61A Lecture 24

Wednesday, October 29
Announcements
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• Homework 7 due Wednesday 11/5 @ 11:59pm
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• CS 61A flash mob Wednesday 3:03pm-3:09pm in Memorial Glade
Scheme is a Dialect of Lisp
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What are people saying about Lisp?
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  - Alan Kay, co-inventor of Smalltalk and OOP
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http://imgs.xkcd.com/comics/lisp_cycles.png
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```
> (quotient 10 2)  
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> (quotient (+ 8 7) 5)  
3
```

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

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(Demo)
Special Forms
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- **if** expression:  (if <predicate> <consequent> <alternative>)
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**Evaluation:**
1. Evaluate the predicate expression
2. Evaluate either the consequent or alternative
Special Forms

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- **if** expression:  \((\text{if } \langle\text{predicate}\rangle \ \langle\text{consequent}\rangle \ \langle\text{alternative}\rangle)\)
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- Binding symbols: \((\text{define} \ \text{<symbol>} \ \text{<expression>})\)

\[
> (\text{define pi 3.14})
> (* \text{pi} 2)
6.28
\]
Special Forms

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

- **if** expression:  \((\text{if } <\text{predicate}> <\text{consequent}> <\text{alternative}>\))
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\[
\begin{align*}
> & \text{(define pi 3.14)} \\
> & (*) \text{ pi 2) } \\
& 6.28
\end{align*}
\]

Evaluation:
(1) Evaluate the predicate expression
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The symbol “pi” is bound to 3.14 in the global frame
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- **if** expression:  
  \[
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- **and** and **or**:  
  \[
  \text{(and <e1> ... <en>), (or <e1> ... <en>)}
  \]

- Binding symbols:  
  \[
  \text{(define <symbol> <expression>)}
  \]

- New procedures:  
  \[
  \text{(define (<symbol> <formal parameters>) <body>)}
  \]

```scheme
> (define pi 3.14)
> (* pi 2)
6.28
```

Evaluation:

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- Binding symbols: \((\text{define } <\text{symbol}> <\text{expression}>)\)
- New procedures: \((\text{define } (<\text{symbol}> <\text{formal parameters}>) <\text{body}>)\)

```
> (define pi 3.14)
> (* pi 2)
6.28

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

---

**Evaluation:**
(1) Evaluate the predicate expression
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\[\begin{align*}
> & (\text{define } \pi \ 3.14) \\
> & (* \ pi \ 2) \\
& 6.28 \\
> & (\text{define } (\text{abs } \ x) \ (\text{if } (\ < \ x \ 0) \ (- \ x) \ x)) \\
> & (\text{abs } -3) \\
& 3
\end{align*}\]

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

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

A procedure is created and bound to the symbol “abs”
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>)`
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Evaluation:
1. Evaluate the predicate expression
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> `(define pi 3.14)`  
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> `6.28`

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> `x))`  
> `(abs -3)`  
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<table>
<thead>
<tr>
<th>(define pi 3.14)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(* pi 2)</td>
</tr>
<tr>
<td>6.28</td>
</tr>
<tr>
<td>(define (abs x)</td>
</tr>
<tr>
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</tr>
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Scheme Interpreters

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

Lambda expressions evaluate to anonymous procedures

\( \lambda\) (\(<\text{formal-parameters}>\)) \(<\text{body}>) \)
Lambda Expressions

Lambda expressions evaluate to anonymous procedures

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

Two equivalent expressions:

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

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

Lambda expressions evaluate to anonymous procedures

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

Two equivalent expressions:

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

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

An operator can be a call expression too:

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

Lambda expressions evaluate to anonymous procedures.

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

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

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

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

Two equivalent expressions:

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

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

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\((\text{(lambda} \ (x \ y \ z) \ (+ \ x \ y \ (\text{square} \ z)))\ 1 \ 2 \ 3)\)

Evaluates to the \(x+y+z^2\) procedure
Pairs and Lists
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- **cons**: Two-argument procedure that creates a pair
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- A (linked) list in Scheme is a pair in which the second element is **nil** or a Scheme list.
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> (define x (cons 1 2))
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```
> (define x (cons 1 2))
> x
(1 . 2)
> (car x)
1
> (cdr x)
2
```
Pairs and Lists

In the late 1950s, computer scientists used confusing names

- **cons**: Two-argument procedure that creates a pair
- **car**: Procedure that returns the first element of a pair
- **cdr**: Procedure that returns the second element of a pair
- **nil**: The empty list

They also used a non-obvious notation for linked lists

- A (linked) list in Scheme is a pair in which the second element is **nil** or a Scheme list.
- **Important!** Scheme lists are written in parentheses separated by spaces
- A dotted list has any value for the second element of the last pair; maybe not a list!

```scheme
> (define x (cons 1 2))
> x
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> (cons 1 (cons 2 (cons 3 (cons 4 nil))))
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(Demo)
Symbolic Programming
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Symbols normally refer to values; how do we refer to symbols?
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Quotation can also be applied to combinations to form lists.
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Scheme Lists and Quotation
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![Diagram of list structure](image-url)
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![Diagram](attachment:image.png)
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> (cdr '(((1 2) . (3 4) . (5)))))
(3 4 5)
Sierpinski's Triangle

(Demo)