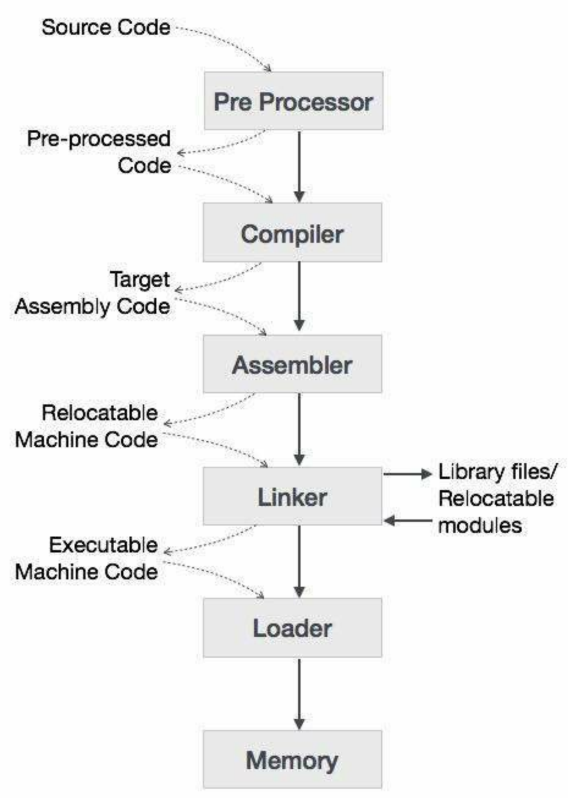
Lexical Scanner

Team Members : Arvind Sai K (15CO207) and Derik Clive (15CO213)

Pipeline for execution of a program

The following image shows the typical flow for an execution of a program starting from the raw source code stage.



What is a compiler?

A compiler is computer software that transforms computer code written in one programming language (the source language) into another programming language (the target language). Compilers are a type of translator that support digital devices, primarily computers. The name compiler is primarily used for programs that translate source code from a high-level programming language to a lower level language (e.g., assembly language, object code, or machine code) to create an executable program.

Introduction to compilers

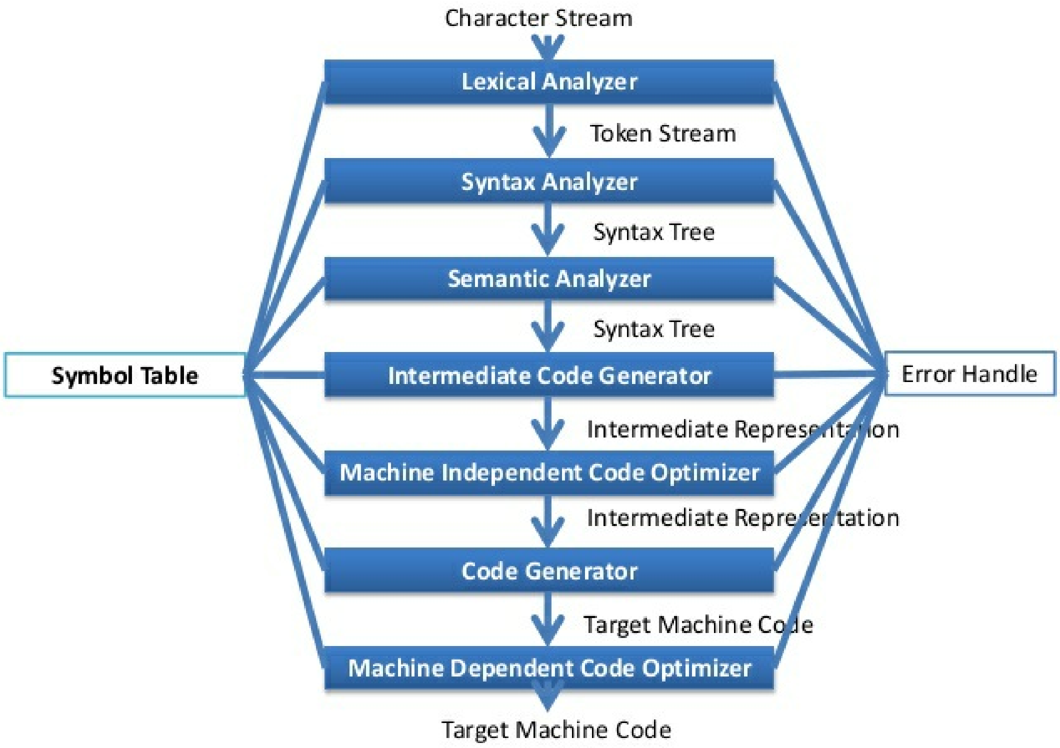
Up to this point we have treated a compiler as a single box that maps a source program into a semantically equivalent target program. If we open up this box a little, we see that there are two parts to this mapping: analysis and synthesis.

The analysis part breaks up the source program into constituent pieces and imposes a grammatical structure on them. It then uses this structure to cre- ate an intermediate representation of the source program. If the analysis part detects that the source program is either syntactically ill formed or semanti- cally unsound, then it must provide informative messages, so the user can take corrective action. The analysis part also collects information about the source program and stores it in a data structure called a symbol table, which is passed along with the intermediate representation to the synthesis part.

The synthesis part constructs the desired target program from the interme- diate representation and the information in the symbol table. The analysis part is often called the front end of the compiler; the synthesis part is the back end.

If we examine the compilation process in more detail, we see that it operates as a sequence of phases, each of which transforms one representation of the source program to another. A typical decomposition of a compiler into phases is shown in figure below. In practice, several phases may be grouped together, and the intermediate representations between the grouped phases need not be constructed explicitly. The symbol table, which stores information about the entire source program, is used by all phases of the compiler.

Some compilers have a machine-independent optimization phase between the front end and the back end. The purpose of this optimization phase is to perform transformations on the intermediate representation, so that the back end can produce a better target program than it would have otherwise pro- duced from an unoptimized intermediate representation. Since optimization is optional, one or the other of the two optimization phases shown in figure below may be missing.



Analysis phase in compilers

Lexical Analysis

The first phase of scanner works as a text scanner. This phase scans the source code as a stream of characters and converts it into meaningful lexemes. Lexical analyzer represents these lexemes in the form of tokens as below.

<token-name, attribute-value>

Syntax Analysis

The next phase is called the syntax analysis or parsing. It takes the token produced by lexical analysis as input and generates a parse tree (or syntax tree). In this phase, token arrangements are checked against the source code grammar, i.e. the parser checks if the expression made by the tokens is syntactically correct.

Semantic Analysis

Semantic analysis checks whether the parse tree constructed follows the rules of language. For example, assignment of values is between compatible data types, and adding string to an integer. Also, the semantic analyzer keeps track of identifiers, their types and expressions; whether identifiers are declared before use or not etc. The semantic analyzer produces an annotated syntax tree as an output.

Intermediate Code Generation

After semantic analysis the compiler generates an intermediate code of the source code for the target machine. It represents a program for some abstract machine. It is in between the high-level language and the machine language. This intermediate code should be generated in such a way that it makes it easier to be translated into the target machine code.

Synthesis phase in compilers

Code Optimization

The next phase does code optimization of the intermediate code. Optimization can be assumed as something that removes unnecessary code lines, and arranges the sequence of statements in order to speed up the program execution without wasting resources (CPU, memory).

Code Generation

In this phase, the code generator takes the optimized representation of the intermediate code and maps it to the target machine language. The code generator translates the intermediate code into a sequence of (generally) re-locatable machine code. Sequence of instructions of machine code performs the task as the intermediate code would do.

Symbol Table (Common to all the above phases)

It is a data-structure maintained throughout all the phases of a compiler. All the identifier's names along with their types are stored here. The symbol table makes it easier for the compiler to quickly search the identifier record and retrieve it. The symbol table is also used for scope management.

Details of the lexical analysis phase

As the first phase of a compiler, the main task of the lexical analyzer is to read the input characters of the source program, group them into lexemes, and produce as output a sequence of tokens for each lexeme in the source program. The stream of tokens is sent to the parser for syntax analysis. It is common for the lexical analyzer to interact with the symbol table as well. When the lexical analyzer discovers a lexeme constituting an identifier, it needs to enter that lexeme into the symbol table. In some cases, information regarding the kind of identifier may be read from the symbol table by the lexical analyzer to assist it in determining the proper token it must pass to the parser.

