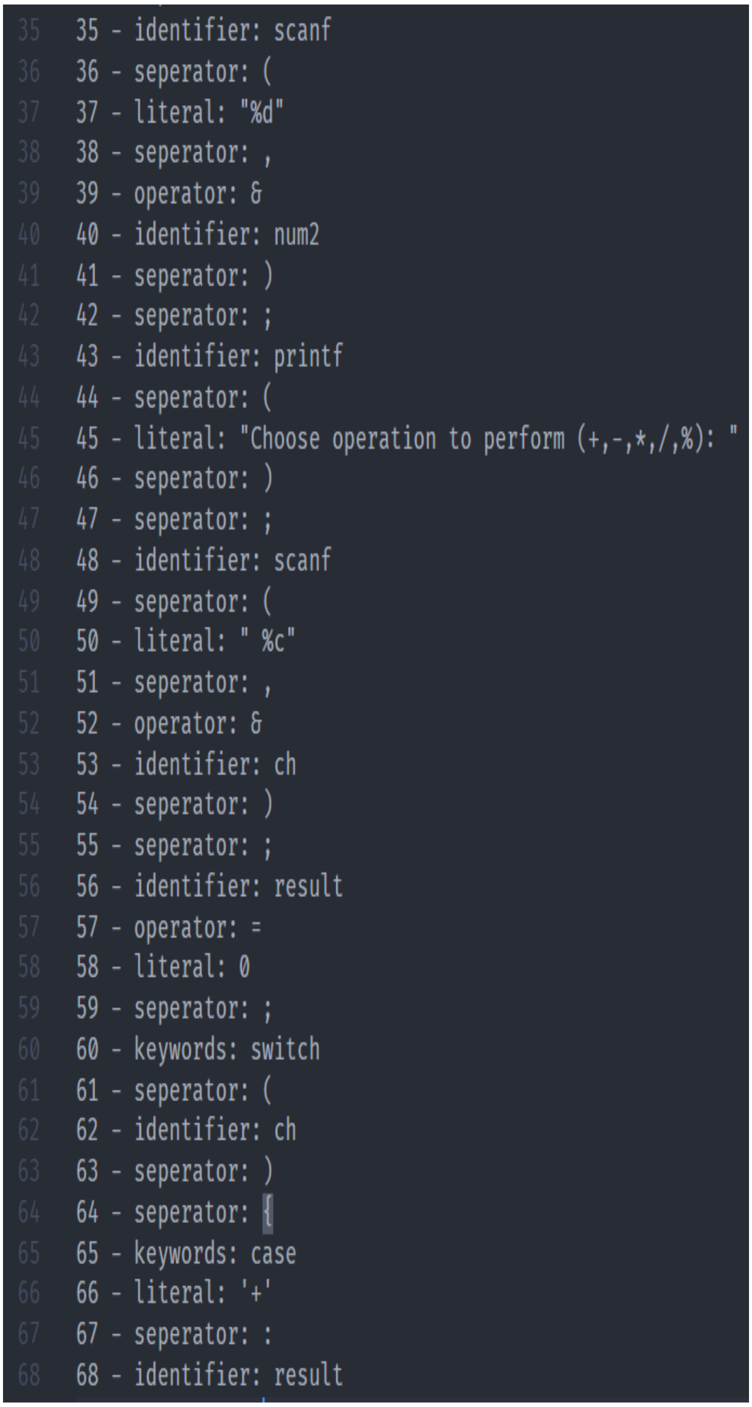
Figure 15 execution of count_token.l

Output file in which generated token is stored:

