Announcements
Scheme
Scheme is a Dialect of Lisp
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What are people saying about Lisp?
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"The greatest single programming language ever designed."

– Alan Kay, co-inventor of Smalltalk and OOP (from the user interface video)
Scheme Fundamentals
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```scheme
> (quotient 10 2)
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> (quotient (+ 8 7) 5)
3
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```
> (quotient 10 2)
5
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> (+ (* 3
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   (+ 3 5)))
  (+ (- 10 7)
   6))
```

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(Demo)
Special Forms
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**Evaluation:**
(1) Evaluate the predicate expression
(2) Evaluate either the consequent or alternative
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> (define pi 3.14)
> (* pi 2)
6.28
A combination that is not a call expression is a special form:

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```
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The symbol “pi” is bound to 3.14 in the global frame
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> (define (abs x)
   (if (< x 0)
       (- x)
       x))
> (abs -3)
3

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- **if** expression:  
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- Binding symbols:  
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  \[(\text{define } (<\text{symbol}> <\text{formal parameters}>) <\text{body}>)\]

Evaluation:
(1) Evaluate the predicate expression
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\[
> (\text{define pi } 3.14) \\
> (* pi 2) \\
6.28
\]

\[
> (\text{define (abs x)} \\
\hspace{1cm} (\text{if } (< x 0) \\
\hspace{2cm} (- x) \\
\hspace{2cm} x)) \\
> (\text{abs } -3) \\
3
\]

The symbol “pi” is bound to 3.14 in the global frame

A procedure is created and bound to the symbol “abs”
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(Demo)
Scheme Interpreters

(Demo)
Lambda Expressions
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(lambda (<formal-parameters>) <body>)
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Lambda expressions evaluate to anonymous procedures

\[(\text{lambda } (<\text{formal-parameters}>)) \text{ <body>}\]

Two equivalent expressions:

\[\text{(define (plus4 } x) \text{ (+ } x \text{ 4))}\]

\[\text{(define plus4 (lambda } (x) \text{ (+ } x \text{ 4)))}\]
Lambda Expressions

Lambda expressions evaluate to anonymous procedures

$$\lambda \text{\langle formal-parameters\rangle \ <body>\}$$

Two equivalent expressions:

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

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

An operator can be a call expression too:
Lambda Expressions

Lambda expressions evaluate to anonymous procedures

\[
\lambda \ (\text{<formal-parameters>}) \ \text{<body>}
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Two equivalent expressions:

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(\text{define (plus4 x) (+ x 4)})
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\[
(\text{define plus4 (lambda (x) (+ x 4)))}
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An operator can be a call expression too:

\[
((\text{lambda (x y z) (+ x y (square z))) 1 2 3})
\]
Lambda Expressions

Lambda expressions evaluate to anonymous procedures

\[(\text{lambda (}<\text{formal-parameters}>\text{)} <\text{body}>\)\]

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Evaluates to the \[x+y+z^2\] procedure
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Lambda expressions evaluate to anonymous procedures

\[ \lambda \text{<formal-parameters>} \text{<body>} \]

Two equivalent expressions:

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\text{(define (plus4 x) (+ x 4))}
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\[
\text{(define plus4 (lambda (x) (+ x 4)))}
\]

An operator can be a call expression too:

\[
((\text{lambda (x y z) (+ x y (square z))}) 1 2 3) \rightarrow 12
\]

Evaluates to the \(x+y+z^2\) procedure
Pairs and Lists
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• Important! Scheme lists are written in parentheses separated by spaces
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```scheme
> (define x (cons 1 2))
```
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```lisp
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```
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```scheme
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> x
(1 . 2)
> (car x)
1
```
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> (cdr x)
2
```
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> (cons 1 (cons 2 (cons 3 (cons 4 nil)))))
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Not a well-formed list!
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(1 2 3 4)  
(Demo)
```
Symbolic Programming
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Symbols normally refer to values; how do we refer to symbols?
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> (define a 1)
Symbolic Programming

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

> (define a 1)
> (define b 2)
Symbolic Programming

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> (define a 1)
> (define b 2)
> (list a b)
Symbols normally refer to values; how do we refer to symbols?

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(1 2)
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No sign of “a” and “b” in the resulting value
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Quotation is used to refer to symbols directly in Lisp.

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> (list 'a 'b)
Symbolic Programming

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

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\[
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![Diagram of list structure]
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\]

(1 2 . 3)

\[
> '(1 2 . (3 4))
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What is the printed result of evaluating this expression?
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```

However, dots appear in the output only of ill-formed lists.

```
> '(1 2 . 3)
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> '(1 2 . (3 4))
(1 2 3 4)
> '(1 2 3 . nil)
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```

What is the printed result of evaluating this expression?

```
> (cdr '((1 2) . (3 4 . (5))))
(3 4 5)
```