Since the lexical analyzer is the part of the compiler that reads the source text, it may perform certain other tasks besides identification of lexemes. One such task is stripping out comments and whitespace (blank, newline, tab, and perhaps other characters that are used to separate tokens in the input). Another task is correlating error messages generated by the compiler with the source program. For instance, the lexical analyzer may keep track of the number of newline characters seen, so it can associate a line number with each error message. In some compilers, the lexical analyzer makes a copy of the source program with the error messages inserted at the appropriate positions. If the source program uses a macro-preprocessor, the expansion of macros may also be performed by the lexical analyzer.

Lexical analyzers are divided into a cascade of two processes:

1. Scanning consists of the simple processes that do not require tokenization of the input, such as deletion of comments and compaction of consecutive whitespace characters into one.
2. Lexical analysis proper is the more complex portion, where the scanner produces the sequence of tokens as output.

When discussing lexical analysis, we use three related but distinct terms:

1. A token is a pair consisting of a token name and an optional attribute value. The token name is an abstract symbol representing a kind of lexical unit, e.g., a particular keyword, or a sequence of input characters denoting an identifier. The token names are the input symbols that the parser processes. In what follows, we shall generally write the name of a token in boldface. We will often refer to a token by its token name.
2. A pattern is a description of the form that the lexemes of a token may take. In the case of a keyword as a token, the pattern is just the sequence of characters that form the keyword. For identifiers and some other tokens, the pattern is a more complex structure that is matched by many strings.
3. A lexeme is a sequence of characters in the source program that matches the pattern for a token and is identified by the lexical analyzer as an instance of that token.

