Lisp
Functional Programming

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Outline

- Specified in 1958
- One of the oldest high-level programming languages
- Prefix notation
- First language to use lambda calculus

Programming language

- Low versus high abstraction
- *Computer think* are not for humans
- Can it be generalised?

Linguistics: Language science Traditionally occupied with human language.
Noam Chomsky: Chomsky hierarchy

Type-3 grammar Regular language (state automata)

Type-2 grammar Context-free (no ambiguity)

Type-1 grammar Context-sensitive (ambiguity)

Type-0 grammar Unrestricted grammar (no restrictions on I/O)

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"The most intelligent way to misuse a computer" - Edgar W. Dijkstra

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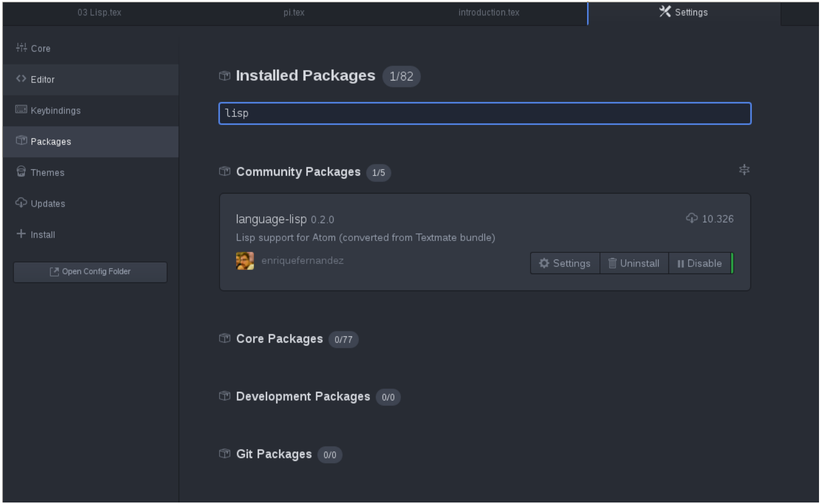
Many (!) dialects: `Scheme`, `Common Lisp`, `Emacs Lisp`, `AutoLisp`, `Racket`, `Clojure` (JVM), `CLisp`

Installing Lisp package in Atom



Installing CLisp

Go to `http://clisp.org/` and:

On Windows Download the Cygwin package by running the Cygwin installer

On Unix Download the package for your system or build it from source

Lisp syntax

- Prefix notation: *Function first* then arguments
- Function call surrounded by parenthesis

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(+ 1 1)
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(+ 1 1)

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

(* 1 (+ 2 3))

(write (- 5 2))
```

Exercise 1

1.1: Divide $5 + 3$ with $4 - 2$

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1.2: Write $9 * 2 - 3 + 5$ to the console

Procedural programming

`(setf variable 10)` ← mutable

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Procedural programming

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Functional programming

Local variables: `let`-binding

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(let ((a 10)) (write a) )
```

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Why is the `let`-binding preferred in functional programming?

Lisp exercises

Clone the `lisp-exercises` from
`cphbus-functional-programming`

`https://github.com/cphbus-functional-programming/lisp-exercises`

Work on the `variables.lisp` file

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Mathematics!

Lambda calculus

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$f(5) = y \mapsto y^2 + 25$

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$$f(5) = y \mapsto y^2 + 25 \quad = \lambda y.y^2 + 25$$

Lisp functions

- Functions defined with `defun`
- Takes three expressions: name, arguments and function body

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```
(defun test (a) (write a))
```

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```
(defun test (a) (write a))

(test 10)
```

Lambdas in Lisp

```
(lambda () ())
```

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```
(lambda () ())

(lambda (x) (* x x))
```

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((lambda (x) (* x x)) 5)
```

`if` statements

What do you need to know in an `if` statement?

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(if condition then else)
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```
(if (= a 0) 0 1)
```

Lists

Lists are made by calling the function `list` followed by the list content

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```
(list 10 5 2)
```

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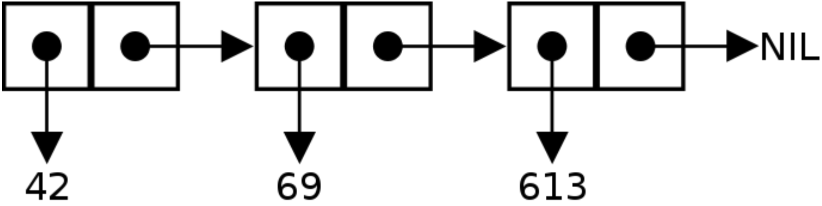
Lists in lisp is built using *linked lists*



