Evaluation Rules for cond

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

First question is literally true or else

\[
\text{(cond}
\text{[true answer]} \quad \rightarrow \quad \text{answer}
\text{...}
\text{[question answer]})
\]

• Keep only the first answer
Evaluation Rules for cond

First question is literally \texttt{true} or \texttt{else}

\[
\text{(cond}\n\quad \text{[true answer]} \quad \rightarrow \text{answer} \\
\quad \ldots \\
\quad \text{[question answer]})
\]

- Keep only the first answer

Example:

\[
(+ 1 \text{ (cond} 
\quad \rightarrow (+ 1 1) \rightarrow 2 \\
\quad \text{[true 1]} \\
\quad \text{[false 0])})
\]
Evaluation Rules for cond

First question is literally true or else

\[
\text{(cond}
\begin{array}{l}
\text{[true \ \textit{answer}]} \quad \rightarrow \textit{answer} \\
\ldots
\end{array}
\text{[question \ \textit{answer}]})
\]

• Keep only the first answer

Example:

\[
(-1 \ \text{(cond} \\
\text{[true 0]} \\
\text{[(< 10 12) 10]} \\
\text{[(>= 10 12) 12]])}
\rightarrow (-1 0) \rightarrow 1
\]
Evaluation Rules for cond

First question is literally true or else

\[
\begin{align*}
\text{(cond} \\
\quad [\text{true answer}] & \rightarrow \text{answer} \\
\ldots \\
\quad [\text{question answer}])
\end{align*}
\]

• Keep only the first answer

Example:

\[
(* \ 1 \ (\text{cond} \rightarrow (* \ 1 \ 0) \rightarrow 0 \\
\quad [\text{true} \ 0]))
\]
Evaluation Rules for cond

First question is literally \textit{false}

\begin{verbatim}
(cond
  [false answer]
  [question answer]
  ...
  [question answer])
\end{verbatim}

• Throw away the first line
Evaluation Rules for cond

First question is literally \textit{false}

\begin{verbatim}
(cond [false answer] [question answer] ...
 [question answer])
\end{verbatim}

• Throw away the first line

Example:

\begin{verbatim}
(+ 1 (cond [false 1] [true 17]))
\end{verbatim}

\begin{verbatim}
→ (+ 1 17) → 18
\end{verbatim}
Evaluation Rules for cond

First question isn’t a value, yet

\[
\text{(cond}
\begin{array}{l}
[\text{question} \hspace{1em} \text{answer}] \\
\vdots \\
[\text{question} \hspace{1em} \text{answer}] \\
\end{array}
\text{)} \quad \rightarrow \quad \text{(cond}
\begin{array}{l}
[\text{nextques} \hspace{1em} \text{answer}] \\
\vdots \\
[\text{question} \hspace{1em} \text{answer}] \\
\end{array}
\text{)}
\]

where \text{question} \rightarrow \text{nextques}

• Evaluate first question as sub-expression
Evaluation Rules for cond

First question isn’t a value, yet

\[
\text{(cond}
\begin{array}{l}
\text{[question answer]} \\
\ldots \\
\text{[question answer]})
\end{array}
\rightarrow
\text{(cond}
\begin{array}{l}
\text{[nextques answer]} \\
\ldots \\
\text{[question answer]})
\end{array}
\]

where \text{question} \rightarrow \text{nextques}

• Evaluate first question as sub-expression

Example:

\[
(+ 1 \text{ (cond}
\begin{array}{l}
\text{[(< 1 2) 5]} \\
\text{[else 8]}))
\end{array})
\rightarrow (+ 1 \text{ (cond}
\begin{array}{l}
\text{[true 5]} \\
\text{[else 8]}))
\end{array})
\rightarrow (+ 1 5) \rightarrow 6
\]
Evaluation Rules for cond

No true answers

\[(\text{cond}) \rightarrow \text{error}\]

Just an else

\[(\text{cond}\n\text{[else answer]}) \rightarrow \text{answer}\]
➤ Evaluation Rules for cond
➤ Design Recipe with cond
➤ Helper Functions and Reuse
➤ Compound Data
Design Recipe I

**Data**

- Understand the input data: `num`, `bool`, `string`, or `image`

**Signature, Purpose, and Header**

- Describe (but don’t write) the function

**Examples**

- Show what will happen when the function is done

**Body**

- The most creative step: implement the function body

**Test**

- Run the examples
Examples

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

Write the function \textit{line-part} that determines whether a number is on zero, to the left, or to the right on a number line
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")
```
Design Recipe I

Data

• Understand the input data: **num**, **bool**, **string**, or **image**

Signature, Purpose, and Header

• Describe (but don’t write) the function

Examples

• Show what will happen when the function is done

Body

• The most creative step: implement the function body

Test

• Run the examples
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
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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
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:**

```scheme
(define (line-part n)
  (cond
    [(= n 0) ...]
    [(< n 0) ...]
    [(> n 0) ...]))
```
Evaluation Rules for cond
Design Recipe with cond
Helper Functions and Reuse
Compound Data
Designing Programs

Design recipe

• As outlined last lecture
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
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
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) ...)
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) ...)
Another Example

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

```scheme
; 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

```scheme
; 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)))
```

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

*Wish list: image-size*
Another Example

Write the function \texttt{bigger-image?} which checks whether one image has more pixels than a second image

