CS 2010
Computer Science I

Instructor: **Matthew Flatt**

This Course is About...

Fundamentals of programming

- From specification to implementation
- Software engineering principles

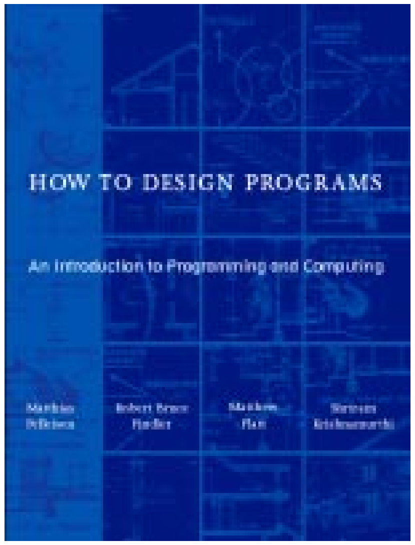
This Course is...

Not about...

- A particular programming language (e.g., Java, C++, Scheme)
- A particular programming tool (e.g., gcc, DrScheme)
- Specific libraries or protocols (e.g., Gtk, XML, HTTP)
- How programs get translated into electronic signals

Book

How to Design Programs



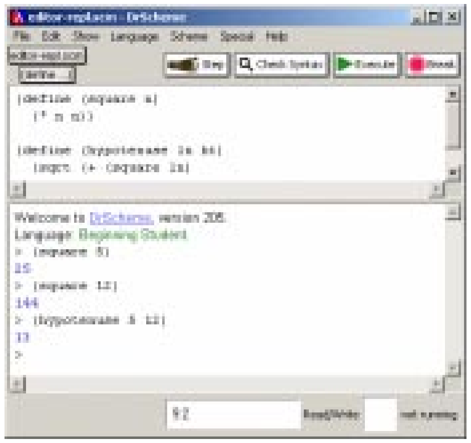
HOW TO DESIGN PROGRAMS

An Introduction to Programming and Computing

Matthias Felleisen · Robert Bruce Findler · Matthew Flatt · Shriram Krishnamurthi

Programming Environment

DrScheme


editor-repl.scm - DrScheme
File Edit Show Language Scheme Special Help
Step
Check Syntax
Execute
Break
Read/Write
not running

```
(define (square n)
  (* n n))

(define (hypotenuse a b)
  (sqrt (+ (square a)
```

```
Welcome to DrScheme, version 208.
Language: Beginning Student.
> (square 5)
25
> (square 12)
144
> (hypotenuse 5 12)
13
>
```

What is Scheme?

- **Scheme** is a programming language
  - Used to implement DrScheme, for example
- The language for this course matches a subset of Scheme
- The course content is not Scheme-specific

Pragmatics

- MWF lecture
- Th/F lab sessions (3%)
- Weekly programming assignments (47%)
- Two mid-term exams (15% each)
- Final exam (20%)

`http://www.cs.utah.edu/classes/cs2010/`

Things you Need to Do

- Read the course syllabus
- Subscribe to **`cs2010@cs.utah.edu`**
  - See the course web page for instructions
- Go to lab this week
- Do assignment 1
  - On the course schedule page

Friday

No class on Friday, August 22

Getting Started:

Arithmetic, Algebra, and Computing

Arithmetic is Computing

- Fixed, pre-defined rules for ***primitive operators***:

$$2 + 3 = 5$$

$$4 \times 2 = 8$$

$$\cos(0) = 1$$

Arithmetic is Computing

- Fixed, pre-defined rules for ***primitive operators***:

$$2 + 3 \rightarrow 5$$

$$4 \times 2 \rightarrow 8$$

$$\cos(0) \rightarrow 1$$

- Rules for combining other rules:
  - Evaluate sub-expressions first

$$4 \times (2 + 3) \rightarrow 4 \times 5 \rightarrow 20$$

  - Precedence determines subexpressions:

$$4 + 2 \times 3 \rightarrow 4 + 6 \rightarrow 10$$

Algebra as Computing

- Definition:

  f(x) = cos(x) + 2

- Expression:

  f(0) $\rightarrow$ cos(0) + 2 $\rightarrow$ 1 + 2 $\rightarrow$ 3

- First step uses the ***substitution*** rule for functions

Notation

- Why do some primitive operators go in the middle, like +, while others go at the front, like cos?
- What are the precedence rules?
- How do we know which arguments go with which operators?
- Which parentheses are redundant?
- When does = mean definition and when does it mean a computation step?
- ...

Simplified Expression Notation

- Put all operators at the front
- Start every operation with an open parenthesis
- Put a close parenthesis after the last argument
- Never add extra parentheses

Old	New
1 + 2	`(+ 1 2)`
4 + 2 × 3	`(+ 4 (* 2 3))`
cos(0) + 1	`(+ (cos 0) 1)`

Simplified Definition Notation

- Use the keyword **`define`** instead of =
- Put **`define`** at the front, and group with parentheses
- Move open parenthesis from after function name to before

Old	New
f(x) = cos(x) + 2	`(define (f x) (+ (cos x) 2))`

- Move open parenthesis in function calls

Old	New
f(0)	`(f 0)`
f(2+3)	`(f (+ 2 3))`

Evaluation is the Same as Before

```
(define (f x) (+ (cos x) 2))

(f 0)
```

Evaluation is the Same as Before

```
(define (f x) (+ (cos x) 2))

(f 0)
 → (+ (cos 0) 2)
```

Evaluation is the Same as Before

```
(define (f x) (+ (cos x) 2))

(f 0)
 → (+ (cos 0) 2)
 → (+ 1 2)
```

Evaluation is the Same as Before

```
(define (f x) (+ (cos x) 2))

(f 0)
 → (+ (cos 0) 2)
 → (+ 1 2)
 → 3
```

Beyond Numbers: Booleans

Numbers are not the only kind of values:

Old	New
$1 < 2 \rightarrow$ true	`(< 1 2)` $\rightarrow$ `true`
$1 > 2 \rightarrow$ true	`(> 1 2)` $\rightarrow$ `false`
$1 > 2 \rightarrow$ true	`(> 1 2)` $\rightarrow$ `false`
$2 \geq 2 \rightarrow$ true	`(>= 1 2)` $\rightarrow$ `true`

Beyond Numbers: Booleans

Old	New
true and false	`(and true false)`
true or false	`(or true false)`
$1 < 2$ and $2 > 3$	`(and (< 1 2) (> 2 3))`
$1 \leq 0$ and $1 = 1$	`(or (<= 1 0) (= 1 1))`
$1 \neq 0$	`(not (= 1 0))`

Beyond Numbers: Symbols

(symbol=? 'apple 'apple) $\rightarrow$ true

(symbol=? 'apple 'banana) $\rightarrow$ false

Beyond Numbers: Images

(solid-box 35 35 'red) $\rightarrow$ 🟥

(solid-dot 25 25 'blue) $\rightarrow$ 🔵

(image+ 🟥 🔵) $\rightarrow$

(offset-image+ 🟥 5 5 🔵) $\rightarrow$

(offset-masked-image+ 🟥 5 5 ● 🔵) $\rightarrow$

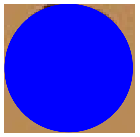
(image=? (image+ 🟥 🔵))

$\rightarrow$ (image=?)

$\rightarrow$ true

Programming with Images

```
(define (anonymize i)
  (offset-masked-image+
   i 0 0
   (solid-dot (image-width i) (image-height i)
              'black)
   (solid-dot (image-width i) (image-height i)
              'blue)))
```

(anonymize) → ... → 

Use the stepper to see all steps