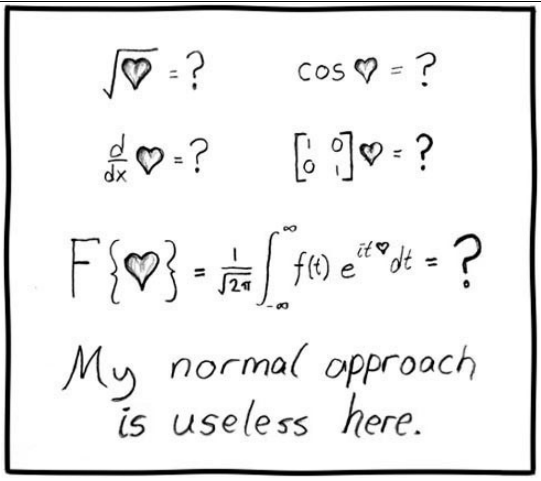

$\sqrt{\heartsuit} = ?$
$\cos \heartsuit = ?$
$\frac{d}{dx} \heartsuit = ?$
$\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \heartsuit = ?$
$F\{\heartsuit\} = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} f(t)\, e^{it\heartsuit} dt = ?$
My normal approach is useless here.

The Value of Everything & Procedure Practice

One-Slide Summary

- In Scheme, expressions **evaluate** to values. Five **evaluation rules** describe this process.
- **Lambda** means "make a function". A lambda expression specifies the formal parameter and the function body.
- Evaluating a **function application** involves evaluating the function, finding its body, replacing the formal parameters with the evaluated actual arguments, and evaluating the result.

Lecture Outline

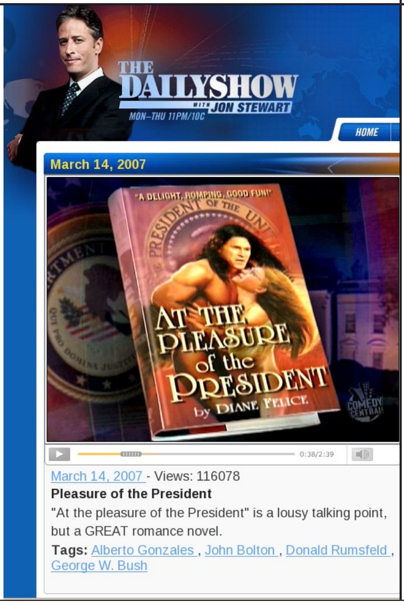
- Survey Responses
- Evaluation Rules
  - Lambda
- Problem Set 1
  - Decent Scheme

How To Use Lab Hours

- Read the problems on your own and try them out first.
  - You can **not** just go to a TA and say "I don't get it, what do I do."
    - The TA is allowed to send you away.
  - You must demonstrate about five minutes worth of work: either on scratch paper, or with code you've tried and commented out.
  - For example: how would you do it in English?
- Talk to your friends.
- Do **not** expect to finish the Problem Sets in just the staffed lab time.
  - They take longer. You must do much work alone.

The Forum!

- Your questions for me are answered on the forum.
- Any questions right now?
  - Congrats to Gitae B., Hyosang K., and Sarah P. who already have perfect PS1 coding scores ...


THE DAILY SHOW WITH JON STEWART
MON–THU 11PM/10C
HOME
"A DELIGHT, ROMPING, GOOD FUN!"
AT THE PLEASURE of the PRESIDENT
by DIANE FELICE

March 14, 2007

March 14, 2007 - Views: 116078
Pleasure of the President
"At the pleasure of the President" is a lousy talking point, but a GREAT romance novel.
Tags: Alberto Gonzales , John Bolton , Donald Rumsfeld , George W. Bush

Who Is Your Hero?