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

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

\textit{Wish list: image-size}

Fullfill wishes by applying the recipe again
\textit{(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) ...)
```

```scheme
(check-expect (max-image ■ ■) ■)
(check-expect (max-image ■ ■) ■)
```
Reuse

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

```scheme
; 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) ...)
```

```scheme
(check-expect (max-image ■ ■) ■)
(check-expect (max-image ■ ■) ■)
```
Reuse

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

```scheme
; max-image : image image -> image
; Returns a if a has more pixels than b, otherwise returns b
(define (max-image a b)
  (cond
   [(bigger-image? a b) a]
   [else b]))
```

```scheme
(check-expect (max-image ■ ■) ■)
(check-expect (max-image ■ □) ■)
```
- Evaluation Rules for \( \text{cond} \)
- Design Recipe with \( \text{cond} \)
- Helper Functions and Reuse
- Compound Data
Positions

• A `posn` is

\[
\text{(make-posn X Y)}
\]

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

• A \texttt{posn} is

\begin{center}
\texttt{(make-posn \hspace{1em} X \hspace{1em} Y)}
\end{center}

where \texttt{X} is a \texttt{num} and \texttt{Y} is a \texttt{num}

Examples:

\begin{center}
\texttt{(make-posn \hspace{1em} 1 \hspace{1em} 2)}
\end{center}

\begin{center}
\texttt{(make-posn \hspace{1em} 17 \hspace{1em} 0)}
\end{center}
Positions

- A `posn` is

  \[(\text{make-posn } X \ Y)\]

  where \(X\) is a `num` and \(Y\) is a `num`

Examples:

  \[(\text{make-posn } 1 \ 2)\]

  \[(\text{make-posn } 17 \ 0)\]

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**:

\[(posn-x \ (make-posn \ 1 \ 2)) \rightarrow 1\]

\[(posn-y \ (make-posn \ 1 \ 2)) \rightarrow 2\]
posn-x and posn-y

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

\[
(posn-x \ (make-posn \ 1 \ 2)) \rightarrow 1 \\
(posn-y \ (make-posn \ 1 \ 2)) \rightarrow 2
\]

• General evaluation rules for any values `X` and `Y`:

\[
(posn-x \ (make-posn \ X \ Y)) \rightarrow X \\
(posn-y \ (make-posn \ X \ Y)) \rightarrow Y
\]
Positions and Values

Is (make-posn 100 200) a value?
Positions and Values

Is \(\text{make-posn}\ 100\ 200\) a value?

Yes.

A posn is

\(\text{make-posn}\ X\ Y\)

where \(X\) is a num and \(Y\) is a num
Positions and Values

Is \( \text{make-posn} \ (+ \ 1 \ 2) \ 200 \) a value?
Positions and Values

Is \[(\text{make-posn} \ (+ \ 1 \ 2) \ 200)\] a value?

\textbf{No.} \[(+ \ 1 \ 2)\] is not a \textit{num}, yet.
Positions and Values

Is \((\text{make-posn } (+ \ 1 \ 2) \ 200)\) a value?

\textbf{No.} \((+ \ 1 \ 2)\) is not a \texttt{num}, yet.

• Two more evaluation rules:

\[(\text{make-posn } X \ Y) \rightarrow (\text{make-posn } Z \ Y)\]
when \(X \rightarrow Z\)

\[(\text{make-posn } X \ Y) \rightarrow (\text{make-posn } X \ Z)\]
when \(Y \rightarrow Z\)
Positions and Values

Is \((\text{make-posn} \ (+ \ 1 \ 2) \ 200)\) a value?

\textbf{No.} \((+ \ 1 \ 2)\) is not a \texttt{num}, yet.

- Two more evaluation rules:

\[
(\text{make-posn} \ X \ Y) \rightarrow (\text{make-posn} \ Z \ Y) \quad \text{when } X \rightarrow Z
\]

\[
(\text{make-posn} \ X \ Y) \rightarrow (\text{make-posn} \ X \ Z) \quad \text{when } Y \rightarrow Z
\]

Example:

\[
(\text{make-posn} \ (+ \ 1 \ 2) \ 200) \rightarrow \\
(\text{make-posn} \ 3 \ 200)
\]
More Examples

Try these in DrRacket’s stepper:

\[(\text{make-posn} \ (+ \ 1 \ 2) \ (+ \ 3 \ 4))\]

\[(\text{posn-x} \ (\text{make-posn} \ (+ \ 1 \ 2) \ (+ \ 3 \ 4)))\]

; \text{pixels-from-corner} : \text{posn} \ \rightarrow \ \text{num}
\begin{align*}
\text{(define} & \ (\text{pixels-from-corner} \ \text{p}) \\
& \ (+ \ (\text{posn-x} \ \text{p}) \ (\text{posn-y} \ \text{p}))) \\
\text{(pixels-from-corner} & \ (\text{make-posn} \ 1 \ 2))
\end{align*}

; \text{flip} : \text{posn} \ \rightarrow \ \text{posn}
\begin{align*}
\text{(define} & \ (\text{flip} \ \text{p}) \\
& \ (\text{make-posn} \ (\text{posn-y} \ \text{p}) \ (\text{posn-x} \ \text{p}))) \\
\text{(flip} & \ (\text{make-posn} \ 1 \ 2))
\end{align*}