Review & Computing with First-class Functions

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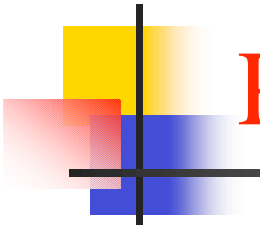
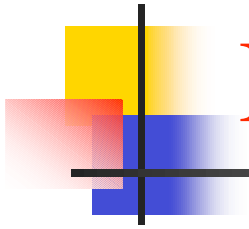


Plan for today

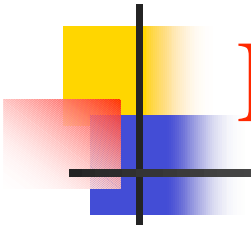
- Review of the design recipe including some in-class drill.
- Do `arrangements` problem in class
- More immersion in computing with functions as values.



Review: the Design Recipe

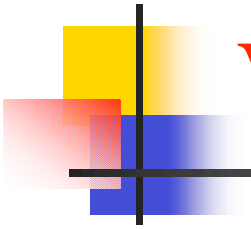
How should I go about writing programs?

- Analyze problem, which includes:
  - defining any requisite data types (and templates) that are not primitive;
  - determining what top-level (visible) functions must written.
- For each top-level function *f* to be written:
  1. State contract (type signature) and purpose of *f*.
  2. Give input-output examples for *f* written as tests
  3. Select and instantiate a template for the function body. In most cases, the template is simple structural recursion. Other common examples include:
     1. a degenerate template, e.g. trivial function, delegation to help function
     2. minor varations on structural recursion
        1. simultaneous structural recursion, e.g. adding two vectors represented as lists
        2. extra base cases, but often better handled by a help function, e.g. max of list
     3. a generative recursion template.
  4. Code the function by filling in the template
  5. Run the tests and confirm that they succeed.
- Writing a function may require help functions. Add these functions to the list of functions to be written. Use local? Perhaps.



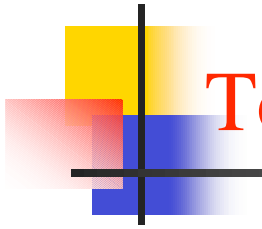
Extra Base Cases?

- ```
  ; fib: nat -> nat
  ; Purpose computes nth Fibonacci number
  (define (fib n)
    (cond [(= n 0) 1)]
          [(= n 1) 1)]
          [else (+ (fib (- n 1)) (fib (- n 2)))]))
  ```
- ```
  ; max-list: list-of-numbers -> number
  ; Purpose: (max-list lon) finds the maximum element in
  ;    lon; throws an error on the empty list
  (define (max-list lon)
    (local [(define (ml-help ans lon)
              (cond [(empty? lon) ans]
                    [(< ans (first lon)) (ml-help (first lon) (rest lon))]
                    [else (ml-help ans (rest lon))]))]
      (cond [(empty? lon) (error 'max-list "applied to empty")]
            [else (ml-help (first lon) (rest lon))])))
  ```



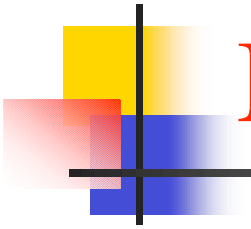
What goes in a template?

- Division into cases corresponding to an inductive definition of the data.
- Identification of recursive sub-problems (form of recursive calls)
- No calls on auxiliary functions or predicates other than those required for case analysis, such as:
  - testing that input has form assumed in contract
  - including logic from the "glue" code (what is inserted in the ellipsis of a properly written template)



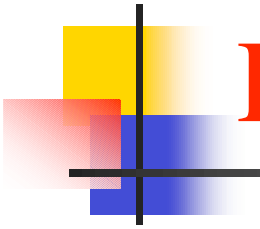
Template vs. Template Instantiation

- Template is part of a **data definition**
  - function name is generic
  - extra arguments to function are unspecified
- Template Instantiation is a prelude to writing a specific function. After you select the appropriate template, you tailor it to the function you are writing:
  - function name is specific
  - extra argument are specified in header and in recursive calls if possible
- Nothing else appears in a template instantiation.



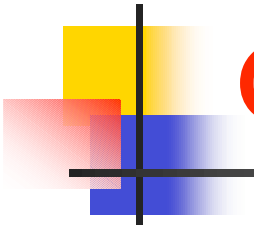
More review materials

- Homework problems
- Look at past first and second mid-terms from Comp 210, ignoring last 5 pages of 2nd exam which cover
  - Parsing
  - Graph traversal
  - Software engineering trade-off questions



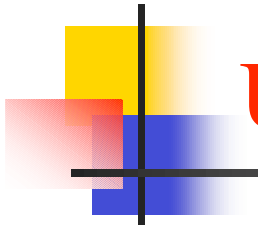
Exam Description

- Take home. Closed book. Closed computer.
- Don't worry about Scheme library functions. You will be given all of the operations you can use in coding.
- Three hours with optional 15 minute break in middle.



Class exercise

- Write insert-everywhere/in-all-words (problem 12.4.2 from HTDP)
- See link to 12.4.2.sol.ss on wiki



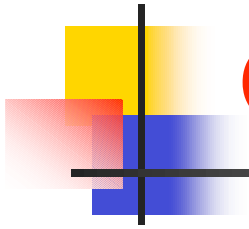
Using Functions to Represent Objects

- How can we represent a pair so that the only operations that code can perform on pairs are:

```
(create-pair x y)
(pair-first p)
(pair-second p)
(pair-equal? p1 p2)
```

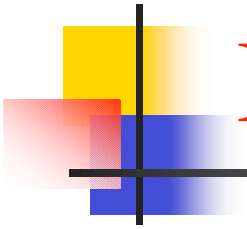
- What if we represent a pair as a list? As a struct? Structs are not as robust as you might think. In the advanced language level try:

```
(define-struct Pair (first second))
(define p (make-Pair 1 2))
(set-Pair-first! P 17)
p
```



Objects as closures

```
(define (make-pair x y)
  (lambda (msg)
    (cond [(equal? msg 'first) (lambda () x)]
          [(equal? msg 'second) (lambda () y)]
          [(equal? msg 'equal)
           (lambda (p)
             (and (equal? (pair-first p) x)
                  (equal? (pair-second p) y)))])))
(define (pair-first p) ((p 'first)))
(define (pair-second p) ((p 'second)))
(define (pair-equal? p1 p2) ((p1 'equal) p2))
```



For Next Class

- New Homework due Monday
- Labs today and tomorrow
- Reading: review for the exam.