Lex code for lexical analyser

```
%x comment
%x string_literal
%{
    #include<stdio.h>

    #define KNRM  "\x1B[0m"
    #define KRED  "\x1B[31m"
    #define KGRN  "\x1B[32m"
    #define KYEL  "\x1B[33m"
    #define KBLU  "\x1B[34m"
    #define KMAG  "\x1B[35m"
    #define KCYN  "\x1B[36m"
    #define KWHT  "\x1B[37m"

   #define n_buckets 1000
   int pstack[100];
   int ptop=-1;
   int cstack[100];
   int ctop=-1;
   int line_num = 1;
   int nested_comment_stack=0;
   char token[100];

   struct table_entry
   {
      void *key, *value;
      struct table_entry *next;
      unsigned int line;
   };

   struct table_entry *s_head[n_buckets];
   struct table_entry *c_head[n_buckets];

   void install_symbol();
   void install_constant();

%}

identifier [a-zA-Z_]([a-zA-Z0-9])*
digit [0-9]
BID             ([0-9]|!|@|#|$|%)+([a-zA-Z0-9])+
escape_sequence [a|n|b|t|f|r|v|\|"|'|?]
white_space [ \t]
backslash [\]
double_quotes ["]

%%

\n {yylineno++;}
{white_space}*

#include[ ]*<[^>]+> {printf("%s\n%40s%40s%40d", KBLU,
yytext,"Preprocessor-directive", yylineno);}
printf {printf("%s\n%40s%40s%40d", KBLU,"printf",
"Pre-defined function", yylineno);strcpy(token,
"function");install_symbol();}
scanf {printf("%s\n%40s%40s%40d", KBLU,"scanf", "Pre-
defined function", yylineno);strcpy(token,
"function");install_symbol();}
"/*"                    {BEGIN(comment);
nested_comment_stack=1; yymore();}
<comment><<EOF>>        {printf("\nMulti-line
Comment: \""); yyless(yyleng-2); ECHO; printf("\",
not terminted."); yyterminate();}
<comment>"/*"           {nested_comment_stack++;
yymore();}
<comment>.              {yymore();}
<comment>\n             {yymore();yylineno++;}
<comment>"*/"           {nested_comment_stack--;
                        if(nested_comment_stack<0)
                        {
                          printf("\nComment: \"%s\",
not balanced at line no: %d.", yytext, yylineno);
                          yyterminate();
                        }
                        else
if(nested_comment_stack==0)
                        {
                          /*printf("\nMulti-line
comment : \"%s\" at line number: %d.", yytext,
yylineno);*/
                          BEGIN(INITIAL);
                        }
                        else
                          yymore();
                        }

"*/"                    {printf("\n Uninitialised
comment at line number: %d.", yylineno);
yyterminate();}

"//".*                  {printf("\nSingle-line
comment : \"%s\" at line number: %d.", yytext,
yylineno);}



<INITIAL>{double_quotes}
{ BEGIN(string_literal); yymore();}
<string_literal>"\\"+{escape_sequence}
{printf("%s\n%40s%c%39s%40d", KBLU,  "\\",
yytext[yyleng-1],"Escape Sequence", yylineno);

yymore();}
<string_literal>"\\"+[^a|n|b|t|f|r|v|\|"|'|?]
{printf("\nUnrecognized escape seqence at line
number: %d.", yylineno);}
<string_literal>{double_quotes}
{printf("%s\n%40s%40s%40d",KBLU, yytext, "String
Constant",yylineno);

strcpy(token, "String Constant");
install_constant(); BEGIN(INITIAL);}

<string_literal>\n
{printf("\nError : Unterminated string: %s at line
number: %d.", yytext, yylineno);yylineno++;
BEGIN(INITIAL);}
<string_literal>[^\\]
```

```
{yymore();}

{digit}+        {printf("%s\n%40s%40s%40d", KBLU,
yytext, "Integer Constant", yylineno); strcpy(token,
"INT Constant");  install_constant();}
{digit}*\.?{digit}*(E[+|-]?{digit}+*\.?{digit}*)?
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Floating
Point Constant",yylineno); strcpy(token, "FP
Constant");  install_constant();}
{digit}*\.?{digit}*E.?  {printf("%s\nError No
exponent provided: %s , line number: %d.", KBLU,
yytext,yylineno);}
\'.\'   {printf("%s\n%40s%40s%40d", KBLU, yytext,
"Character Constant",yylineno); strcpy(token, "Char
Constant");  install_constant();}

^{white_space}*(unsigned|signed)?
(void|int|char|short|long|float|double){white_space}+
{identifier}{white_space}*\([^)]*\){white_space}*  {

if(strstr(yytext, "main")!=NULL)

{

printf("%s\n%40s%40s%40d", KBLU, "main", "Main
Function", yylineno);

strcpy(token, "Main function");



}

else

{

printf("%s\n%40s%40s%40d", KBLU,  yytext, "User-
defined function", yylineno);
strcpy(token, "User Defined function");


}

install_symbol();

}


"auto"
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Keyword",
yylineno); strcpy(token,"Keyword");
install_symbol();}
"break"
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Keyword",
yylineno);  strcpy(token,"Keyword");
install_symbol();}
"case"
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Keyword",
yylineno);  strcpy(token,"Keyword");
install_symbol();}
"char"
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Keyword",
yylineno);  strcpy(token,"Keyword");
install_symbol();}
"const"
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Keyword",
yylineno);  strcpy(token,"Keyword");
install_symbol();}
"continue"
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Keyword",
yylineno);  strcpy(token,"Keyword");
install_symbol();}
"default"
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Keyword",
yylineno);  strcpy(token,"Keyword");
install_symbol();}
"do"
```

```
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Keyword",
yylineno);  strcpy(token,"Keyword");
install_symbol();}
"double"
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Keyword",
yylineno);  strcpy(token,"Keyword");
install_symbol();}
"else"
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Keyword",
yylineno);  strcpy(token,"Keyword");
install_symbol();}
"enum"
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Keyword",
yylineno);  strcpy(token,"Keyword");
install_symbol();}
"extern"
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Keyword",
yylineno);  strcpy(token,"Keyword");
install_symbol();}
"float"
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Keyword",
yylineno);  strcpy(token,"Keyword");
install_symbol();}
"for"
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Keyword",
yylineno);  strcpy(token,"Keyword");
install_symbol();}
"goto"
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Keyword",
yylineno);  strcpy(token,"Keyword");
install_symbol();}
"if"
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Keyword",
yylineno);  strcpy(token,"Keyword");
install_symbol();}
"int"
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Keyword",
yylineno);  strcpy(token,"Keyword");
install_symbol();}
```

```
"long"
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Keyword",
yylineno);  strcpy(token,"Keyword");
install_symbol();}
"register"
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Keyword",
yylineno);  strcpy(token,"Keyword");
install_symbol();}
"return"
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Keyword",
yylineno);  strcpy(token,"Keyword");
install_symbol();}
"short"
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Keyword",
yylineno);  strcpy(token,"Keyword");
install_symbol();}
"signed"
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Keyword",
yylineno);  strcpy(token,"Keyword");
install_symbol();}
"sizeof"
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Keyword",
yylineno);  strcpy(token,"Keyword");
install_symbol();}
"static"
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Keyword",
yylineno);  strcpy(token,"Keyword");
install_symbol();}
"struct"
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Keyword",
yylineno);  strcpy(token,"Keyword");
install_symbol();}
"switch"
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Keyword",
yylineno);  strcpy(token,"Keyword");
install_symbol();}
"typedef"
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Keyword",
yylineno);  strcpy(token,"Keyword");
install_symbol();}
"union"
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Keyword",
yylineno);  strcpy(token,"Keyword");
install_symbol();}
"unsigned"
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Keyword",
yylineno);  strcpy(token,"Keyword");
install_symbol();}
"void"
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Keyword",
yylineno);  strcpy(token,"Keyword");
install_symbol();}
"volatile"
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Keyword",
yylineno);  strcpy(token,"Keyword");
install_symbol();}
"while"
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Keyword",
yylineno);  strcpy(token,"Keyword");
install_symbol();}




{identifier}
{printf("%s\n%40s%40s%40d", KBLU,  yytext,
"Identifier", yylineno); strcpy(token,"Identifier");
install_symbol();}



{BID}                   {printf("%s\n%40s%40s%40d",
KRED, yytext, "Invalid Identifier", yylineno); }



^{white_space}*(unsigned|signed)?
(void|int|char|short|long|float|double)
{white_space}+\*+[ ]*{identifier}
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Pointer
Declration", yylineno);}
```

```
{identifier}+\[{digit}*\]
{printf("%s\n%40s%40s%40d", KBLU, yytext, "Array
Declaration", yylineno);}

[\(]        {if(ptop==-1)
              {
                ptop=0;
                pstack[ptop] = yylineno;
              }
              else
              {
                ptop++;
                pstack[ptop] = yylineno;
              }
              printf("%s\n%40s%40s%40d", KBLU,
yytext, "Operator",yylineno);
            }

[\)]      {
            if(ptop==0)
             {
               ptop=-1;
             }
             else
             {
                ptop--;
             }
              printf("%s\n%40s%40s%40d", KBLU,
yytext, "Operator",yylineno);
          }

[\{]        {if(ctop==-1)
              {
                ctop=0;
                cstack[ctop] = yylineno;
              }
              else
              {
                ctop++;
                cstack[ctop] = yylineno;
              }
              printf("%s\n%40s%40s%40d", KBLU,
yytext, "Operator",yylineno);
            }

[\}]      {
            if(ctop==0)
             {
               ctop=-1;
             }
             else
             {
                ctop--;
             }
              printf("%s\n%40s%40s%40d", KBLU,
yytext, "Operator",yylineno);
          }

(\+|-|\*|\/|\&|\[|\]|\>|\<|!=|\+\+|--|\%|>=|
<=|==|&&|\|\||!|\+=|-=|\/=|\*=|\%=|\&=|\|=|\^=|\.|\-
\>|=|\{|\}|\))  {printf("%s\n%40s%40s%40d", KBLU,
yytext, "Operator",yylineno); }
[,]
{printf("%s\n%40s%40s%40d", KBLU, yytext,
"Separator", yylineno);}
[;]
{printf("%s\n%40s%40s%40d", KBLU, yytext,
"Delimiter",yylineno);}
\'.
{printf("%s\nUnterminated CHARACTER LITERAL: %s,
\tline no:%d\n",KRED, yytext, yylineno);}
.
{printf("%s\n%40s%40s%40d", KRED, yytext, "Invalid
Character", yylineno);}
%%

unsigned int get_hash(char *str)
{
    unsigned int hash = 5381;
    int c;

    while ((c = *str++))
        hash = ((hash << 5) + hash) + c; /* hash * 33
+ c */

    return hash%1000;
}

struct table_entry *create_node()
{
  struct table_entry *temp = (struct table_entry
*)malloc(sizeof(struct table_entry));
  if(temp==NULL)
  {
    printf("\nCould not allocate memory for the
symbol table.");
    exit(1);
  }
  temp->next = NULL;
  return temp;
}

void insert(struct table_entry *head[], unsigned int
index, void *key, void *value, unsigned int line)
{
  struct table_entry *temp = create_node();
  temp->key = key;
  temp->value = value;
  temp->line = line;
  temp->next = head[index];

  head[index] = temp;
}

struct table_entry *search(struct table_entry *head,
void *key)
{
  struct table_entry *temp = head;
  while(temp!=NULL)
  {
    if(strcmp((char *)temp->key, (char *)key)==0)
      return temp;
    temp = temp->next;
  }
  return temp;
}



void install_symbol()
{
  char *key = (char *)malloc(sizeof(char)*yyleng);
  char *value = (char *)malloc(sizeof(char)*yyleng);

  strcpy(key, yytext);
  strcpy(value, token);
  unsigned int index = get_hash(key);


  struct table_entry *temp = search(s_head[index],
key);
  if(temp==NULL)
    insert(s_head, index, key, value, yylineno);
}

void install_constant()
{
  char *key = (char *)malloc(sizeof(char)*yyleng);
  char *value = (char *)malloc(sizeof(char)*yyleng);

  strcpy(key, yytext);
  strcpy(value, token);
  unsigned int index = get_hash(key);

  struct table_entry *temp = search(c_head[index],
key);
```

```
  if(temp==NULL);
    insert(c_head, index, key, value, yylineno);
}


void print_symbol_table()
{
  int i;
  char a[100]="<";

printf("%s\n=========================================
=====================================================
=====================================================
===========", KRED);
  printf("%s\n\t\t\t\t\t\t\t\t\tSYMBOL TABLE", KBLU);

printf("%s\n=========================================
=====================================================
=====================================================
===========", KRED);
  printf("%s\n%40s%40s%40s", KCYN, "TOKEN", "TOKEN
TYPE", "LINE NUMBER");
  for(int i=0;i<n_buckets;i++)
  {
      if(s_head[i]!=NULL)
      {
        struct table_entry *temp = s_head[i];
        while(temp!=NULL)
        {
          printf("%s\n%40s%40s>%40d", KWHT, (char
*)temp->key, strcat(a, (char *)temp->value), temp-
>line);
          strcpy(a, "<");
          temp = temp->next;
        }
      }
  }
  printf("\n");
}
```

```
void print_constant_table()
{int i;
  char a[100]="<";

printf("%s\n=========================================
=====================================================
=====================================================
===========", KRED);
  printf("%s\n\t\t\t\t\t\t\t\t\tCONSTANT TABLE",
KBLU);

printf("%s\n=========================================
=====================================================
=====================================================
===========", KRED);
  printf("%s\n%40s%40s%40s", KCYN, "TOKEN", "TOKEN
TYPE", "LINE NUMBER");
  for(int i=0;i<n_buckets;i++)
  {
      if(c_head[i]!=NULL)
      {
        struct table_entry *temp = c_head[i];
        while(temp!=NULL)
        {
          printf("%s\n%40s%40s>%40d", KWHT, (char
*)temp->key, strcat(a, (char *)temp->value), temp-
>line);
          strcpy(a, "<");
          temp = temp->next;
        }
      }
  }
  printf("\n");
}


int main()
{
  FILE *fp;
  fp = fopen("sample.c", "r");
  yyin = fp;

printf("\n===========================================
=====================================================
=====================================================
======");
  printf("\n%40s%40s%40s", "TOKEN", "TOKEN TYPE",
"LINE NUMBER");

printf("\n===========================================
=====================================================
=====================================================
======");
  int newtoken = 1;
  while(newtoken){
        newtoken = yylex();
  }
  if(ptop!=-1)
  {
    printf("\n\n\t\t\'(\' has not been matched at
line number %d.", pstack[ptop]);
  }
  if(ctop!=-1)
  {
    printf("\n\n\t\t\'{\' has not been matched at
line number %d.", cstack[ctop]);
  }
  print_symbol_table();
  print_constant_table();
  return 0;
}
int yywrap()
{
  return 1;
}
```

Test cases

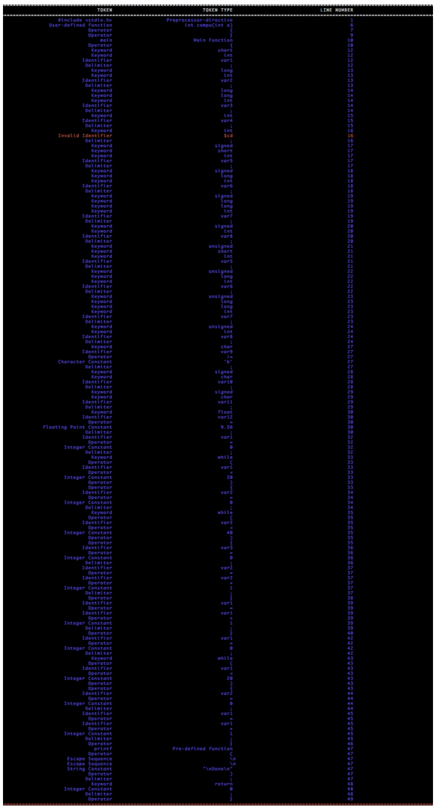
Test case 1

1) Test for identifying int and char data types and their corresponding sub-types like short , long , signed, unsigned.

