

# Mini-LISP

The language that your project's interpreter will process is a subset of [LISP](#), which we call it Mini-LISP for convenience. This handout first offers a general description, then goes into details such as lexical structure and grammar of the subset.

## Overview

LISP is an ancient programming language based on [S-expressions](#) and [lambda calculus](#). All operations in Mini-LISP are written in parenthesized [prefix notation](#). For example, a simple mathematical formula “ $(1 + 2) * 3$ ” written in Mini-LISP is:

```
(* (+ 1 2) 3)
```

As a simplified language, Mini-LISP has only three types (**Boolean**, **number** and **function**) and a few operations.

## Type Definition

- Boolean: Boolean type includes two values, `#t` for true and `#f` for false.
- Number: **Signed integer from  $-(2^{31})$  to  $2^{31} - 1$** , behavior out of this range is not defined.
- Function: See [Function](#).

Casting: Not allowed, but type checking is a bonus feature.

## Operation Overview

Numerical Operators		
Name	Symbol	Example
Plus	+	<code>(+ 1 2) =&gt; 3</code>
Minus	-	<code>(- 1 2) =&gt; -1</code>
Multiply	*	<code>(* 2 3) =&gt; 6</code>
Divide	/	<code>(/ 6 3) =&gt; 2</code>
Modulus	mod	<code>(mod 8 3) =&gt; 2</code>
Greater	>	<code>(&gt; 1 2) =&gt; #f</code>
Smaller	<	<code>(&lt; 1 2) =&gt; #t</code>
Equal	=	<code>(= 1 2) =&gt; #f</code>

Logical Operators		
Name	Symbol	Example
And	and	(and #t #f) => #f
Or	or	(or #t #f) => #t
Not	not	(not #t) => #f

**Other Operators:** define, fun, if

Note that all operators are **reserved words**, you cannot use any of these words as ID.

## Lexical Details

Preliminary Definitions:

separator ::= '\t'(tab) | '\n' | '\r' | ''(space)

letter ::= [a-z]

digit ::= [0-9]

Token Definitions:

number ::= 0 | [1-9]digit\* | -[1-9]digit\*

*Examples: 0, 1, -23, 123456*

ID ::= letter (letter | digit | '-' )\*

*Examples: x, y, john, cat-food*

bool-val ::= #t | #f

## Grammar Overview

PROGRAM ::= STMT<sup>+</sup>

STMT ::= EXP | DEF-STMT | PRINT-STMT

PRINT-STMT ::= (print-num EXP) | (print-bool EXP)

EXP ::= bool-val | number | VARIABLE | NUM-OP | LOGICAL-OP  
| FUN-EXP | FUN-CALL | IF-EXP

NUM-OP ::= PLUS | MINUS | MULTIPLY | DIVIDE | MODULUS | GREATER  
| SMALLER | EQUAL

PLUS ::= (+ EXP EXP<sup>+</sup>)

MINUS ::= (- EXP EXP)

MULTIPLY ::= (\* EXP EXP<sup>+</sup>)

DIVIDE ::= (/ EXP EXP)

MODULUS ::= (mod EXP EXP)

GREATER ::= (> EXP EXP)

SMALLER ::= (< EXP EXP)

EQUAL ::= (= EXP EXP<sup>+</sup>)

LOGICAL-OP ::= AND-OP | OR-OP | NOT-OP

AND-OP ::= (and EXP EXP<sup>+</sup>)

OR-OP ::= (or EXP EXP<sup>+</sup>)

NOT-OP ::= (not EXP)

DEF-STMT ::= (define VARIABLE EXP)

VARIABLE ::= id

FUN-EXP ::= (fun FUN\_IDS FUN-BODY)

FUN-IDS ::= (id<sup>\*</sup>)

FUN-BODY ::= EXP

FUN-CALL ::= (FUN-EXP PARAM<sup>\*</sup>) | (FUN-NAME PARAM<sup>\*</sup>)

PARAM ::= EXP

LAST-EXP ::= EXP

FUN-NAME ::= id

IF-EXP ::= (if TEST-EXP THAN-EXP ELSE-EXP)

TEST-EXP ::= EXP

THEN-EXP ::= EXP

ELSE-EXP ::= EXP

## Grammar and Behavior Definition

### 1. Program

PROGRAM ::= STMT<sup>+</sup>

STMT ::= EXP | DEF-STMT | PRINT-STMT

### 2. Print

PRINT-STMT ::= (print-num EXP)

**Behavior: Print exp in decimal.**

| (print-bool EXP)

