

# *Modula<sup>-</sup>*: A Simple Modula Programming Language

## Programming Assignment 1

### Lexical Definition

**Due Date: 1:20PM, April 30, 2019**

Your assignment is to write a scanner for the *Modula<sup>-</sup>* language in **lex**. This document gives the lexical definition of the language, while the syntactic definition and code generation will follow in subsequent assignments.

Your programming assignments are based around this division and later assignments will use the parts of the system you have built in the earlier assignments. That is, in the first assignment you will implement the scanner using **lex**, in the second assignment you will implement the syntactic definition in **yacc**, and in the last assignment you will generate assembly code for the Java Virtual Machine by augmenting your **yacc** parser.

This definition is subject to modification as the semester progresses. You should take care in implementation that the programs you write are well-structured and easily changed.

## 1 Character Set

*Modula<sup>-</sup>* programs are formed from ASCII characters. Control characters are not used in the definition of the language. In addition, *sF* is case-sensitive, i.e.  $CASE \neq Case \neq CaSe$ .

## 2 Lexical Definitions

Tokens are divided into two classes: tokens that will be passed to the parser and tokens that will be discarded by the scanner (i.e. recognized but not passed to the parser).

### 2.1 Tokens That Will Be Passed to the Parser

The following tokens will be recognized by the scanner and will be eventually passed to the parser:

#### Delimiters

Each of these delimiters should be passed back to the parser as a token.

comma	,
colon	:
period	.
semicolon	;
parentheses	( )
square brackets	[ ]
brackets	{ }

## Arithmetic, Relational, and Logical Operators

Each of these operators should be passed back to the parser as a token.

arithmetic	+ - * /
remainder	%
relational	< <= >= > = <>
logical	&&    ~
assignment	:=

## Keywords

The following keywords are reversed words of *Modula-2* (Note that the case is not significant):

**array boolean begin break char case const continue do else end exit false for fn if in integer  
loop module print println procedure repeat return real string record then true type use  
until var while**

Each of these keywords should be passed back to the parser as a token.

## Identifiers

An identifier is a string of letters and digits beginning with a letter. Case of letters is relevant, i.e. **ident**, **Ident**, and **IDENT** are not the same identifier. Note that keywords are not identifiers.

## Integer Constants

A sequence of one or more digits.

## Boolean Constants

Either **true** or **false**.

## Real Constants

A sequence of one or more digits containing a decimal point, optionally preceded by a sign (+ or -), and optionally following by an exponent letter and exponent.

## String Constants

A string constant is a sequence of zero or more ASCII characters appearing between double-quote (") delimiters. A double-quote appearing with a string must be written after a \. For example, **"aa""bb"** denotes the string constant **aa"bb**.

## 2.2 Tokens that will be discarded

The following tokens will be recognized by the scanner, but should be discarded rather than passing back to the parser.

## Whitespace

A sequence of blanks (spaces), tabs, and newlines.

## Comments

Comments can be denoted in several ways:

- *Modula-style* is text surrounded by “( \* ” and “ \* ) ” delimiters, which may span more than one line;
- *C++-style* comments are a text following a “ / / ” delimiter running up to the end of the line.

Whichever comment style is encountered first remains in effect until the appropriate comment close is encountered. For example

```
// a comment // line *( )* with (* delimiters *) before the end
```

and

```
(* this is a comment // line with some (* and  
C delimiters *)
```

are both valid comments.

## 3 Symbol Tables

You must implement symbol tables to store all identifiers. Symbols tables should be designed for efficient insertion and retrieval operations, and hence they are usually organized as hash tables. In order to create and manage the tables, at least the following functions should be provided:

**create():** Creates a symbol table.

**lookup(*s*):** Returns index of the entry for string *s*, or *nil* if *s* is not found.

**insert(*s*):** Inserts *s* into a new entry of the symbol table and returns index of the entry.

**dump():** Dumps all entries of the symbol table. returns index of the entry.

## 4 Implementation Hints

You should write your scanner actions using the macros `token`, `tokenInteger`, and `tokenString`. The macro `tokenInteger` is used for tokens that return an integer value as well as a token (e.g. integer constants), while `tokenString` is used for tokens that return a string as well as a token. The macro `token` is used for all other tokens. The first argument of all three macros is a string. This string names the token that will be passed to the parser. The macro `tokenInteger` takes a second argument that must be an integer and `tokenString` takes a second argument that must be a string. Following are some examples:

Token	Lexeme	Macro Call
left parenthesis	(	token('(')
IF	if	token(IF)
identifier	ab123	tokenString(identifier, "ab123"); tokenString(identifier, yytext);
integer constant	23	tokenInteger(integer, "23");
boolean constant	true	token(TRUE);

## 5 What Should Your Scanner Do?

Your goal is to have your scanner print each token on a separate line, surrounded by angle brackets. Each line should be listed along with a line number. In addition, the identifiers that are stored in the symbol table must be dumped. For example, given the input:

```
(* Hello World Example *)
module HelloWorld
begin
  // Print text to the console
  print ("Hello World");
end HelloWorld.
```

Your scanner should output:

```
1: (* Hello World Example *)
<MODULE>
<id: HelloWorld>
2: module HelloWorld
<BEGIN>
3: begin
4:   // Print text to the console
<PRINT>
<' ('>
<string:Hello World>
<')'>
<' ; '>
5:   print ("Hello World");
<END>
<id: HelloWorld>
<' .'>
6: end HelloWorld.
```

```
Symbol Table:
HelloWorld
```

## 6 *lex* Template

This template may be found online on the Compilers home page.

```
%{
#define MAX_LINE LENG 256
#define LIST      strcat(buf,yytext)
#define token(t)  {LIST; printf("<%s>\n", "t");}
#define tokenInteger(t,i) {LIST; printf("<%s:%d>\n", "t", i);}
#define tokenString(t,s) {LIST; printf("<%s:%s>\n", "t", s);}

int linenum = 0;
char buf[MAX_LINE LENG];
}%

%%
"("      {token(' (');}

\n      {
        LIST;
        printf("%d: %s", linenum, buf);
        linenum++;
        buf[0] = '\0';
      }

[ \t]*  {LIST;}

.       {
        LIST;
        printf("%d:%s\n", linenum, buf);
        printf("bad character:'%s'\n",yytext);
        exit(-1);
      }

%%
```