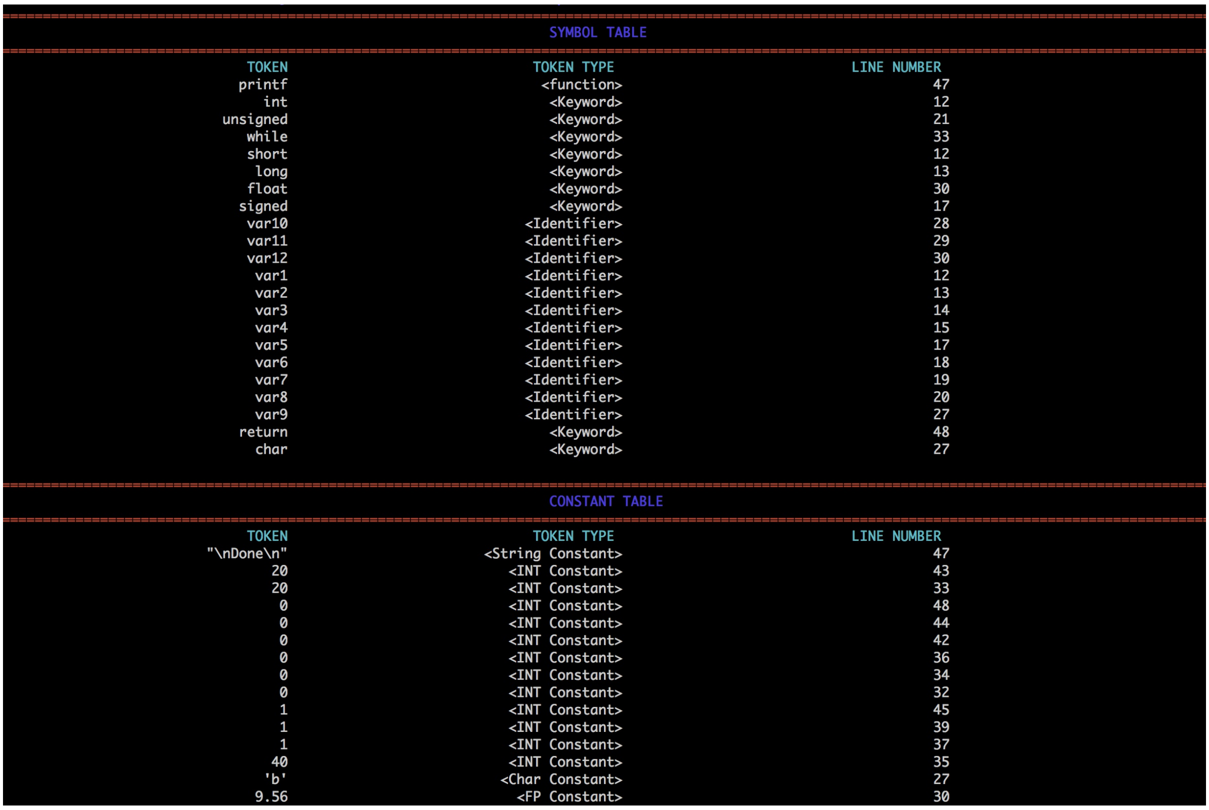
2) Test for identifying while and nested while constructs

```
#include <stdio.h>

/* 1 ) Test for identifying int and char data types
and their corresponding sub-types
like short , long , signed, unsigned.
2 ) Test for identifying while and nested while
constructs  */
int compu(int a)
{

}
int main(){
    /* test for various integer types supported */
    short int var1;
    long int var2;
    long long int var3;
    int var4;
    int $cd;
    signed short int var5;
    signed long int var6;
    signed long long int var7;
    signed int var8;
    unsigned short int var5;
    unsigned long int var6;
    unsigned long long int var7;
    unsigned int var8;

    /* test for various character types supported */
    char var9 != 'b';
    signed char var10;
    signed char var11;
    float var12 = 9.56;
    /* test for while and nested while */
    var1 = 0;
    while(var1 < 20){
        var2 = 0;
        while(var2 < 40){
            var3 = 0;
            var2 = var2 + 1;
        }
        var1 = var1 + 1;
    }

    var1 = 0;
    while(var1 < 20){
        var2 = 0;
        var1 = var1 + 1;
    }
    printf("\nDone\n");
    return 0;
}
```

Output 1



```
                   TOKEN                TOKEN TYPE     LINE NUMBER
      #include <stdio.h>    Preprocessor-directive               1
   User-defined function          int compu(int a)               6
                Operator                         {               7
                Operator                         }               9
                    main             Main Function              10
                Operator                         {              10
                 Keyword                     short              12
                 Keyword                       int              12
              Identifier                      var1              12
               Delimiter                         ;              12
                 Keyword                      long              13
                 Keyword                       int              13
              Identifier                      var2              13
               Delimiter                         ;              13
                 Keyword                      long              14
                 Keyword                      long              14
                 Keyword                       int              14
              Identifier                      var3              14
               Delimiter                         ;              14
                 Keyword                       int              15
              Identifier                      var4              15
               Delimiter                         ;              15
                 Keyword                       int              16
      Invalid Identifier                       $cd              16
               Delimiter                         ;              16
                 Keyword                    signed              17
                 Keyword                     short              17
                 Keyword                       int              17
              Identifier                      var5              17
               Delimiter                         ;              17
                 Keyword                    signed              18
                 Keyword                      long              18
                 Keyword                       int              18
              Identifier                      var6              18
               Delimiter                         ;              18
                 Keyword                    signed              19
                 Keyword                      long              19
                 Keyword                      long              19
                 Keyword                       int              19
              Identifier                      var7              19
               Delimiter                         ;              19
                 Keyword                    signed              20
                 Keyword                       int              20
              Identifier                      var8              20
               Delimiter                         ;              20
                 Keyword                  unsigned              21
                 Keyword                     short              21
                 Keyword                       int              21
              Identifier                      var5              21
               Delimiter                         ;              21
                 Keyword                  unsigned              22
                 Keyword                      long              22
                 Keyword                       int              22
              Identifier                      var6              22
               Delimiter                         ;              22
                 Keyword                  unsigned              23
                 Keyword                      long              23
                 Keyword                      long              23
                 Keyword                       int              23
              Identifier                      var7              23
               Delimiter                         ;              23
                 Keyword                  unsigned              24
                 Keyword                       int              24
              Identifier                      var8              24
               Delimiter                         ;              24
                 Keyword                      char              27
              Identifier                      var9              27
                Operator                        !=              27
      Character Constant                       'b'              27
               Delimiter                         ;              27
                 Keyword                    signed              28
                 Keyword                      char              28
              Identifier                     var10              28
               Delimiter                         ;              28
                 Keyword                    signed              29
                 Keyword                      char              29
              Identifier                     var11              29
               Delimiter                         ;              29
                 Keyword                     float              30
              Identifier                     var12              30
                Operator                         =              30
 Floating Point Constant                      9.56              30
               Delimiter                         ;              30
              Identifier                      var1              32
                Operator                         =              32
        Integer Constant                         0              32
               Delimiter                         ;              32
                 Keyword                     while              33
                Operator                         (              33
              Identifier                      var1              33
                Operator                         <              33
        Integer Constant                        20              33
                Operator                         )              33
                Operator                         {              33
              Identifier                      var2              34
                Operator                         =              34
        Integer Constant                         0              34
               Delimiter                         ;              34
                 Keyword                     while              35
                Operator                         (              35
              Identifier                      var2              35
                Operator                         <              35
        Integer Constant                        40              35
                Operator                         )              35
                Operator                         {              35
              Identifier                      var3              36
                Operator                         =              36
        Integer Constant                         0              36
               Delimiter                         ;              36
              Identifier                      var2              37
                Operator                         =              37
              Identifier                      var2              37
                Operator                         +              37
        Integer Constant                         1              37
               Delimiter                         ;              37
                Operator                         }              38
              Identifier                      var1              39
                Operator                         =              39
              Identifier                      var1              39
                Operator                         +              39
        Integer Constant                         1              39
               Delimiter                         ;              39
                Operator                         }              40
              Identifier                      var1              42
                Operator                         =              42
        Integer Constant                         0              42
               Delimiter                         ;              42
                 Keyword                     while              43
                Operator                         (              43
              Identifier                      var1              43
                Operator                         <              43
        Integer Constant                        20              43
                Operator                         )              43
                Operator                         {              43
              Identifier                      var2              44
                Operator                         =              44
        Integer Constant                         0              44
               Delimiter                         ;              44
              Identifier                      var1              45
                Operator                         =              45
              Identifier                      var1              45
                Operator                         +              45
        Integer Constant                         1              45
               Delimiter                         ;              45
                Operator                         }              46
                  printf      Pre-defined function              47
                Operator                         (              47
         Escape Sequence                        \n              47
         Escape Sequence                        \n              47
         String Constant                "\nDone\n"              47
                Operator                         )              47
               Delimiter                         ;              47
                 Keyword                    return              48
        Integer Constant                         0              48
               Delimiter                         ;              48
                Operator                         }              49
```



```
                                        SYMBOL TABLE

                   TOKEN                TOKEN TYPE               LINE NUMBER
                  printf                <function>                        47
                     int                 <Keyword>                        12
                unsigned                 <Keyword>                        21
                   while                 <Keyword>                        33
                   short                 <Keyword>                        12
                    long                 <Keyword>                        13
                   float                 <Keyword>                        30
                  signed                 <Keyword>                        17
                   var10              <Identifier>                        28
                   var11              <Identifier>                        29
                   var12              <Identifier>                        30
                    var1              <Identifier>                        12
                    var2              <Identifier>                        13
                    var3              <Identifier>                        14
                    var4              <Identifier>                        15
                    var5              <Identifier>                        17
                    var6              <Identifier>                        18
                    var7              <Identifier>                        19
                    var8              <Identifier>                        20
                    var9              <Identifier>                        27
                  return                 <Keyword>                        48
                    char                 <Keyword>                        27

                                        CONSTANT TABLE

                   TOKEN                TOKEN TYPE               LINE NUMBER
              "\nDone\n"         <String Constant>                        47
                      20            <INT Constant>                        43
                      20            <INT Constant>                        33
                       0            <INT Constant>                        48
                       0            <INT Constant>                        44
                       0            <INT Constant>                        42
                       0            <INT Constant>                        36
                       0            <INT Constant>                        34
                       0            <INT Constant>                        32
                       1            <INT Constant>                        45
                       1            <INT Constant>                        39
                       1            <INT Constant>                        37
                      40            <INT Constant>                        35
                     'b'           <Char Constant>                        27
                    9.56             <FP Constant>                        30
```

