CS 251 Spring 2020
Principles of Programming Languages
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Higher-order Functions

+hof.rkt

Topics

- Functions are first-class.
- Using first-class/higher-order functions
- Map and filter

- Later: getting the semantics right

First-class and higher order functions

Functions are **first-class values**, can be used or created *wherever* we use or create any other values:

- Arguments to (*higher order*) function calls
- Results of (*higher order*) function bodies
- Stored in cons cells or other data structures
- Bound (named) by variables
- ...

Higher order functions take or return other functions.

Powerful ways to:

- *factor out* common functionality
- parameterize general patterns with specific behavior

Function closures support lexical scope for nested functions.

Sneak peak:

- Function bodies can use any bindings in scope where function is defined, *including from outside the function definition*.
- Distinct concept from *first-class functions*
- Back to this powerful idea soon!

Functions as arguments: `hof.rkt`

```
(define (map-pair f pair)
   (cons (f (car pair)) (f (cdr pair))))
```

Elegant strategy for factoring out code for common patterns of data manipulation.

Combines well with anonymous functions.

See hof.rkt

A style point

~~`(if x #t #f)`~~

~~`(lambda (x) (f x))`~~

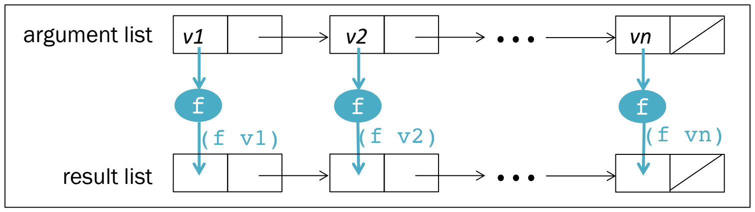
✗ `(n-times (lambda (x) (cdr x)) 2 (list 1 2 3 4))`

✓ `(n-times cdr 2 (list 1 2 3 4))`

HOF HOF

Map

```
(define (map f elems)
    (if (null? elems)
        null
        (cons (f (first elems))
              (map f (rest elems)))))
```



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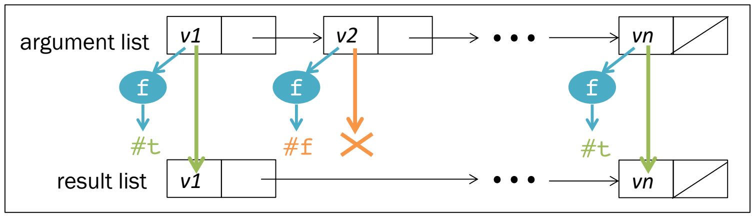
Filter

```
(define (filter f elems)
    (if (null? elems)
        null
        (if (f (first elems))
            (cons (first elems)
                  (filter f (rest elems)))
            (filter f (rest elems)))))
```



List practice with HOFs: `lists.rkt`

- Which functions could be built using map/filter?
- For which functions does this feel more or less elegant than your original implementation?

Generalizing

Our examples of first-class functions so far:

- Take one function as an argument to another function
- Process a number or a list

But first-class functions are useful anywhere for any kind of data

- Pass several functions as arguments
- Put functions in data structures (tuples, lists, etc.)
- Return functions as results
- Write higher-order functions that traverse other data structures

Powerful idioms to:

- factor out and reuse common functionality
- parameterize general patterns with specific behavior
- clearly communicate high-level meaning/intent