- **Helper Functions and Reuse**
- **Evaluation Rules for `cond`**
- **Design Recipe with `cond`**
- **Compound Data**

Designing Programs

Design recipe

- As outlined last lecture

Helper functions and reuse

- Writing writing a function, consider whether existing functions help
  - Example: `insert-at-middle` uses `middle`
- Look for functions that you wish you had written
  - Example: `same-person-maybe-disguised?` needs `wearing-beard?`

Another Example

Write the function **`bigger-image?`** which checks whether one image has more pixels than a second image

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```
; bigger-image? : image image -> bool
; Returns true if a has more pixels than b
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Write the function **`bigger-image?`** which checks whether one image has more pixels than a second image

```
; bigger-image? : image image -> bool
; Returns true if a has more pixels than b
(define (bigger-image? a b) ...)
```

Another Example

Write the function **bigger-image?** which checks whether one image has more pixels than a second image

```
; bigger-image? : image image -> bool
; Returns true if a has more pixels than b
(define (bigger-image? a b) ...)
```

```
(check-expect (bigger-image? ■ ■) true)
(check-expect (bigger-image? ■ ■) false)
```

Another Example

Write the function **bigger-image?** which checks whether one image has more pixels than a second image

```
; bigger-image? : image image -> bool
; Returns true if a has more pixels than b
(define (bigger-image? a b)
  (> (* (image-width a) (image-height a))
     (* (image-width b) (image-height b))))

(check-expect (bigger-image? ■ ■) true)
(check-expect (bigger-image? ■ ■) false)
```

Another Example

Write the function **bigger-image?** which checks whether one image has more pixels than a second image

```
; bigger-image? : image image -> bool
; Returns true if a has more pixels than b
(define (bigger-image? a b)
  (> (image-size a) (image-size b)))
```

```
(check-expect (bigger-image? ■ ■) true)
(check-expect (bigger-image? ■ ■) false)
```

Wish list: **image-size**

Another Example

Write the function **`bigger-image?`** which checks whether one image has more pixels than a second image

```
; bigger-image? : image image -> bool
; Returns true if a has more pixels than b
(define (bigger-image? a b)
  (> (image-size a) (image-size b)))
```

```
(check-expect (bigger-image? ■ ■) true)
(check-expect (bigger-image? ■ ■) false)
```

Wish list: **`image-size`**

Fullfill wishes by applying the recipe again

(exercise for the reader)

Reuse

We should be able to use **`bigger-image?`** to write the **`max-image`** function

Reuse

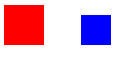
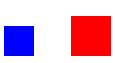
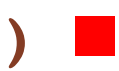
We should be able to use **`bigger-image?`** to write the **`max-image`** function

```
; max-image : image image -> image
; Returns a if a has more pixels than b,
; otherwise returns b
(define (max-image a b) ...)
```

Reuse

We should be able to use **bigger-image?** to write the **max-image** function

```
; max-image : image image -> image
; Returns a if a has more pixels than b,
; otherwise returns b
(define (max-image a b) ...)
```

```
(check-expect (max-image   )  )
(check-expect (max-image   )  )
```

Reuse

We should be able to use **`bigger-image?`** to write the **`max-image`** function

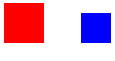
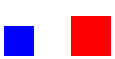
```
; max-image : image image -> image
; Returns a if a has more pixels than b,
; otherwise returns b
(define (max-image a b)
  ... (bigger-image? a b) ...)

(check-expect (max-image   )  )
(check-expect (max-image   )  )
```

Reuse

We should be able to use **`bigger-image?`** to write the **`max-image`** function

```
; max-image : image image -> image
; Returns a if a has more pixels than b,
; otherwise returns b
(define (max-image a b)
  ... (bigger-image? a b) ...)

(check-expect (max-image   )  )
(check-expect (max-image   )  )
```

Instead of returning a **`bool`**, we need to do one of two things, so we need **`cond`**

Recap: Conditionals in Racket

```
(cond
 [question answer]
 ...
 [question answer])
```

- Any number of **`cond`** "lines"
- Each line has one *question* expression and one *answer* expression

```
(define (absolute x)
  (cond
   [(> x 0) x]
   [else (- x)]))
```

```
(absolute 10) → 10

(absolute -7) → 7
```

Completing max-image

Use **cond** to complete **max-image**:

```
(define (max-image a b)
  (cond
   [(bigger-image? a b) a]
   [else b]))
```

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Evaluation Rules for cond

First question is literally `true` or `else`

```
(cond
 [true answer]
 ...
 [question answer])
```
→ *answer*