Test case 2

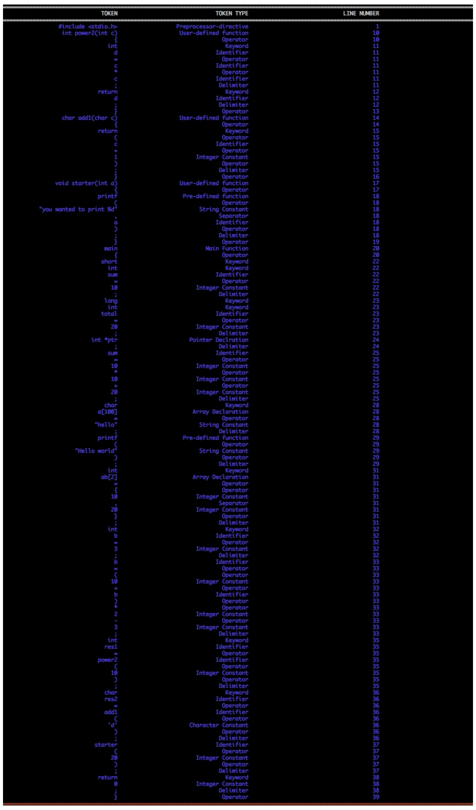
1) Test case for identifying function with single argument

2) Test for identifiers and constants supported

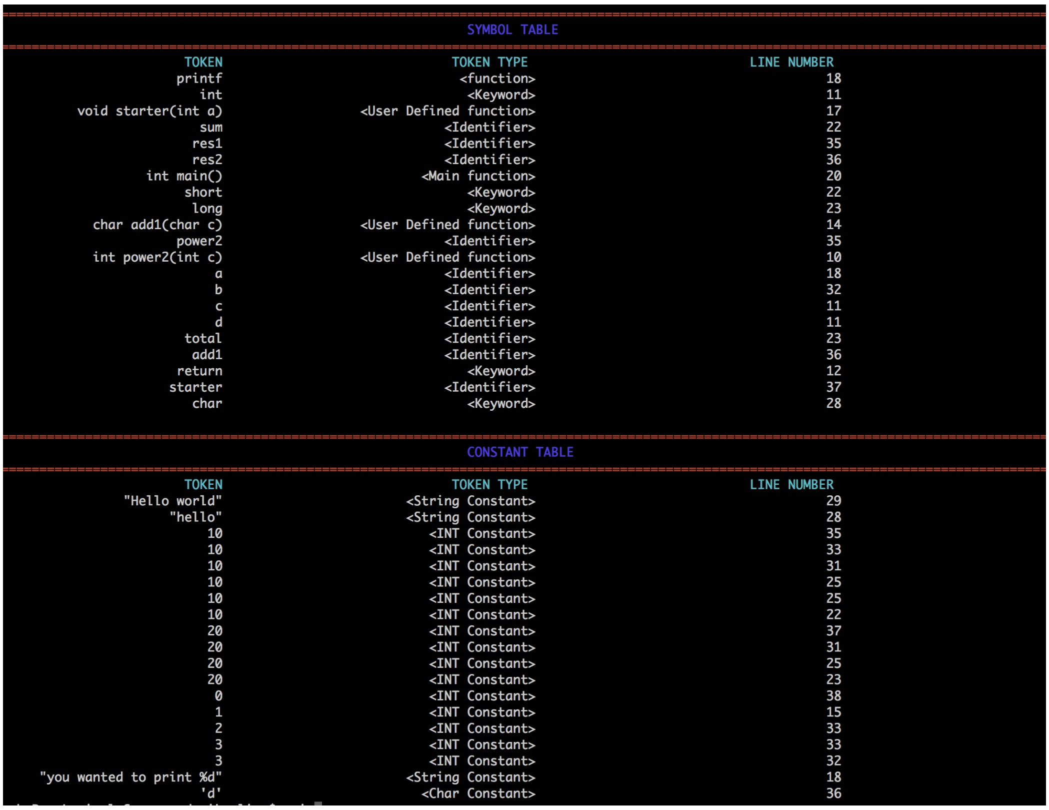
3) Test for strings and special symbols supported

```
#include <stdio.h>

/* 1 ) Test case for identifying function with single
argument
2 ) Test for identifiers and constants supported
3 ) Test for strings and special symbols supported
*/


/* Test case for identifying function with single
argument */
int power2(int c){
    int d = c*c;
    return d;
}
char add1(char c){
    return (c+1);
}
void starter(int a){
    printf("you wanted to print %d",a);
}
int main(){
    /* test for identifiers and constants supported
*/
    short int sum = 10;
    long int total = 20;
    sum = 10*10 + 20;

    /* test for strings and special symbols supported
*/
    char a[100] = "hello";
    printf("Hello world");

    int ab[2] = {10,20};
    int b = 3;
    b = (10 + b)*2 - 3;
    int res1 = power2(10);
    char res2 = add1('d');
    starter(20);
    return 0;
}
```