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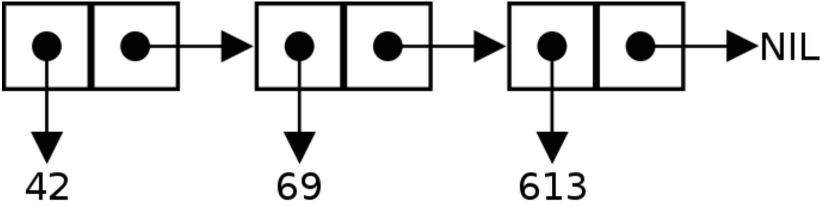

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Linked lists

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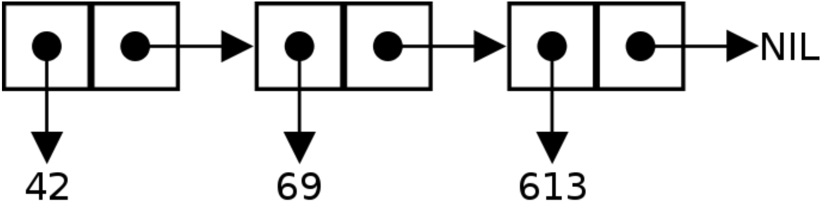

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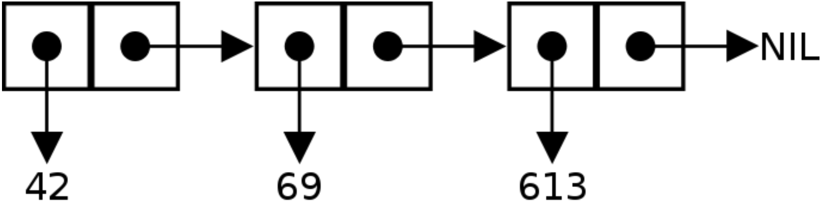

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A cell is called a *cons*

The two pointers is called `car` and `cdr`

Cons, car and cdr

A list can be constructed using `cons`: `(cons 4 nil)`

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What is `(car (cons 4 nil))`?

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What is `(car (cons 4 nil))`?

What is `(cdr (cons 4 nil))`?

Append appends a list on another

```
(append (list 1 2) (list 3 4))
```

append and reverse

Append appends a list on another

```
(append (list 1 2) (list 3 4))
```

Reverse a list with `nreverse`

```
(nreverse (list 1 2 3))
```

List exercises

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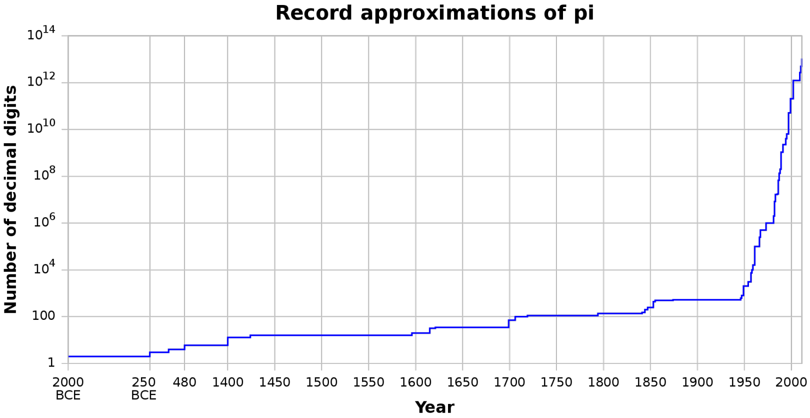
Record approximations of pi
Number of decimal digits
10^14
10^12
10^10
10^8
10^6
10^4
100
1
2000 BCE
250 BCE
480
1400
1450
1500
1550
1600
1650
1700
1750
1800
1850
1900
1950
2000
Year

Theory: Elliptic integrals

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$$\begin{aligned} a_{n+1} = \tfrac{a_n + b_n}{2}, &\quad b_{n+1} = \sqrt{a_n b_n} \\ t_{n+1} = t_n - p_n(a_n - a_{n+1})^2, &\quad p_{n+1} = 2p_n \end{aligned} \tag{2}$$

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Start values:

$$a_0 = 1 \qquad b_0 = \frac{1}{\sqrt{2}} \qquad t_0 = \frac{1}{4} \qquad p_0 = 1 \tag{3}$$