- Keep only the first answer

Example:

```
(* 1 (cond [true 0]))
```
→ `(* 1 0)` → `0`

Evaluation Rules for cond

First question is literally `false`

```
(cond
 [false answer]
 [question answer]   →   (cond
 ...                      [question answer]
 [question answer])       ...
                          [question answer])
```

- Throw away the first line

Example:

```
(+ 1 (cond          → (+ 1 (cond
       [false 1]                [true 17]))
       [true 17]))

                    → (+ 1 17) → 18
```

Evaluation Rules for cond

First question isn't a value, yet

```
(cond                          (cond
 [question answer]      →       [nextques answer]
 ...                            ...
 [question answer])             [question answer])
```

where *question* → *nextques*

- Evaluate first question as sub-expression

Example:

```
(+ 1 (cond          → (+ 1 (cond
       [(< 1 2) 5]              [true 5]
       [else 8]))               [else 8]))

                    → (+ 1 5) → 6
```

Evaluation Rules for cond

No true answers

(cond) → *error*

- **Helper Functions and Reuse**
- **Evaluation Rules for `cond`**
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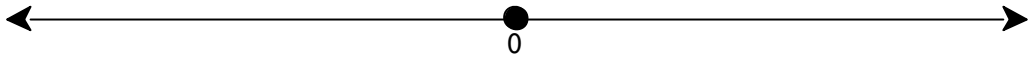
Examples

When the problem statement divides the input into several categories, test each one

Example:

Write the function **`line-part`** that determines whether a number is on zero, to the left, or to the right on a number line




```
(check-expect (line-part 0) "zero")
(check-expect (line-part -3) "left")
(check-expect (line-part 3) "right")
```

Body

When the problem statement divides the input into *N* categories:

- Start the body with a **`cond`** expression and *N* lines
- Formulate a question to recognize each category

Example:

Write the function **`line-part`** that determines whether a number is on zero, to the left, or to the right on a number line

Three cases, so three lines:

```
(define (line-part n)
  (cond
   [(= n 0) ...]
   [(< n 0) ...]
   [(> n 0) ...]))
```

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Dropping a Ball

Last time, we wrote **distance**:

```
; distance : num [positive] -> num
; Takes t seconds and report how far
; a ball has fallen in feet at that time
(define (distance t)
  (* 1/2 32 (expt t 2)))

(check-expect (distance 0) 0)
(check-expect (distance 1) 16)
(check-expect (distance 100) 160000)
```

Tossing a Ball

Suppose that we give the ball an initial velocity:

```
; toss : num num -> num
; With initial velocity v0 after t seconds,
; how far a ball is from its initial position
(define (toss v0 t)
  (+ (* v0 t) (distance t)))

(check-expect (toss 10 0) 0)
(check-expect (toss 10 1) 26)
(check-expect (toss -10 1) 6)
(check-expect (toss -32 1) -16)
```

Tossing a Ball Sideways

Suppose that we don't toss the ball straight up:

```
; toss-2d : num num num -> num num
```

Must return a single value

Correct contract:

```
; toss-2d : num num num -> posn
```

A `posn` is a ***compound value***

Positions

- A **posn** is

  (make-posn X Y)

  where **X** is a **num** and **Y** is a **num**

Examples:

(make-posn 1 2)

(make-posn 17 0)

A **posn** is a value, just like a number, symbol, or image

posn-x and posn-y

The **posn-x** and **posn-y** operators extract numbers from a **posn**:

```
(posn-x (make-posn 1 2)) → 1

(posn-y (make-posn 1 2)) → 2
```

- General evaluation rules for any **X** and **Y**:

```
(posn-x (make-posn X Y)) → X

(posn-y (make-posn X Y)) → Y
```

Positions and Values

Is `(make-posn 100 200)` a value?

Yes.

A `posn` is

`(make-posn X Y)`

where `X` is a `num` and `Y` is a `num`

Positions and Values

Is `(make-posn (+ 1 2) 200)` a value?

No. `(+ 1 2)` is not a `num`, yet.

- Two more evaluation rules:

```
(make-posn X Y) → (make-posn Z Y)
                  when X → Z

(make-posn X Y) → (make-posn X Z)
                  when Y → Z
```

Example:

```
(make-posn (+ 1 2) 200) →
(make-posn 3 200)
```

More Examples

Try these in DrRacket's stepper:

```
(make-posn (+ 1 2) (+ 3 4))

(posn-x (make-posn (+ 1 2) (+ 3 4)))

; pixels-from-corner : posn -> num
(define (pixels-from-corner p)
  (+ (posn-x p) (posn-y p)))
(pixels-from-corner (make-posn 1 2))

; flip : posn -> posn
(define (flip p)
  (make-posn (posn-y p) (posn-x p)))
(flip (make-posn 1 2))
```