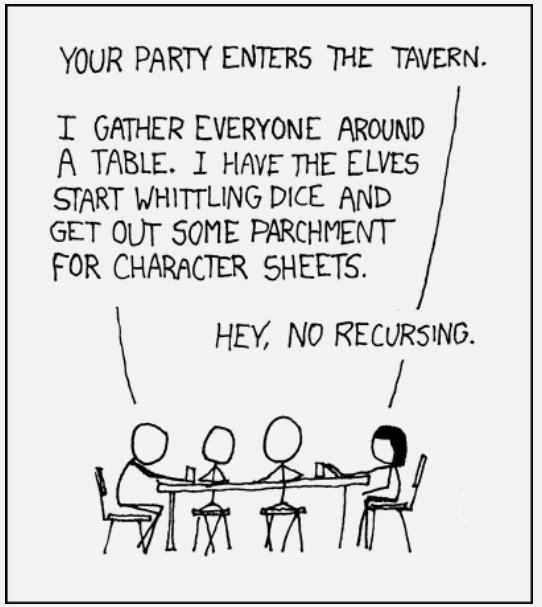
UMass Boston Computer Science

CS450 High Level Languages (section 2)

more Recursive Data Definitions

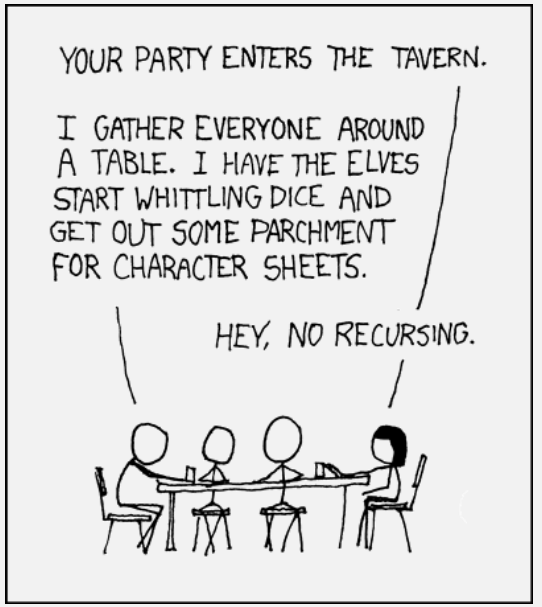
Wednesday, October 4, 2023



Logistics

- HW 3 out today
  - due: Sun 10/15 11:59 pm EST
  - (2 weeks)

- No class: next Monday 10/9
  - Indigenous Peoples Day

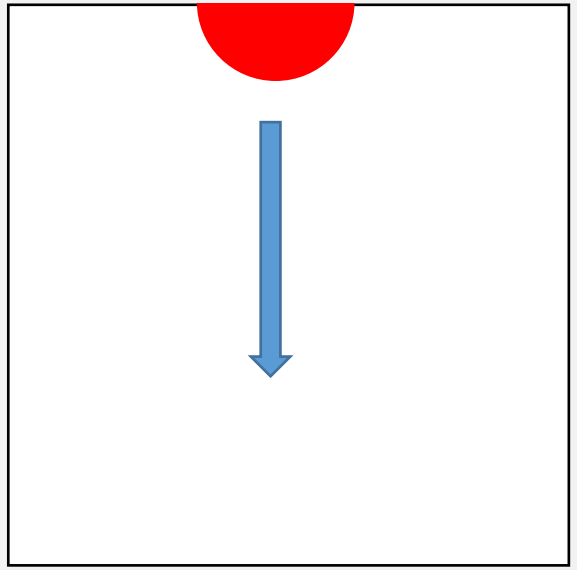


HW 1 recap (part 2)

```
;; A WorldState is a Non-negative Integer
;; Interp: Represents the y Coordinate of a
;;         ball (center) in `big-bang` animation
```

Your task: **Modify this**

(and then the code)



So ball …

HW 1 recap (part 2)

```
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;; Interp: Represents the y Coordinate of a
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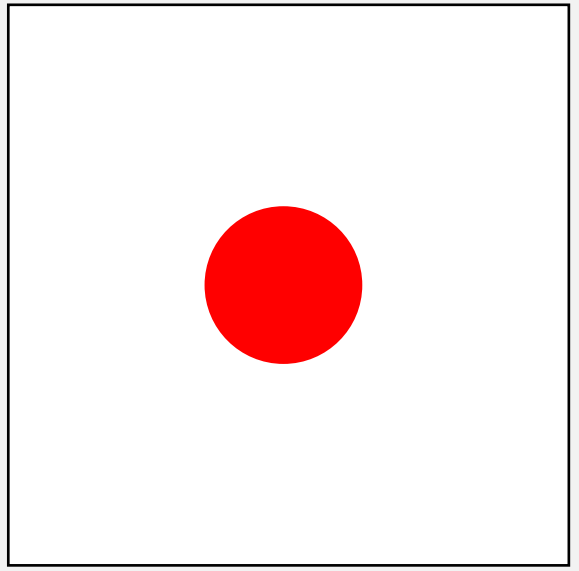
```