- Vonnegut, Rosalind Franklin, Mom, Batman, Gaiman, Casteen, King Sejong, Ramanujan, Tony Mata, Dawkins, Jesus, Einstein x2, Newton x3, Dyson, Nobel, Bach, Escher, Cantor, Hari Seldon, Sagan, Pausch, Jefferson, Father, Fareed Zakaria, Erdos, Robert Langdon, Tesla, Marx.
  - CS 1120 Gestalt Student, Fall 2010
  - (first proper name mentioned per response)

Problem Set 1

- Scheme's **Evaluation Rules** tell you how to find the value of any expression.
- Questions 1 and 2 ask you to evaluate Scheme expressions in your mind
  - This is a popular exam question.
- Without Evaluation Rules: guesswork
- Once you know the Evaluation Rules, you can answer without any guessing!

Evaluation Rules

- **Primitives** (* 55 66)
  - Evaluate to their pre-defined values
- **Names** (+ x 2)
  - Evaluate to the value associated with that name
- **Application** (square-root 144)
  - Eval all sub-expressions. Apply the value of the first (a function) to the values of the others.
- **Lambda** (lambda (x) (* x x x))
  - Evaluates to a function with parameters and body
- **If** (if (< 3 5) 99 11)
  - Eval predicate. If #f, eval second option. Otherwise, eval the first option.

Primitive Examples

5
-88
#t
#f
+

What do these evaluate to?

Primitive Examples

55	-->	5
-88	-->	-88
#t	-->	true (#t)
#f	-->	false (#f)
+	-->	primitive addition

Name Examples

(define x 55)
(define y 66)

x
y
z

What do these evaluate to?

Name Examples

(define x 55)
(define y 66)

x --> 55
y --> 66
z --> *reference to undefined identifier: z*

Application E

What do these evaluate to?

(sqrt 16)

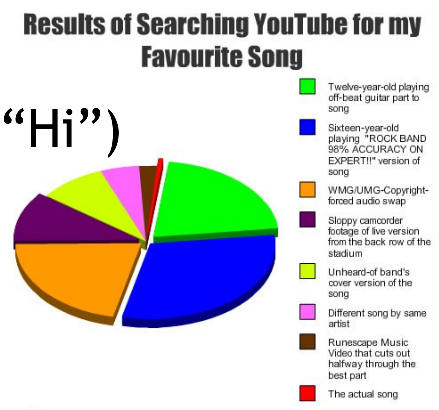
(abs -5)

(string-length “Hi”)

(+ 1 2)

(+ 1 2 3)

(+ 1)



Application Examples

(sqrt 16)	--> 4
(abs -5)	--> 5
(string-length “Hi”)	--> 2
(+ 1 2)	--> 3
(+ 1 2 3)	--> 6
(+ 1)	--> 1

Liberal Arts Trivia: Anthropology

- This American cultural anthropologist is famous for her studies of Samoa and her reports about the purportedly healthy attitude towards sex in South Pacific and Southeast Asian traditional cultures, which influenced the women's liberation movement (e.g., by claiming that females dominated in Chambri and Papau New Guinea without problems). Five years after she died, her work was challenged by Derek Freeman.

Liberal Arts: Slavic Folklore

- This witch-like character in Slavic folklore lives in a walking house with chicken feet (but no windows and no doors), flies around on a giant mortar, and kidnaps (presumably to eat) small children. Modest Mussorgsky's *Pictures at an Exhibition*, a piano suite composed in 1874, features "The Hut on Bird's Legs" as its penultimate movement.

Lambda

- **Lambda** means “make a function”.
- Consider: cube(x) = x * x * x
- Scheme-y: cube(x) = (* x x x)
- Lambda: cube = (lambda (x) (* x x x))
- Pure Scheme:

  (define cube (lambda (x) (* x x x)))

Anatomy Of A Function

- **(define cube (lambda $\underbrace{\textbf{(x)}}_{\text{formal parameters}}$ $\underbrace{\textbf{(* x x x)}}_{\text{function body}}$))**
- $\underbrace{\textbf{(cube } \underbrace{\textbf{5}}_{\text{actual arguments}}\textbf{)}}_{\text{function application}}$
- To **<u>evaluate a function application</u>**, replace it with the function body, and then replace every formal parameter with its corresponding actual argument.
- (cube 5) -> (* x x x) -> (* 5 5 5) -> 125

Lambda Examples

```
(define cube (lambda (x) (* x x x)))
(define foo (lambda (p q) (+ p q)))
(define bar (lambda (a b c) (* a c)))
(cube 3)
(foo 5 6)
(bar 4 5 6)
(foo (cube 3) 1)
```

What do these evaluate to?