**Behavior: Print #t if EXP is true. Print #f, otherwise.**

### 3. Expression (EXP)

EXP ::= bool-val | number | VARIABLE

| NUM-OP | LOGICAL-OP | FUN-EXP | FUN-CALL | IF-EXP

### 4. Numerical Operations (NUM-OP)

NUM-OP ::= PLUS | MINUS | MULTIPLY | DIVIDE | MODULUS |  
| GREATER | SMALLER | EQUAL

PLUS ::= (+ EXP EXP<sup>+</sup>)

**Behavior: return sum of all EXP inside.**

Example: (+ 1 2 3 4) → 10

MINUS ::= (- EXP EXP)

**Behavior: return the result that the 1<sup>st</sup> EXP minus the 2<sup>nd</sup> EXP.**

Example: (- 2 1) → 1

MULTIPLY ::= (\* EXP EXP<sup>+</sup>)

**Behavior: return the product of all EXP inside.**

Example: (\* 1 2 3 4) → 24

DIVIDE ::= (/ EXP EXP)

**Behavior: return the result that 1<sup>st</sup> EXP divided by 2<sup>nd</sup> EXP.**

Example: (/ 10 5) → 2

(/ 3 2) → 1 (just like C++)

MODULUS ::= (mod EXP EXP)

**Behavior: return the modulus that 1<sup>st</sup> EXP divided by 2<sup>nd</sup> EXP.**

Example: (mod 8 5) → 3

GREATER ::= (> EXP EXP)

**Behavior:** return #t if 1<sup>st</sup> EXP greater than 2<sup>nd</sup> EXP. #f otherwise.

Example: (> 1 2) → #f

SMALLER ::= (< EXP EXP)

**Behavior:** return #t if 1<sup>st</sup> EXP smaller than 2<sup>nd</sup> EXP. #f otherwise.

Example: (< 1 2) → #t

EQUAL ::= (= EXP EXP<sup>+</sup>)

**Behavior:** return #t if all EXPs are equal. #f otherwise.

Example: (= (+ 1 1) 2 (/6 3)) → #t

## 5. Logical Operations (LOGICAL-OP)

LOGICAL-OP ::= AND-OP | OR-OP | NOT-OP

AND-OP ::= (and EXP EXP<sup>+</sup>)

**Behavior:** return #t if all EXPs are true. #f otherwise.

Example: (and #t (> 2 1)) → #t

OR-OP ::= (or EXP EXP<sup>+</sup>)

**Behavior:** return #t if at least one EXP is true. #f otherwise.

Example: (or (> 1 2) #f) → #f

NOT-OP ::= (not EXP)

**Behavior:** return #t if EXP is false. #f otherwise.

Example: (not (> 1 2)) → #t

## 6. define Statement (DEF-STMT)

DEF-STMT ::= (define id EXP)

VARIABLE ::= id

**Behavior:** Define a variable named id whose value is EXP.

Example:

(define x 5)

(+ x 1) → 6

Note: Redefining is not allowed.

## 7. Function

FUN-EXP ::= (fun FUN-IDs FUN-BODY)

FUN-IDs ::= (id\*)

```

FUN-BODY ::= EXP
FUN-CALL ::= (FUN-EXP PARAM*)
           | (FUN-NAME PARAM*)
PARAM ::= EXP
LAST-EXP ::= EXP
FUN-NAME ::= id

```

### Behavior:

**FUN-EXP defines a function. When a function is called, bind FUN-IDs to PARAMs, just like the define statement. If an id has been defined outside this function, prefer the definition inside the FUN-EXP. The variable definitions inside a function should not affect the outer scope. A FUN-CALL returns the evaluated result of FUN-BODY Note that variables used in FUN-BODY should be bound to PARAMs**

### Examples:

```

((fun (x) (+ x 1)) 2) → 3
  ↑ fun-exp         ↑ fun-call

```

```

(define foo (fun () 0))
(foo) → 0

```

```

(define x 1)
(define bar (fun (x y) (+ x y)))
(bar 2 3) → 5
x → 1

```

### 8. if Expression

```

IF-EXP ::= (if TEST-EXP THEN-EXP ELSE-EXP)
TEST-EXP ::= EXP
THEN-EXP ::= EXP
ELSE-EXP ::= EXP

```

**Behavior: When TEST-EXP is true, returns THEN-EXP. Otherwise, returns ELSE-EXP.**

### Example:

```

(if (= 1 0) 1 2) → 2
(if #t 1 2) → 1

```