HW 1 recap (part 2)

```
;; A WorldState is a Non-negative Integer
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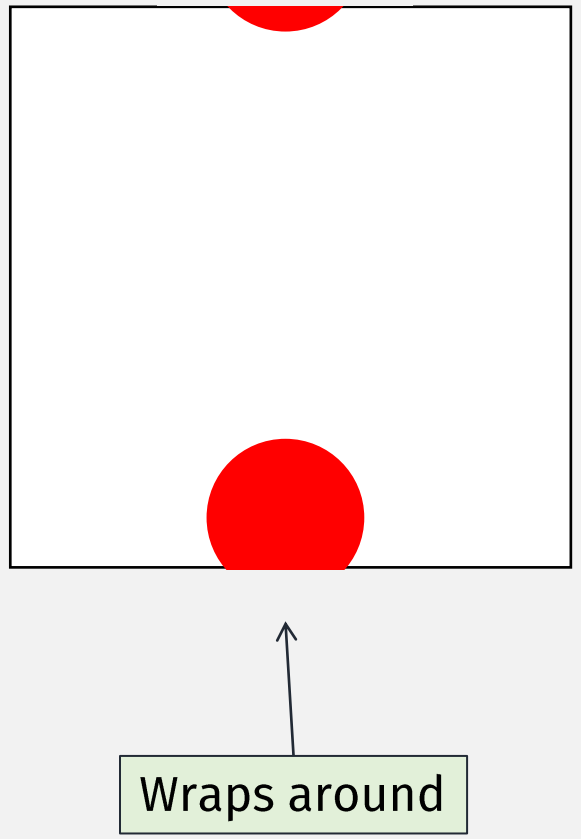
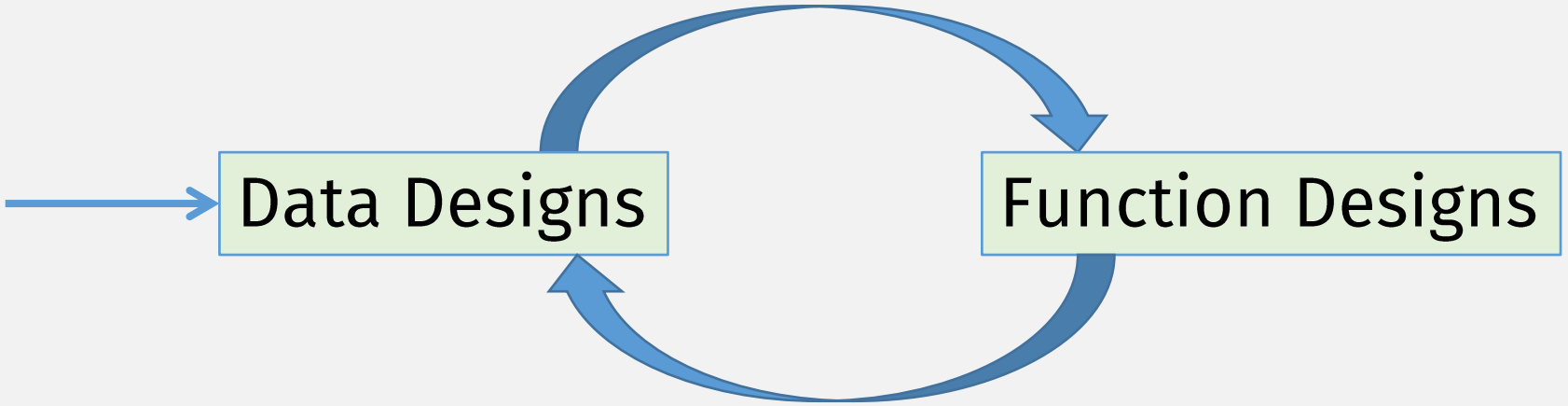


Program Design Recipe (initially)

1. Data Designs
2. Function Designs

Program Design Recipe (more accurately)



Function Design Recipe

1. **Name**
2. **Signature** – types of function input(s) and output
3. **Description** – explain (in English prose) function behavior
4. **Examples** – show (using `rackunit`) function behavior
5. **Template** – sketch out function structure (using input's Data Definition)
6. **Code** – implement rest of function (with arithmetic)
7. **Tests** – check (using `rackunit`) function behavior

Function Design Recipe

… is iterative!

1. **Name**
