Mid-Term I

Mid-term I on Sept 22, in one week

- In-class
- Open-book
- Open-notes
- Closed-computer

HW 5 (Sept 17 - Sept 23) will be lighter than usual

Example Mid-Term

A pipe has a particular length, and it is made of some particular material, such as copper, lead, or plastic

A pipeline is a sequence of pipes

- Define data representations for pipes and pipelines
- Implement the function **`total-length`** which takes a pipeline and returns its total length
- Implement the function **`modernize`**, which replaces every **`'lead`** pipe in a pipeline with a **`'copper`** pipe of the same length

Actual exam may be shorter

Example solution on the web page

Outline

- **Sorting a List**
- **Multiple Complex Inputs**
- **Natural Numbers**

Sorting Lists

- Implement **`sort-list`**, which takes a list of numbers and returns a sorted list of the same numbers

Outline

- Sorting a List
- Multiple Complex Inputs
- Natural Numbers

Multiple Complex Arguments

- Implement **`append-lists`**, which takes two lists of numbers and returns a list with all of the numbers from the first list followed by all of the numbers from the second list
- Implement **`parallel-sum`**, which takes two lists of numbers (of the same length) and returns a list of sums
- Implement **`merge-lists`**, which takes two *sorted* lists of numbers and returns a sorted list with all of the numbers

```
; append-lists : list-of-num list-of-num -> list-of-num

(append-lists empty empty) "should be" empty

(append-lists (list 1 3 5) (list 0 4 6))
"should be" (list 1 3 5 0 4 6)
```

Multiple Complex Arguments

- Implement **`append-lists`**, which takes two lists of numbers and returns a list with all of the numbers from the first list followed by all of the numbers from the second list
- Implement **`parallel-sum`**, which takes two lists of numbers (of the same length) and returns a list of sums
- Implement **`merge-lists`**, which takes two *sorted* lists of numbers and returns a sorted list with all of the numbers

```
; parallel-sum : list-of-num list-of-num -> list-of-num

(parallel-sum empty empty) "should be" empty


(parallel-sum (list 1 3 5) (list 0 4 6))
"should be" (list 1 7 11)
```

Multiple Complex Arguments

- Implement **`append-lists`**, which takes two lists of numbers and returns a list with all of the numbers from the first list followed by all of the numbers from the second list
- Implement **`parallel-sum`**, which takes two lists of numbers (of the same length) and returns a list of sums
- Implement **`merge-lists`**, which takes two *sorted* lists of numbers and returns a sorted list with all of the numbers

```
; merge-lists : list-of-num list-of-num -> list-of-num

(merge-lists empty empty) "should be" empty

(merge-lists (list 1 3 5) (list 0 4 6))
"should be" (list 0 1 3 4 5 6)
```

Multiple Complex Arguments

- Implement **`append-lists`**, which takes two lists of numbers and returns a list with all of the numbers from the first list followed by all of the numbers from the second list
- Implement **`parallel-sum`**, which takes two lists of numbers (of the same length) and returns a list of sums
- Implement **`merge-lists`**, which takes two *sorted* lists of numbers and returns a sorted list with all of the numbers

```
; func : list-of-num list-of-num -> list-of-num
```

What template do we use for a function for *two* lists?

Multiple Complex Arguments

- Sometimes a complex argument is "along for the ride", so use the template for the other argument

```
(append-lists (list 1 3 5) (list 0 4 6))
"should be" (list 1 3 5 0 4 6)

(define (append-lists al bl)
  (cond
    [(empty? al) ...]
    [(cons? al)
     ... (first al)
     ... (append-lists (rest al) bl) ...]))
```

Multiple Complex Arguments

- Sometimes the arguments are exactly the same shape, so use essentially the one-argument template

```
(parallel-sum (list 1 3 5) (list 0 4 6))
"should be" (list 1 7 11)
```

```
(define (parallel-sum al bl)
  (cond
    [(empty? al) ...]
    [(cons? al)
     ... (first al) ... (first bl)
     ... (parallel-sum (rest al) (rest bl)) ...]))
```

Multiple Complex Arguments

- Sometimes you have to consider all possible combinations, so use a template that considers all combinations

```
(merge-lists (list 1 3 5) (list 0 4 6))
"should be" (list 0 1 3 4 5 6)
```

```
(define (merge-lists al bl)
  (cond
    [(and (empty? al) (empty? bl)) ...]
    [(and (empty? al) (cons? bl))
     ... (first bl) ... (merge-lists al (rest bl)) ...]
    [(and (cons? al) (empty? bl))
     ... (first al) ... (merge-lists (rest al) bl) ...]
    [(and (cons? al) (cons? bl))
     ... (first al) ... (first bl)
     ... (merge-lists (rest al) bl)
     ... (merge-lists al (rest bl))
     ... (merge-lists (rest al) (rest bl)) ...]))
```