Output 2



```
                   TOKEN                TOKEN TYPE         LINE NUMBER
      #include <stdio.h>    Preprocessor-directive                   1
       int power2(int c)     User-defined function                  10
                       {                  Operator                  10
                     int                   Keyword                  11
                       d                Identifier                  11
                       =                  Operator                  11
                       c                Identifier                  11
                       *                  Operator                  11
                       c                Identifier                  11
                       ;                 Delimiter                  11
                  return                   Keyword                  12
                       d                Identifier                  12
                       ;                 Delimiter                  12
                       }                  Operator                  13
       char add1(char c)     User-defined function                  14
                       {                  Operator                  14
                  return                   Keyword                  15
                       (                  Operator                  15
                       c                Identifier                  15
                       +                  Operator                  15
                       1          Integer Constant                  15
                       )                  Operator                  15
                       ;                 Delimiter                  15
                       }                  Operator                  16
     void starter(int a)     User-defined function                  17
                       {                  Operator                  17
                  printf      Pre-defined function                  18
                       (                  Operator                  18
"you wanted to print %d"           String Constant                  18
                       ,                 Separator                  18
                       a                Identifier                  18
                       )                  Operator                  18
                       ;                 Delimiter                  18
                       }                  Operator                  19
                    main             Main Function                  20
                       {                  Operator                  20
                   short                   Keyword                  22
                     int                   Keyword                  22
                     sum                Identifier                  22
                       =                  Operator                  22
                      10          Integer Constant                  22
                       ;                 Delimiter                  22
                    long                   Keyword                  23
                     int                   Keyword                  23
                   total                Identifier                  23
                       =                  Operator                  23
                      20          Integer Constant                  23
                       ;                 Delimiter                  23
                int *ptr        Pointer Declration                  24
                       ;                 Delimiter                  24
                     sum                Identifier                  25
                       =                  Operator                  25
                      10          Integer Constant                  25
                       *                  Operator                  25
                      10          Integer Constant                  25
                       +                  Operator                  25
                      20          Integer Constant                  25
                       ;                 Delimiter                  25
                    char                   Keyword                  28
                  a[100]         Array Declaration                  28
                       =                  Operator                  28
                 "hello"           String Constant                  28
                       ;                 Delimiter                  28
                  printf      Pre-defined function                  29
                       (                  Operator                  29
           "Hello world"           String Constant                  29
                       )                  Operator                  29
                       ;                 Delimiter                  29
                     int                   Keyword                  31
                   ab[2]         Array Declaration                  31
                       =                  Operator                  31
                       {                  Operator                  31
                      10          Integer Constant                  31
                       ,                 Separator                  31
                      20          Integer Constant                  31
                       }                  Operator                  31
                       ;                 Delimiter                  31
                     int                   Keyword                  32
                       b                Identifier                  32
                       =                  Operator                  32
                       3          Integer Constant                  32
                       ;                 Delimiter                  32
                       b                Identifier                  33
                       =                  Operator                  33
                       (                  Operator                  33
                      10          Integer Constant                  33
                       +                  Operator                  33
                       b                Identifier                  33
                       )                  Operator                  33
                       *                  Operator                  33
                       2          Integer Constant                  33
                       -                  Operator                  33
                       3          Integer Constant                  33
                       ;                 Delimiter                  33
                     int                   Keyword                  35
                    res1                Identifier                  35
                       =                  Operator                  35
                  power2                Identifier                  35
                       (                  Operator                  35
                      10          Integer Constant                  35
                       )                  Operator                  35
                       ;                 Delimiter                  35
                    char                   Keyword                  36
                    res2                Identifier                  36
                       =                  Operator                  36
                    add1                Identifier                  36
                       (                  Operator                  36
                     'd'        Character Constant                  36
                       )                  Operator                  36
                       ;                 Delimiter                  36
                 starter                Identifier                  37
                       (                  Operator                  37
                      20          Integer Constant                  37
                       )                  Operator                  37
                       ;                 Delimiter                  37
                  return                   Keyword                  38
                       0          Integer Constant                  38
                       ;                 Delimiter                  38
                       }                  Operator                  39
```



```
==========================================================================================
                                     SYMBOL TABLE
==========================================================================================
                  TOKEN                     TOKEN TYPE                       LINE NUMBER
                 printf                     <function>                                18
                    int                      <Keyword>                                11
      void starter(int a)        <User Defined function>                                17
                    sum                   <Identifier>                                22
                   res1                   <Identifier>                                35
                   res2                   <Identifier>                                36
             int main()                <Main function>                                20
                  short                      <Keyword>                                22
                   long                      <Keyword>                                23
        char add1(char c)        <User Defined function>                                14
                 power2                   <Identifier>                                35
        int power2(int c)        <User Defined function>                                10
                      a                   <Identifier>                                18
                      b                   <Identifier>                                32
                      c                   <Identifier>                                11
                      d                   <Identifier>                                11
                  total                   <Identifier>                                23
                   add1                   <Identifier>                                36
                 return                      <Keyword>                                12
                starter                   <Identifier>                                37
                   char                      <Keyword>                                28

==========================================================================================
                                    CONSTANT TABLE
==========================================================================================
                  TOKEN                     TOKEN TYPE                       LINE NUMBER
          "Hello world"              <String Constant>                                29
                "hello"              <String Constant>                                28
                     10                 <INT Constant>                                35
                     10                 <INT Constant>                                33
                     10                 <INT Constant>                                31
                     10                 <INT Constant>                                25
                     10                 <INT Constant>                                25
                     10                 <INT Constant>                                22
                     20                 <INT Constant>                                37
                     20                 <INT Constant>                                31
                     20                 <INT Constant>                                25
                     20                 <INT Constant>                                23
                      0                 <INT Constant>                                38
                      1                 <INT Constant>                                15
                      2                 <INT Constant>                                33
                      3                 <INT Constant>                                33
                      3                 <INT Constant>                                32
"you wanted to print %d"              <String Constant>                                18
                    'd'                <Char Constant>                                36
```

Test case 3

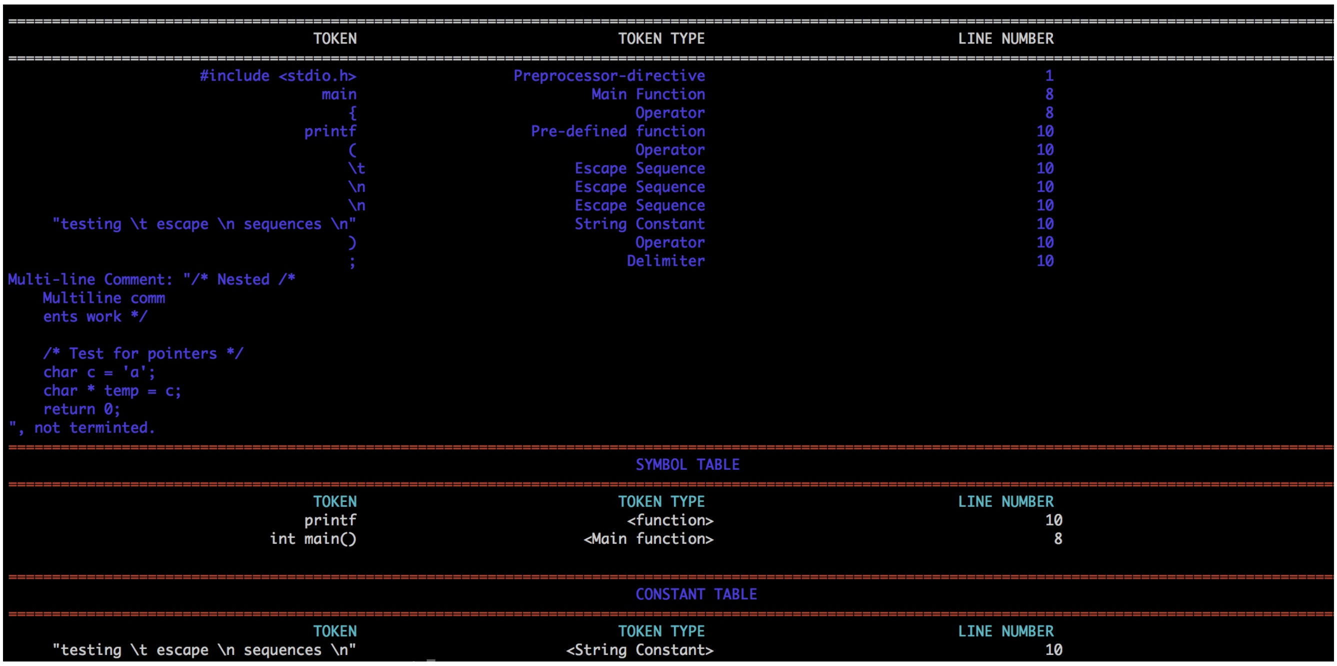
1) Test case for identifying escape sequences

2) Test for some valid multiline comments

3) Test for pointers

```
#include <stdio.h>

/* 1 ) Test case for identifying escape sequences
2 ) Test for some valid multiline comments
3 ) Test for pointers
*/

int main(){
    /* Test case for identifying escape sequences */
    printf("testing \t escape \n sequences \n");

    /* Test for some valid multiline comments  */
    /* Nested /*
    Multiline comm
    ents work */

    /* Test for pointers */
    char c = 'a';
    char * temp = &c;
    return 0;
}
```

