

## Scheme

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## Announcements

Scheme

## Scheme is a Dialect of Lisp

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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)))
      (+ (- 10 7)
          6))
```

“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
```

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

```
> (define (abs x)
  (if (< x 0)
      (- x)
      x))
> (abs -3)
3
```

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

(Demo)

# Scheme Interpreters

(Demo)



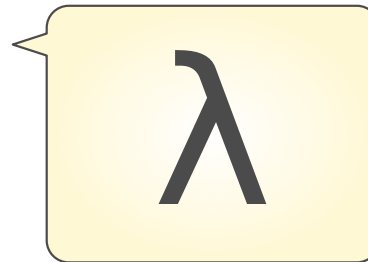
# Lambda Expressions

## Lambda Expressions

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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

More Special Forms

## Cond & Begin

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The cond special form that behaves like if-elif-else statements in Python

```
if x > 10:
    print('big')
elif x > 5:
    print('medium')
else:
    print('small')
```

```
(print
 (cond ((> x 10) (print 'big'))
       ((> x 5)  (print 'medium'))
       (else     (print 'small'))))
```

```
(print
 (cond ((> x 10) 'big)
       ((> x 5)  'medium)
       (else     'small')))
```

The begin special form combines multiple expressions into one expression

```
if x > 10:
    print('big')
    print('guy')
else:
    print('small')
    print('fry')
```

```
(cond ((> x 10) (begin (print 'big) (print 'guy)))
      (else     (begin (print 'small) (print 'fry))))
```

```
(if (> x 10) (begin
              (print 'big)
              (print 'guy))
      (begin
        (print 'small)
        (print 'fry)))
```

## Let Expressions

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The `let` special form binds symbols to values temporarily; just for one expression

```
a = 3
b = 2 + 2
c = math.sqrt(a * a + b * b)
a and b are still bound down here
```

```
(define c (let ((a 3)
                 (b (+ 2 2)))
  (sqrt (+ (* a a) (* b b)))))
a and b are not bound down here
```

# Sierpinski's Triangle

(Demo)

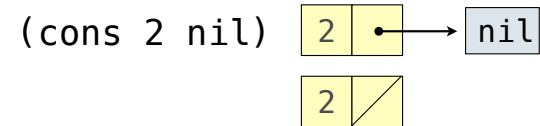
# Lists

## Scheme Lists

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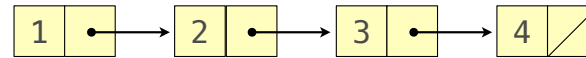
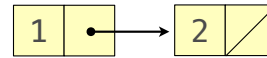
In the late 1950s, computer scientists used confusing names

- **cons**: Two-argument procedure that creates a linked list
- **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)

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# Symbolic Programming

## Symbolic Programming

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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)