Chapter 6: LISP

WMC CS Club

Jan 13, 2022

LISP (LISt Processing language) is one of the simplest computer languages in terms of syntax and semantics, and also one of the most powerful. LISP presents a very different way to think about programming from the "algorithmic" languages, such as Python, C++, and Java. LISP is a prefix language.

§1 Basic Syntax

As its name implies, the basis of LISP is a list. One constructs a list by enumerating elements inside a pair of parentheses. For example, here is a list with four elements:

```
(10 (wmc cs club) hello 123)
```

The second element is a list within the list. The individual elements are called "atoms." In the list above, `10, `wmc, `cs, `club, `hello, 123` are atoms. Everything in LISP is either an atom or a list (but not both). The only exception is "NIL," which is both an atom and a list. It can also be written as "()" – a pair of parentheses with nothing inside.

All statements in LISP are function calls with the following syntax:
`(function arg1 arg2 ... argn)`. To evaluate a LISP statement, each of the arguments (possibly functions themselves) are evaluated, and then the function is invoked with the arguments. For example, `(MULT (ADD 2 3) (ADD 1 4 2))` has a value of 35, since `(ADD 2 3)` has a value of 5, `(ADD 1 4 2)` has a value of 7, and `(MULT 5 7)` has a value of 35. Some functions have an arbitrary number of arguments; others require a fixed number. All statements return a value, which is either an atom or a list.

§2 12 Common LISP Functions

Function	Description	Statement	Result

`SET`	Assign a value to a variable (the first argument must have a quote (since it's a variable), the second argument can be a value (without quote), atom (with quote), or a list (with quote).	`(SET `test 6);`
		`(SET `test `(a b c))`
			6; (a b c)

`SETQ`	Same as `SET`, but it causes LISP to act as if the first argument was quoted.	`(SETQ EX (MULT 2 5))`	10

CAR	Returns the **first** item of the list x (and x must be a list or an error will occur).	(CAR `(This is a list))	This
CDR	Returns the list **without** its first element.	(CDR `(This is a list))	(is a list)
CONS	The function CONS takes two arguments, of which the second must be a list. It returns a list which is composed by placing the first argument as the first element in the second argument's list.	(CONS `red `(pink blue))	(red pink blue)
REVERSE	The function REVERSE returns a list which is its arguments in reverse order.	(REVERSE `(a b c))	(c b a)

ADD	Sum of all arguments (2 to n arguments.)	(ADD 1 2 3)	6
SUB	$a - b$ (2 arguments)	(SUB 9 2)	7
MULT	Product of all arguments (2 to n arguments.)	(MULT 1 2 4)	8
DIV	$\frac{a}{b}$ (2 arguments)	(DIV 8 4)	2
SQUARE	a^2 (1 arguments)	(SQUARE 5)	25
EXP	a^b (2 arguments)	(EXP 2 3)	8

The above functions will be the possible ones in ACSL Intermediate Division. Certainly, there are more functions in LISP: ATOM (to check if a variable is an atom), EVAL (evaluate a variable), EQ (to check if a and b are equal), POS (to check if a number is positive), NEG (to check if a number is negative).

Example 2.1

Evaluate the following expression:

```
(MULT (ADD 6 5 0) (MULT 5 1 2 2) (DIV 9 (SUB 2 5)))
```

Answer: -440

Example 2.2

Consider the following program fragment:

```
(SETQ X `(BC AB SK MB ON))
 (CAR (CDR (REVERSE X)))
```

What is the value of the CAR expression?

Answer: MB

§3 User-defined Functions

LISP also allows us to create our own functions using the DEF function. For example:

```
(DEF SECOND (args) (CAR (CDR args)))
```

defines a new function called SECOND which operates on a single parameter named `args`. `SECOND` will take the `CDR` of the parameter and then the `CAR` of that result. So, for example: ``(SECOND `(a b c d e))`` would first `CDR` the list to give `(b c d e)`, and then `CAR` that value returning the single character `b`.

§4 Practice Problems

Problems

1. Evaluate: `(ADD (SUB 8 7) 6 5)`.
2. Evaluate: `(ADD (SUB 4 1) (EXP 2 4) (MULT 3 5) (MULT (EXP 3 2) (SUB 2 4)))`.
3. Consider the following program segment:

   ```
   (SETQ score (MULT 5 4 3 2 1))
   ```

   What is the value of the expression `(SUB AMOUNT (DIV 100 5))`?
4. Evaluate the expression ``(CDR `((2 (3)) (4 (5 6) 7)))``.
5. Evaluate: ``(CAR (CDR (REVERSE `(ON (AB QC) (NS (NB MB)) (BC PE SK) NL))))``
6. Write a user-defined function that calculate the length of the hypotenuse c given two legs a and b in a right triangle. Recall that the hypotenuse $c = \sqrt{a^2 + b^2}$. Specifically, function `CALC` has two arguments, `a` and `b`, with `c` returned (assume the arguments passed are legal.)
7. Write a user-defined function `FUNC` with one argument that returns the fourth last element in a list (assume the argument is a list with at least four elements.)

Answer Key

1. 12
2. 16
3. 100
4. ((4 (5 6) 7))
5. (BC PE SK)
6. `(DEF CALC (a,b) (EXP (ADD (SQUARE a) (SQUARE b)) 0.5))`
7. `(DEF FUNC (args) (CAR (CDR (CDR (CDR (REVERSE args))))))`