Output 3



```
======================================================================================================================
                              TOKEN                              TOKEN TYPE                              LINE NUMBER
======================================================================================================================
                #include <stdio.h>                  Preprocessor-directive                                        1
                              main                           Main Function                                        8
                                 {                                Operator                                        8
                            printf                     Pre-defined function                                      10
                                 (                                Operator                                       10
                                 \t                        Escape Sequence                                       10
                                 \n                        Escape Sequence                                       10
                                 \n                        Escape Sequence                                       10
   "testing \t escape \n sequences \n"                     String Constant                                       10
                                 )                                Operator                                       10
                                 ;                               Delimiter                                       10
Multi-line Comment: "/* Nested /*
    Multiline comm
    ents work */

    /* Test for pointers */
    char c = 'a';
    char * temp = c;
    return 0;
", not terminted.
======================================================================================================================
                                                          SYMBOL TABLE
======================================================================================================================
                              TOKEN                              TOKEN TYPE                              LINE NUMBER
                            printf                              <function>                                        10
                        int main()                         <Main function>                                         8

======================================================================================================================
                                                          CONSTANT TABLE
======================================================================================================================
                              TOKEN                              TOKEN TYPE                              LINE NUMBER
   "testing \t escape \n sequences \n"                    <String Constant>                                       10
```

Test case 4

1) Test case for string not terminated

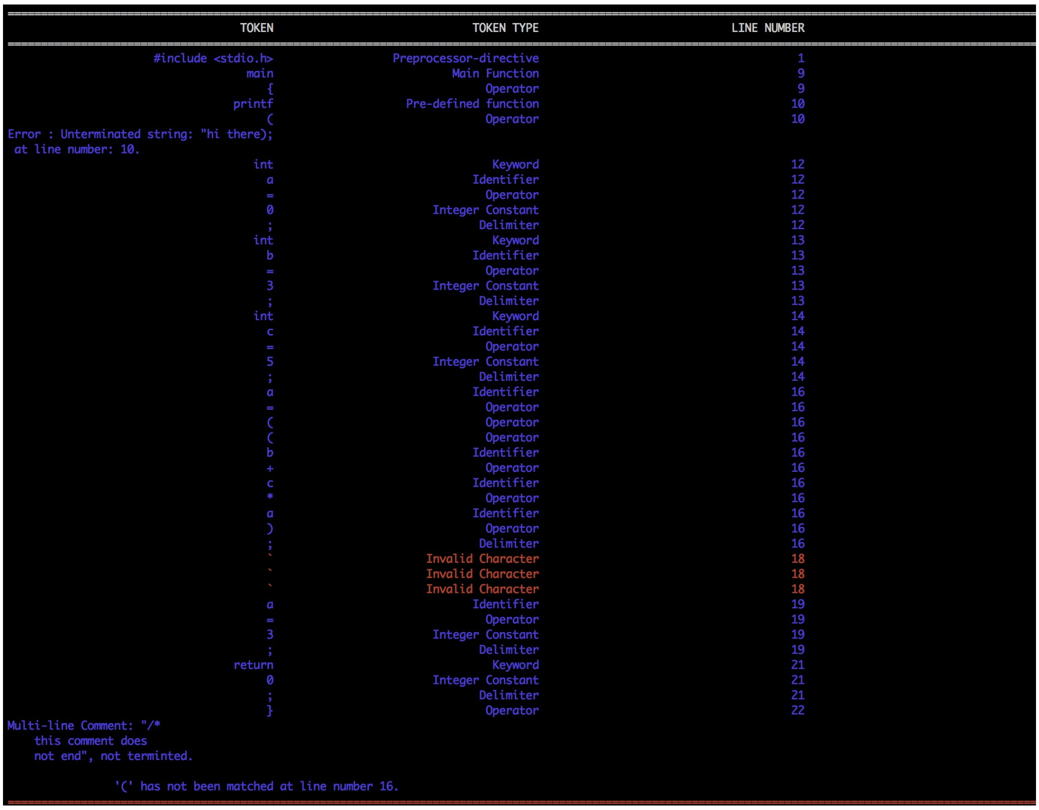
2) Test for unbalanced paranthesis;

3) Test for stray characters

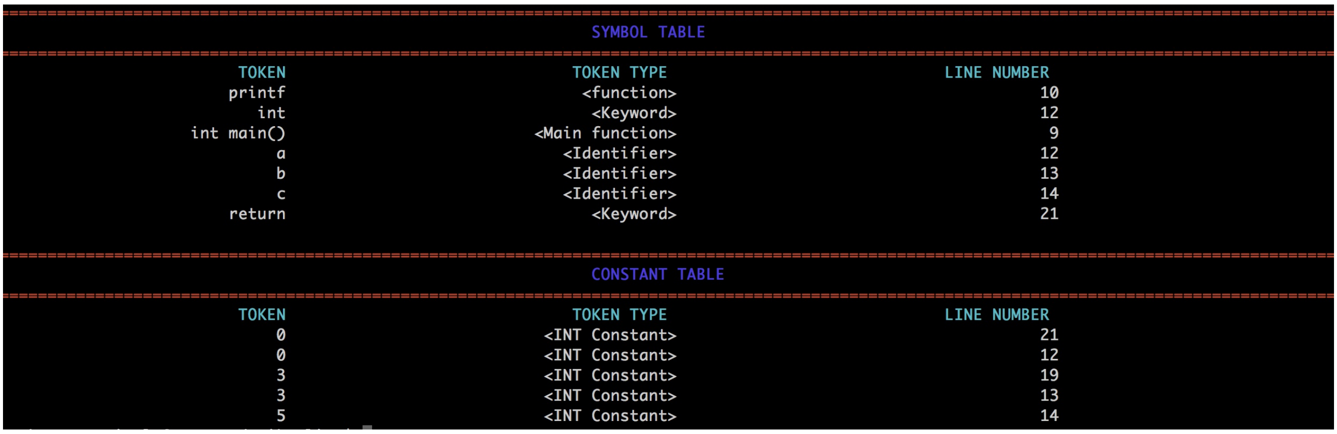
4) Multiline comment not terminated

~~~
#include <stdio.h>

/* 1 ) Test case for string not terminated
2 ) Test for unbalanced paranthesis;
3 ) Test for stray characters
4 ) Multiline comment not terminated
*/

int main(){
    printf("hi there);

    int a = 0;
    int b = 3;
    int c = 5;

    a = ((b+c*a);

    ```
    a = 3;

    return 0;
}

/*
    this comment does
    not end
~~~

Output 4



```
                        TOKEN                          TOKEN TYPE                       LINE NUMBER
           #include <stdio.h>              Preprocessor-directive                                 1
                         main                       Main Function                                 9
                            {                            Operator                                 9
                       printf                 Pre-defined function                               10
                            (                            Operator                                10
Error : Unterminated string: "hi there);
 at line number: 10.
                          int                             Keyword                                12
                            a                          Identifier                                12
                            =                            Operator                                12
                            0                    Integer Constant                                12
                            ;                           Delimiter                                12
                          int                             Keyword                                13
                            b                          Identifier                                13
                            =                            Operator                                13
                            3                    Integer Constant                                13
                            ;                           Delimiter                                13
                          int                             Keyword                                14
                            c                          Identifier                                14
                            =                            Operator                                14
                            5                    Integer Constant                                14
                            ;                           Delimiter                                14
                            a                          Identifier                                16
                            =                            Operator                                16
                            (                            Operator                                16
                            (                            Operator                                16
                            b                          Identifier                                16
                            +                            Operator                                16
                            c                          Identifier                                16
                            *                            Operator                                16
                            a                          Identifier                                16
                            )                            Operator                                16
                            ;                           Delimiter                                16
                            `                   Invalid Character                                18
                            `                   Invalid Character                                18
                            `                   Invalid Character                                18
                            a                          Identifier                                19
                            =                            Operator                                19
                            3                    Integer Constant                                19
                            ;                           Delimiter                                19
                       return                             Keyword                                21
                            0                    Integer Constant                                21
                            ;                           Delimiter                                21
                            }                            Operator                                22
Multi-line Comment: "/*
    this comment does
    not end", not terminted.

               '(' has not been matched at line number 16.
```



```
                                        SYMBOL TABLE

             TOKEN                      TOKEN TYPE                  LINE NUMBER
            printf                      <function>                           10
               int                       <Keyword>                           12
        int main()                 <Main function>                            9
                 a                    <Identifier>                           12
                 b                    <Identifier>                           13
                 c                    <Identifier>                           14
            return                       <Keyword>                           21

                                       CONSTANT TABLE

             TOKEN                      TOKEN TYPE                  LINE NUMBER
                 0                  <INT Constant>                           21
                 0                  <INT Constant>                           12
                 3                  <INT Constant>                           19
                 3                  <INT Constant>                           13
                 5                  <INT Constant>                           14
```