Lambda Examples

```
(define cube (lambda (x) (* x x x)))
(define foo (lambda (p q) (+ p q)))
(define bar (lambda (a b c) (* a c)))
(cube 3)           --> (* 3 3 3)->27
(foo 5 6)          --> (+ 5 6) -> 11
(bar 4 5 6)        --> (* 4 6) -> 24
(foo (cube 3) 1)   --> ... -> 28
```

Lambda Lambda Lambda

- Consider these two functions:
  - **(define cube (lambda (x) (* x x x)))**
  - **(define cube (lambda (y) (* y y y)))**
- Are they different?
- Consider:
  - **(define nail (lambda (x y) (+ x y)))**
  - **(define polish (lambda (y x) (/ y x)))**
- What is:
  - **(polish (nail 6 4) 2)**

Do this now on paper!

Sally Hansen does Lambda

```
(define nail (lambda (x y) (+ x y)))
(define polish (lambda (y x) (/ y x)))
(polish (nail 6 4) 2)
```

- This is a call to **polish** with tricky arguments.
- Recall the rule: evaluate the arguments first.
  - Argument 1: (nail 6 4) -> (+ x y) -> (+ 6 4) -> 10
  - Argument 2: 2 -> 2
- Now take **polish**'s body, and replace the formal parameters with the actual arguments:
  - (/ y x) -> (/ 10 2) -> 5

Why not (/ 2 10) ?

If Examples

```
(if #t “yes” “no”)
(if #f “yes” “no”)
(if (< 3 5) “ant” “bat”)
(if (< 5 3) “cat” “dog”)
(if “x” “y” “z”)
(if (if 11 #f #t) 22 33)
```

What do these evaluate to?

If Examples

```
(if #t “yes” “no”)         -> “yes”
(if #f “yes” “no”)         -> “no”
(if (< 3 5) “ant” “bat”)   -> “ant”
(if (< 5 3) “cat” “dog”)   -> “dog”
(if “x” “y” “z”)           -> “y”
(if (if 11 #f #t) 22 33)   -> 33
```

Scheme Trickery

- (100 + 100)
  - Error: The expression in the first position must be a function (or something special like **if**). 100 is not a function.
- (if (not "batterie") "fouetté" "plié"))
  - "plié". **(not "batterie")** returns **#f**, because **"batterie"** is not **#f**.
    - (define (not v) (if v #f #t))
- Does (if *X* #t #f) always equal *X* ?
  - Yes for #t, #f, (< 3 5), (> 5 6).
  - No for 3, 17, "hello".

#25

Evaluating expressions and **Applying functions** are defined in terms of each other.

Without Eval, there would be no Apply, Without Apply there would be no Eval!

#26

Now You Know All of Scheme!

- Once you understand **Eval** and **Apply**, you can understand all Scheme programs!
- Except:
  - There are many primitives, and you need to know their predefined meaning.
  - There are a few more special forms (like **if**).
  - We have not define the evaluation rules precisely enough to unambiguously understand all programs (e.g., what does "value associated with a name" mean?).

#27

Now On To Problem Set 1

- Smooth transition ...

#28

brighter?

(define brighter? (lambda (color1 color2) (if (> (+ (get-red color1) (get-green color1) (get-blue color1)) (+ (get-red color2) (get-green color2) (get-blue color2)) #t #f)))

Is this correct?

Maybe...but very hard to tell. Your code should appear in a way that reveals its structure

#29

```
(define brighter?
  (lambda (color1 color2)
    (if (> (+ (get-red color1)
              (get-green color1)
              (get-blue color1))
           (+ (get-red color2)
              (get-green color2)
              (get-blue color2))
      #t #f)))
```

Use [Tab] in DrScheme to line up your code structurally!

#30

Brighter **brighter?**?