2. **Signature** – types of function input(s) and output
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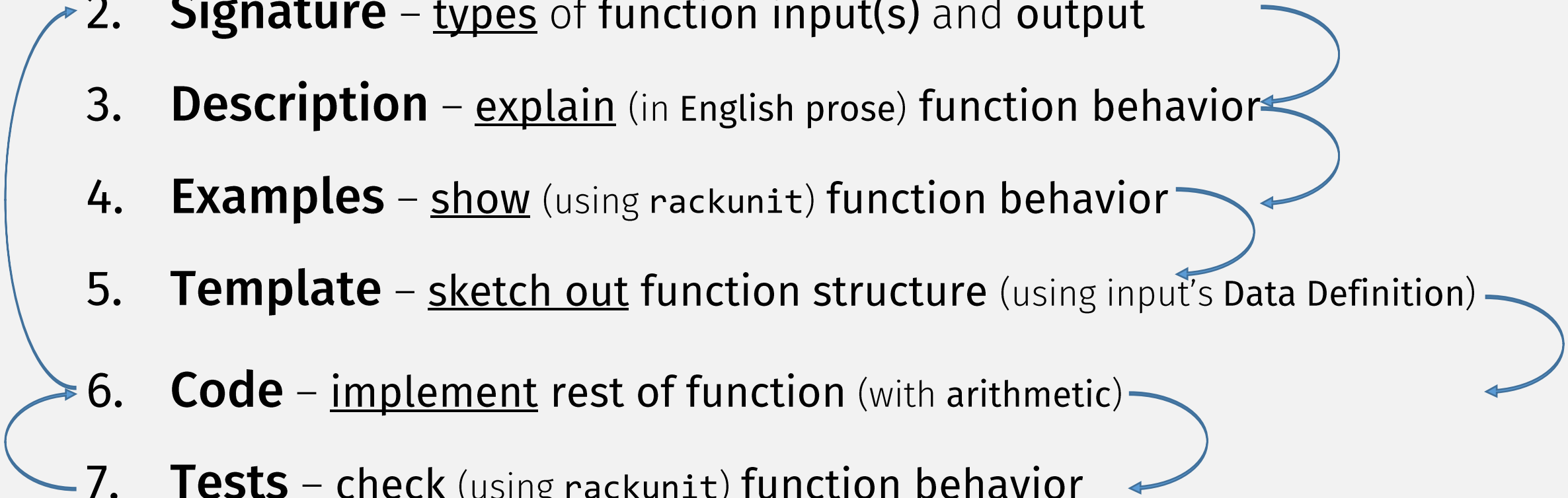

Function Design Recipe

1. **Name**
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Hw said **not** to jump directly to code step!

Most students jumped directly to code step!

Function Design Recipe

1. **Name**
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3. **Description** – explain (in English prose) function behavior
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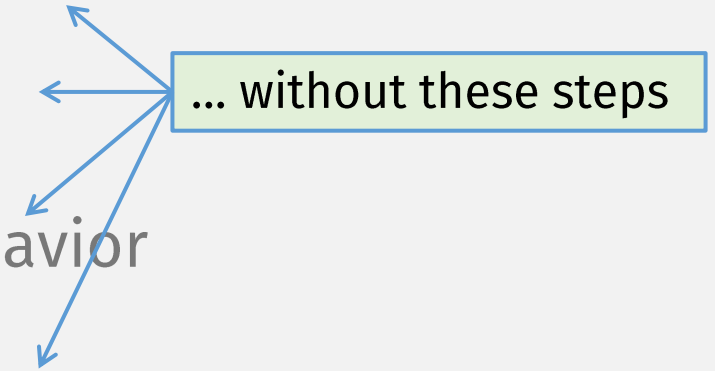
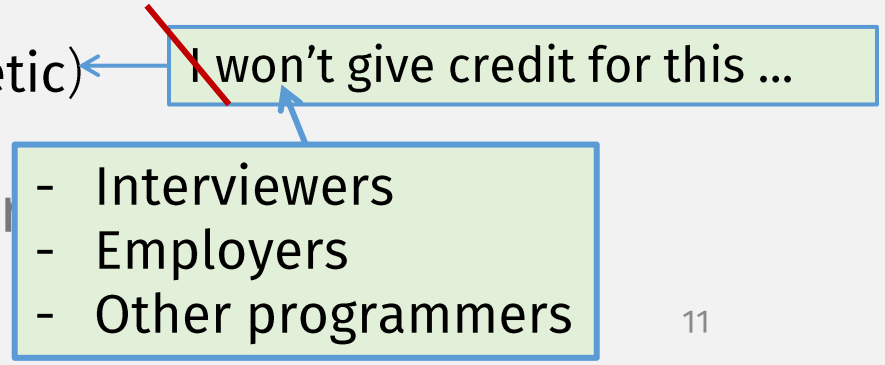


DON'T ONLY FOCUS ON CODE STEP!!!



- Focusing on code is bad because …
- … all code is wrong!
  - i.e., has bugs
- The only hope of fixing it is …
- … if it is readable by others!

Some Student Examples (sorry)