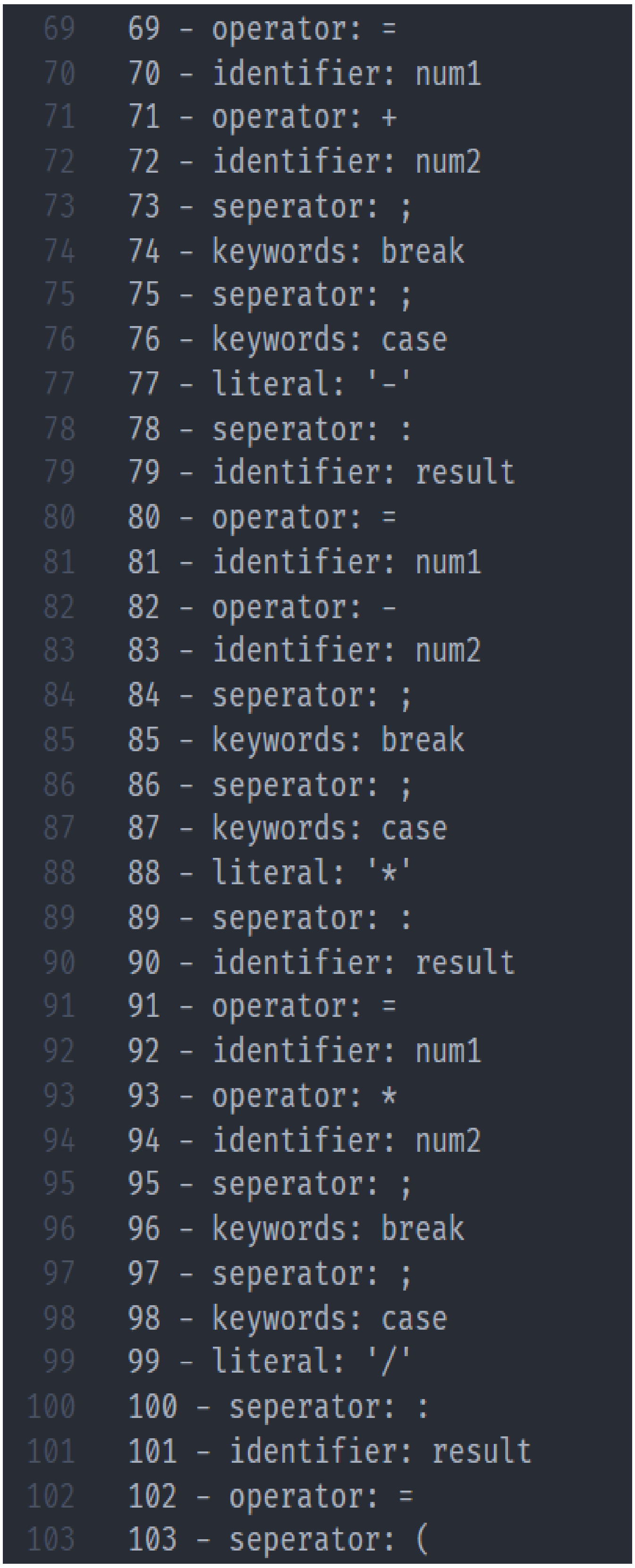


Output.txt

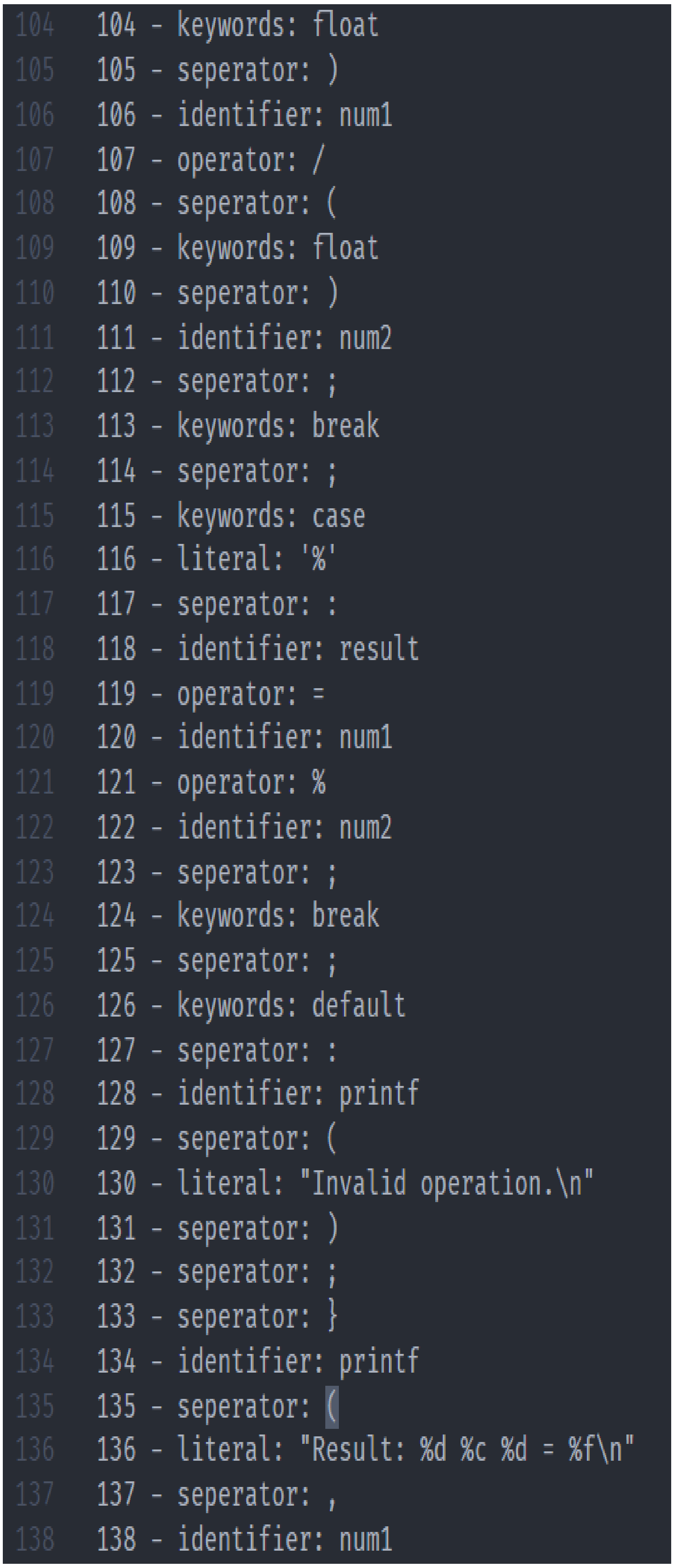
```
1 - keywords: int
2 - identifier: main
3 - seperator: (
4 - seperator: )
5 - seperator: {
6 - keywords: int
7 - identifier: num1
8 - seperator: ,
9 - identifier: num2
10 - seperator: ;
11 - keywords: float
12 - identifier: result
13 - seperator: ;
14 - keywords: char
15 - identifier: ch
16 - seperator: ;
17 - identifier: printf
18 - seperator: (
19 - literal: "Enter first number: "
20 - seperator: )
21 - seperator: ;
22 - identifier: scanf
23 - seperator: (
24 - literal: "%d"
25 - seperator: ,
26 - operator: &
27 - identifier: num1
28 - seperator: )
29 - seperator: ;
30 - identifier: printf
31 - seperator: (
32 - literal: "Enter second number: "
33 - seperator: )
34 - seperator: ;
```