Test case 5

1) Test for '{' not terminated

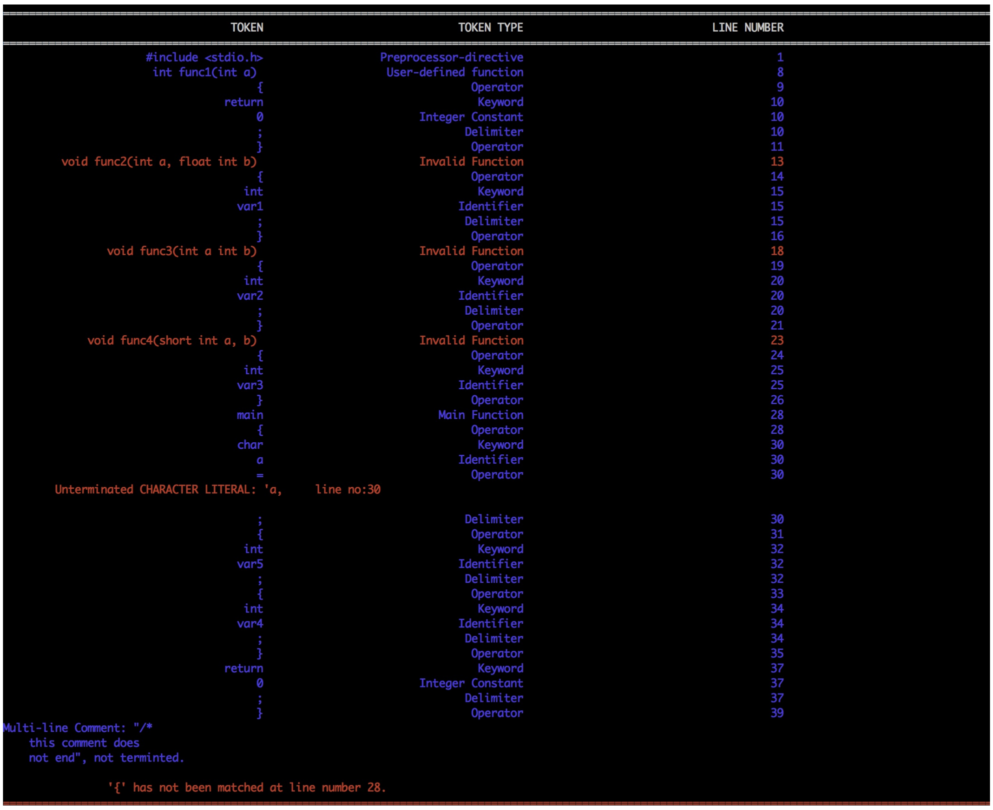
2) Test for unterminated character constant

3) Test for invalid functions

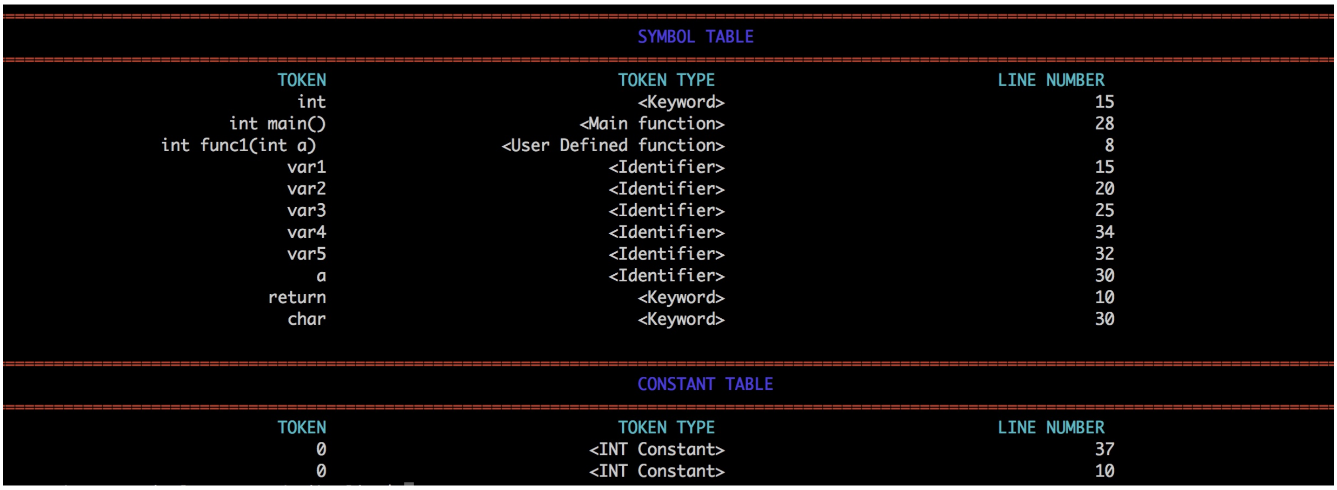
```
#include <stdio.h>

/* 1 ) Test for '{' not terminated
2 ) Test for unterminated character constant
```

```
3 ) Test for invalid functions
*/

int func1(int a) //Valid function
{
    return 0;
}

void func2(int a, float int b) //Valid Function
{
    int var1;
}

void func3(int a int b) //Invalid Function
{
    int var2;
}

void func4(short int a, b) //Invalid Function
{
    int var3
}

int main(){

   char a = 'a;
   {
       int var5;
       {
           int var4;
       }

    return 0;

}

/*
    this comment does
    not end
```

Output 5



```
==========================================================================================
                       TOKEN                      TOKEN TYPE                 LINE NUMBER
==========================================================================================
              #include <stdio.h>         Preprocessor-directive                        1
               int func1(int a)           User-defined function                        8
                               {                       Operator                        9
                          return                        Keyword                       10
                               0               Integer Constant                       10
                               ;                      Delimiter                       10
                               }                       Operator                       11
      void func2(int a, float int b)           Invalid Function                       13
                               {                       Operator                       14
                             int                        Keyword                       15
                            var1                     Identifier                       15
                               ;                      Delimiter                       15
                               }                       Operator                       16
            void func3(int a int b)            Invalid Function                       18
                               {                       Operator                       19
                             int                        Keyword                       20
                            var2                     Identifier                       20
                               ;                      Delimiter                       20
                               }                       Operator                       21
          void func4(short int a, b)           Invalid Function                       23
                               {                       Operator                       24
                             int                        Keyword                       25
                            var3                     Identifier                       25
                               }                       Operator                       26
                            main                  Main Function                       28
                               {                       Operator                       28
                            char                        Keyword                       30
                               a                     Identifier                       30
                               =                       Operator                       30
        Unterminated CHARACTER LITERAL: 'a,     line no:30

                               ;                      Delimiter                       30
                               {                       Operator                       31
                             int                        Keyword                       32
                            var5                     Identifier                       32
                               ;                      Delimiter                       32
                               {                       Operator                       33
                             int                        Keyword                       34
                            var4                     Identifier                       34
                               ;                      Delimiter                       34
                               }                       Operator                       35
                          return                        Keyword                       37
                               0               Integer Constant                       37
                               ;                      Delimiter                       37
                               }                       Operator                       39
Multi-line Comment: "/*
    this comment does
    not end", not terminted.

                '{' has not been matched at line number 28.
==========================================================================================
```



```
=====================================================================================
                                         SYMBOL TABLE
=====================================================================================
                    TOKEN                  TOKEN TYPE                   LINE NUMBER
                      int                   <Keyword>                        15
               int main()             <Main function>                        28
          int func1(int a)     <User Defined function>                        8
                     var1                <Identifier>                        15
                     var2                <Identifier>                        20
                     var3                <Identifier>                        25
                     var4                <Identifier>                        34
                     var5                <Identifier>                        32
                        a                <Identifier>                        30
                   return                   <Keyword>                        10
                     char                   <Keyword>                        30

=====================================================================================
                                         CONSTANT TABLE
=====================================================================================
                    TOKEN                  TOKEN TYPE                   LINE NUMBER
                        0              <INT Constant>                        37
                        0              <INT Constant>                        10
```