

Scheme

Announcements

Scheme

Scheme is a Dialect of Lisp

What are people saying about Lisp?

"If you don't know Lisp, you don't know what it means for a programming language to be powerful and elegant."

- Richard Stallman, created Emacs & the first free variant of UNIX

"The only computer language that is beautiful."

- Neal Stephenson, DeNero's favorite sci-fi author

"The greatest single programming language ever designed."

- Alan Kay, co-inventor of Smalltalk and OOP (from the user interface video)

Scheme Expressions

Scheme programs consist of expressions, which can be:

- Primitive expressions: 2 3.3 true + quotient
- Combinations: (quotient 10 2) (not true)

Numbers are self-evaluating; symbols are bound to values

Call expressions include an operator and 0 or more operands in parentheses

```
> (quotient 10 2)
5
> (quotient (+ 8 7) 5)
3
> (+ 3
  (* 2 4)
  (+ 3 5)))
16
> (- (- 10 7)
  6)
-1
```

"quotient" names Scheme's built-in integer division procedure (i.e., function)

Combinations can span multiple lines (spacing doesn't matter)

(Demo)

Special Forms

Special Forms

A combination that is not a call expression is a special form:

- if expression: (if <predicate> <consequent> <alternative>)
- and and or: (and <e1> ... <en>), (or <e1> ... <en>)
- Binding symbols: (define <symbol> <expression>)
- New procedures: (define (<symbol> <formal parameters>) <body>)

Evaluation:
(1) Evaluate the predicate expression
(2) Evaluate either the consequent or alternative

```
> (define pi 3.14)
> (* pi 2)
6.28
> (define (abs x)
  (if (< x 0)
      (- x)
      x))
> (abs -3)
3
```

The symbol "pi" is bound to 3.14 in the global frame

A procedure is created and bound to the symbol "abs"

(Demo)

Scheme Interpreters

(Demo)

Lambda Expressions

Lambda Expressions

Lambda expressions evaluate to anonymous procedures

```
(lambda (<formal-parameters> <body>)
```



Two equivalent expressions:

```
(define (plus4 x) (+ x 4))
```

```
(define plus4 (lambda (x) (+ x 4)))
```

An operator can be a call expression too:

```
((lambda (x y z) (+ x y (square z))) 1 2 3) ▶ 12
```

Evaluates to the $x+y+z^2$ procedure

Lists

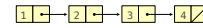
Scheme Lists

In the late 1950s, computer scientists used confusing names

- **cons**: Two-argument procedure that creates a linked list (cons 2 nil)
- **car**: Procedure that returns the first element of a list
- **cdr**: Procedure that returns the rest of a list
- **nil**: The empty list

Important! Scheme lists are written in parentheses with elements separated by spaces

```
> (cons 1 (cons 2 nil))  
(1 2)  
> (define x (cons 1 (cons 2 nil)))  
> x  
(1 2)  
> (car x)  
1  
> (cdr x)  
(2)  
> (cons 1 (cons 2 (cons 3 (cons 4 nil))))  
(1 2 3 4)
```



(Demo)

Symbolic Programming

Symbolic Programming

Symbols normally refer to values; how do we refer to symbols?

```
> (define a 1)  
> (define b 2)  
> (list a b)  
(1 2)
```

No sign of "a" and "b" in the resulting value

Quotation is used to refer to symbols directly in Lisp.

```
> (list 'a 'b)  
(a b)  
> (list 'a b)  
(a 2)
```

Short for (quote a), (quote b):
Special form to indicate that the expression itself is the value.

Quotation can also be applied to combinations to form lists.

```
> '(a b c)  
(a b c)  
> (car '(a b c))  
a  
> (cdr '(a b c))  
(b c)
```

(Demo)

Sierpinski's Triangle

(Demo)