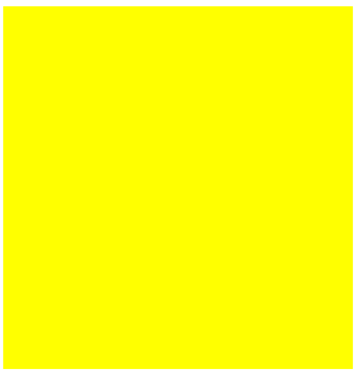
```
(define brighter?
   (lambda (color1 color2)
      (> (+ (get-red color1)
            (get-green color1)
            (get-blue color1))
         (+ (get-red color2)
            (get-green color2)
            (get-blue color2)))))
```

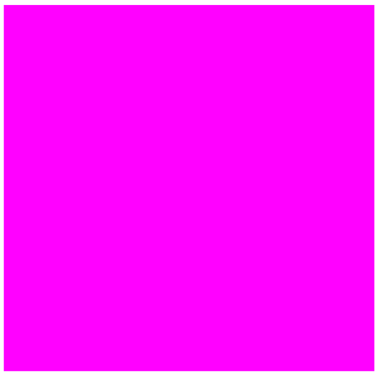
What can we do about this duplicated code?

Brighter **brighter?**?

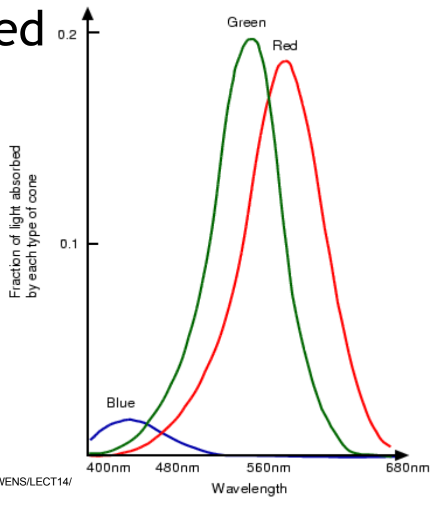
```
(define brightness
   (lambda (color)
      (+ (get-red color)
         (get-green color)
         (get-blue color))))

(define brighter?
   (lambda (color1 color2)
      (> (brightness color1)
         (brightness color2))))
```

Believable **brighter?**?


(make-color 255 255 0)


(make-color 255 1 255)

Color Absorbed



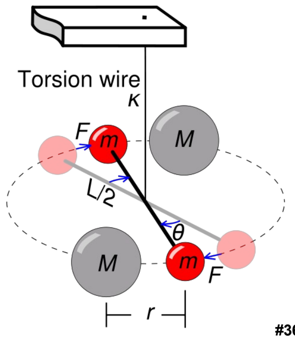
http://homepages.inf.ed.ac.uk/rbf/CVonline/LOCAL_COPIES/OWENS/LECT14/

Cognitive Scientist's Answer

```
(define brightness
   (lambda (color)
      (+ (* 0.299 (get-red color))
         (* 0.587 (get-green color))
         (* 0.114 (get-blue color)))))

(define brighter?
   (lambda (color1 color2)
      (> (brightness color1)
         (brightness color2))))
```

Liberal Arts Trivia: Physics

- This 1797 torsion balance experiment, sometimes called "weighing the earth", was the first to measure the force of gravity between masses in the laboratory, and the first to yield accurate values of the gravitational constant and thus the mass of the Earth.



Liberal Arts Trivia: Grab Bag

- Q. This series of music video games was produced by Konami in 1998. The series pioneered the rhythm and dance genre in video games. Players stand on a “dance platform” or stage and hit colored arrows laid out in a cross with their feet in time with musical and visual cues.

Liberal Arts Trivia: Drama

- This classical Athenian tragedy by Sophocles, first performed in BC 429, is widely considered a supreme masterpiece of the art of Drama. The Oracle at Delphi tells the protagonist that he is doomed to marry his mother and kill his father. He goes on to do so, but not before solving the riddle of the sphinx: What is the creature that walks on four legs in the morning, two legs at noon, and three in the evening? Name the play *and* answer the riddle.