Outline

- Sorting a List
- Multiple Complex Inputs
- Natural Numbers

Numbers to Generate Lists

- Implement **`create-list`**, which takes a non-negative integer *n* and produces a list of numbers from *n* to 0, inclusive

```
; create-list : num -> list-of-num

(create-list 3) "should be" (list 3 2 1 0)

(create-list 0) "should be" (list 0)
```

Numbers to Generate Lists

- Implement **`create-list`**, which takes a non-negative integer *n* and produces a list of numbers from *n* to 0, inclusive

```
; create-list : num -> list-of-num

(create-list 3) "should be" (list 3 2 1 0)

(create-list 0) "should be" (list 0)
```

The template for **num** isn't much help:

```
(define (func-for-num n)
  ...)
```

Numbers to Generate Lists

- Implement **`create-list`**, which takes a non-negative integer *n* and produces a list of numbers from *n* to 0, inclusive

```
; create-list : num -> list-of-num

(create-list 3) "should be" (list 3 2 1 0)

(create-list 0) "should be" (list 0)
```

The template for **`num`** isn't much help:

```
(define (func-for-num n)
  ...)
```

But **`create-list`** actually takes a ***natural number***

Natural Numbers

```
; A nat is either
;  - 0
;  - (add1 nat)
```

Examples:

```
0

(add1 0)

(add1 (add1 (add1 0)))
```

Natural Numbers

```
; A nat is either
;  - 0
;  - (add1 nat)
```

Examples:

```
0

(add1 0)

(add1 (add1 (add1 0)))
```

These examples have shortcuts

`0`, `1`, and `3`

but the long forms correspond to the template

Template for Natural Numbers

```
; A nat is either
;  - 0
;  - (add1 nat)

(define (func-for-nat n)
  (cond
    [(zero? n) ...]
    [else  ... (func-for-nat (sub1 n)) ...]))
```

Template for Natural Numbers

```
; A nat is either
;  - 0
;  - (add1 nat)

(define (func-for-nat n)
  (cond
    [(zero? n) ...]
    [else  ... (func-for-nat (sub1 n)) ...]))

(define (create-list n)
  (cond
    [(zero? n) (list 0)]
    [else  (cons n (create-list (sub1 n)))]))
```

Generating the List the Other Way

- Implement **`create-up-list`**, which takes a non-negative integer *n* and produces a list of numbers from 0 to *n* inclusive

```
; create-up-list : num -> list-of-num

(create-list 3) "should be" (list 0 1 2 3)

(create-list 0) "should be" (list 0)
```

Generating the List the Other Way

- Implement **`create-up-list`**, which takes a non-negative integer *n* and produces a list of numbers from 0 to *n* inclusive

```
; create-up-list : num -> list-of-num

(create-list 3) "should be" (list 0 1 2 3)

(create-list 0) "should be" (list 0)

(define (create-up-list n)
  (cond
    [(zero? n) (list 0)]
    [else
     ... n
     ... (create-up-list (sub1 n)) ...]))
; uh oh... can't cons onto recur result
```

Using Subtraction to Count Up

```
(define (create-up-list n)
  (create-up-to-n-list n n))

; Creates a list with d elements before n
(define (create-up-to-n-list d n)
  (cond
    [(zero? d) (list n)]
    [else
     (cons (- n d)
           (create-up-to-m-list (sub1 d) n))]))
```

Using Subtraction to Count Up

```
(define (create-up-list n)
  (create-up-to-n-list n n))

; Creates a list with d elements before n
(define (create-up-to-n-list d n)
  (cond
    [(zero? d) (list n)]
    [else
     (cons (- n d)
           (create-up-to-m-list (sub1 d) n))]))
```

... or replace **d** with **m = (+ d n)**

As **d** goes down, **m** goes up...

Counting Up Directly

```
(define (create-up-list n)
  (create-m-to-n-list 0 n))

; Creates a list from m to n
(define (create-m-to-n-list m n)
  (cond
    [(= m n) (list n)]
    [else
     (cons m
           (create-m-to-n-list (add1 m) n))]))
```

Counting Up Directly

```
(define (create-up-list n)
  (create-m-to-n-list 0 n))

; Creates a list from m to n
(define (create-m-to-n-list m n)
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    [(= m n) (list n)]
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Use the stepper to see how it works

Counting Up Directly

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    [(= m n) (list n)]
    [else
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           (create-m-to-n-list (add1 m) n))]))
```

Use the stepper to see how it works

Similar ideas work for counting by fives, counting down to 20, etc.