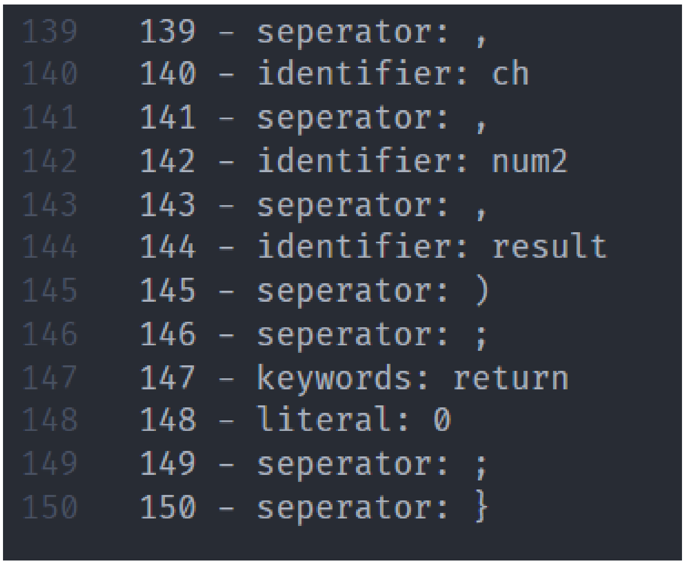
```
35 - identifier: scanf
36 - seperator: (
37 - literal: "%d"
38 - seperator: ,
39 - operator: &
40 - identifier: num2
41 - seperator: )
42 - seperator: ;
43 - identifier: printf
44 - seperator: (
45 - literal: "Choose operation to perform (+,-,*,/,%): "
46 - seperator: )
47 - seperator: ;
48 - identifier: scanf
49 - seperator: (
50 - literal: " %c"
51 - seperator: ,
52 - operator: &
53 - identifier: ch
54 - seperator: )
55 - seperator: ;
56 - identifier: result
57 - operator: =
58 - literal: 0
59 - seperator: ;
60 - keywords: switch
61 - seperator: (
62 - identifier: ch
63 - seperator: )
64 - seperator: {
65 - keywords: case
66 - literal: '+'
67 - seperator: :
68 - identifier: result
```



```
69 - operator: =
70 - identifier: num1
71 - operator: +
72 - identifier: num2
73 - seperator: ;
74 - keywords: break
75 - seperator: ;
76 - keywords: case
77 - literal: '-'
78 - seperator: :
79 - identifier: result
80 - operator: =
81 - identifier: num1
82 - operator: -
83 - identifier: num2
84 - seperator: ;
85 - keywords: break
86 - seperator: ;
87 - keywords: case
88 - literal: '*'
89 - seperator: :
90 - identifier: result
91 - operator: =
92 - identifier: num1
93 - operator: *
94 - identifier: num2
95 - seperator: ;
96 - keywords: break
97 - seperator: ;
98 - keywords: case
99 - literal: '/'
100 - seperator: :
101 - identifier: result
102 - operator: =
103 - seperator: (
```



```
104 - keywords: float
105 - seperator: )
106 - identifier: num1
107 - operator: /
108 - seperator: (
109 - keywords: float
110 - seperator: )
111 - identifier: num2
112 - seperator: ;
113 - keywords: break
114 - seperator: ;
115 - keywords: case
116 - literal: '%'
117 - seperator: :
118 - identifier: result
119 - operator: =
120 - identifier: num1
121 - operator: %
122 - identifier: num2
123 - seperator: ;
124 - keywords: break
125 - seperator: ;
126 - keywords: default
127 - seperator: :
128 - identifier: printf
129 - seperator: (
130 - literal: "Invalid operation.\n"
131 - seperator: )
132 - seperator: ;
133 - seperator: }
134 - identifier: printf
135 - seperator: (
136 - literal: "Result: %d %c %d = %f\n"
137 - seperator: ,
138 - identifier: num1
```



```
139 - seperator: ,
140 - identifier: ch
141 - seperator: ,
142 - identifier: num2
143 - seperator: ,
144 - identifier: result
145 - seperator: )
146 - seperator: ;
147 - keywords: return
148 - literal: 0
149 - seperator: ;
150 - seperator: }
```

Figure 16 Output file in which token generated

Therefore, to verify the above output I calculated the token manually:

Serial Number	Token
1	int
2	main
3	(
4	)
5	{
6	int
7	num1
8	,
9	num2
10	;
11	float
12	result
13	;
14	char
15	ch
16	;
17	printf
18	(
19	"Enter first number:"
20	)
21	;
22	scanf
23	(
24	"%d"
25	,
26	&
27	num1
28	)
29	;
30	printf
31	(
32	"Enter second number:"
33	)
34	;
35	scanf
36	(
37	"%d"
38	,
39	&
40	num2
41	)
42	;
43	printf
44	(

45	"Choose operation to perform (+,-,*,/,%): "
46	)
47	;
48	scanf
49	(
50	" %c"
51	,
52	&
53	ch
54	)
55	;
56	result
57	=
58	0
59	;
60	switch
61	(
62	ch
63	)
64	{
65	case
66	'+'
67	:
68	result
69	=
70	num1
71	+
72	num2
73	;
74	break
75	;
76	case
77	'-'
78	:
79	result
80	=
81	num1
82	-
83	num2
84	;
85	break
86	;
87	case
88	'*'
89	:

90	result
91	=
92	num1
93	*
94	num2
95	;
96	break
97	;
98	case
99	'/'
100	:
101	result
102	=
103	(
104	float
105	)
106	num1
107	/
108	(
109	float
110	)
111	num2
112	;
113	break
114	;
115	case
116	'%'
117	:
118	result
119	=
120	num1
121	%
122	num2
123	;
124	break
125	;
126	default
127	:
128	printf
129	(
130	"Invalid operation.\n"
131	)
132	;
133	}
134	printf

135	(
136	"Result: %d %c %d = %f\n"
137	,
138	num1
139	,
140	ch
141	,
142	num2
143	,
144	result
145	)
146	;
147	return
148	0
149	;
150	}

Hence there are 150 tokens in the given C file. It concludes the lex program is working correctly.

Bibliography

1. https://www.geeksforgeeks.org/lex-program-to-take-input-from-file-and-remove-multiple-spaces-lines-and-tabs/
2. https://www.geeksforgeeks.org/lex-program-to-count-the-number-of-lines-spaces-and-tabs/?ref=rp