What should you do if you can’t get your code to work?

- Keep trying: think of alternate approaches
- Get help from the TAs and your classmates
- But, if it's too late for that ...
  - **In your submission, explain what doesn’t work and as much as you can what you think is right and wrong**
- If you get less than 50% on the automatic adjudication part, the TAs will look over your source and give partial credit.

Evaluation Rules

- A formal review and study guide follows ...

Primitive Expressions

Expression ::= *PrimitiveExpression*
PrimitiveExpression ::= ***Number***
PrimitiveExpression ::= **#t** | **#f**
PrimitiveExpression ::= ***Primitive Procedure***

Evaluation Rule 1: Primitive. If the expression is a *primitive*, it evaluates to its pre-defined value.

```
> +
#<primitive:+>
```

Name Expressions

Expression ::= *NameExpression*
NameExpression ::= ***Name***

Evaluation Rule 2: Name. If the expression is a *name*, it evaluates to the value associated with that name.

```
> (define two 2)
> two
2
```

Definitions

Definition ::= **(define** ***Name*** *Expression***)**

Definition Rule. A definition evaluates the *Expression*, and associates the value of *Expression* with *Name*.

```
> (define dumb (+ + +))
+: expects type <number> as 1st argument, given: #<primitive:+>;
other arguments were: #<primitive:+>
> dumb
reference to undefined identifier: dumb
```

Application Expressions

Expression ::= *ApplicationExpression*
ApplicationExpression ::= (*Expression MoreExpressions*)
MoreExpressions ::= ε | *Expression MoreExpressions*

Evaluation Rule 3: Application. To evaluate an application expression:
a. Evaluate all the subexpressions;
b. Then, **apply** the value of the first subexpression to the values of the remaining subexpressions.

Rules for Application

- **Primitive.** If the procedure to apply is a *primitive*, just do it.
- **Constructed Procedure.** If the procedure is a *constructed (lambda) procedure*, **evaluate** the body of the procedure with each formal parameter replaced by the corresponding actual argument expression value.

Constructing Procedures: Lambda

Expression ::= *ProcedureExpression*
ProcedureExpression
::= **(lambda (***Parameters***)** *Expression***)**
Parameters ::= ε | ***Name*** *Parameters*

Evaluation Rule 4: Lambda. Lambda expressions evaluate to a procedure that takes the given *Parameters* as inputs and has the *Expression* as its body.

Applying Constructed Procedures

Application Rule 2: Constructed Procedure. If the procedure is a *constructed (lambda) procedure*, **evaluate** the body of the procedure with each formal parameter replaced by the corresponding actual argument expression value.

Applying Constructed Procedures

Application Rule 2: Constructed Procedure. If the procedure is a *constructed procedure*, **evaluate** the body of the procedure with each formal parameter replaced by the corresponding actual argument expression value.

```
> ((lambda (n) (+ n 1)) 2)
```

↓ Evaluation Rule 3a: evaluate the subexpressions

((lambda (n) (+ n 1)) 2)

↓ Evaluation Rule 3b, Application Rule 2

(+ 2 1)

↓ Evaluation Rule 3a, 3b, Application Rule 1

3

Evaluation Rule 5: If

Expression ::= **(if** *Expression*$_{\text{Predicate}}$
Expression$_{\text{Consequent}}$
Expression$_{\text{Alternate}}$**)**

Evaluation Rule 5: If. To evaluate an if expression:

- Evaluate the predicate expressions.
- If it evaluates to #f, the value of the if expression is the value of alternate expression. Otherwise, the value of the if expression is the value of consequent expression.

Lambda Example: Tautology Function

```
(lambda      make a procedure
 ()          with no parameters
 #t)         with body #t
```

```
> ((lambda () #t) 150)
#<procedure>: expects no arguments, given 1: 150
> ((lambda () #t))
#t
> ((lambda (x) x) 150)
150
```

Homework

- (In theory) You now know everything you need for PS1, PS2, PS3 and PS4 ...
- Honor Pledge due today (now!)
- Problem Set 1 due Monday September 6
  - ... at 3:30pm