```
;; Draws a WorldState as a 2htdp/image Image
(define/contract (render-world w)
  (-> WorldState? Img?)
  (cond
       [(>= 150 w)
        (place-image
         BALL-IMG
         BALL-X w
         EMPTY-SCENE)]
       [(and (< 150 w) (>= 250 w))
        (place-image
         BALL-IMG
         BALL-X (- w 200)
         (place-image
         BALL-IMG
         BALL-X w
         EMPTY-SCENE))]))
```

What does it do?

Is it “correct”? (**NO**)

How would you fix it?

Some Student Examples (sorry)

```
;; render-world: WorldState -> Image
;; draws a WorldState as a 2htdp/image Image
(define/contract (render-world w)
  (-> WorldState? image?)
  (place-images (list BALL-IMG
                      BALL-IMG
                      BALL-IMG)
                (list (make-posn BALL-X w)
                      (make-posn BALL-X (- w WORLD-HEIGHT))
                      (make-posn BALL-X (+ w WORLD-HEIGHT)))
                EMPTY-SCENE))
```

What does it do?

Is it “correct”? (**NO**)

How would you fix it?

Some Student Examples (sorry)

```
;; render-world: WorldState -> Image
;; Draws a WorldState as a 2htdp/image Image
(define (render-world w)
  (place-image
   BALL-IMG
   BALL-X
   (+ (modulo w (+ WORLD-HEIGHT BALL-RADIUS)) BALL-RADIUS)
   (place-image
    BALL-IMG
    BALL-X
    (- 0 (- WORLD-HEIGHT (modulo w (+ WORLD-HEIGHT BALL-RADIUS))))
    EMPTY-SCENE)))
```

What does it do?

Is it “correct”? (**NO**)

How would you fix it?

Some Student Examples (sorry)

```
;; next-worldstate : WorldState -> WorldState
;; Each tick increments y pos by 1
(define (next-worldstate w)
  (if (= w WORLD-HEIGHT)
      0
      (add1 w)))
```

Wrong description!

Wrong style

Wrong code!

Some Student Examples (sorry)

```
;; next-worldstate : WorldState -> WorldState
;; Each tick increments y pos by 1
(define (next-worldstate w)
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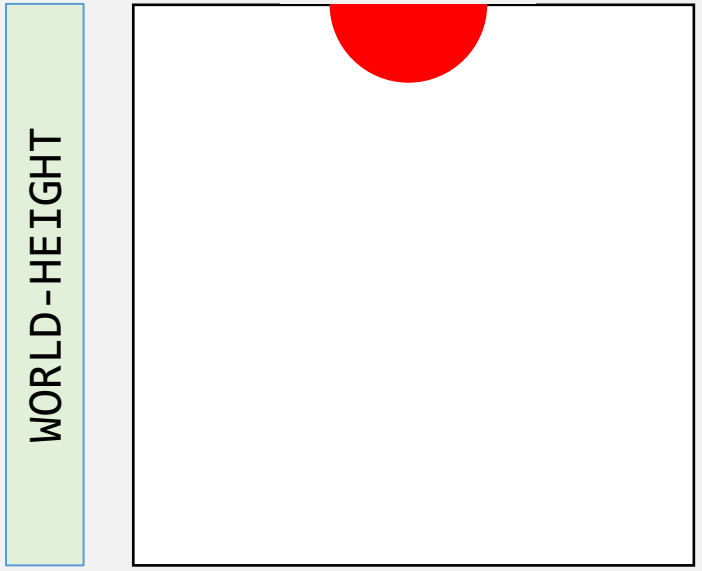

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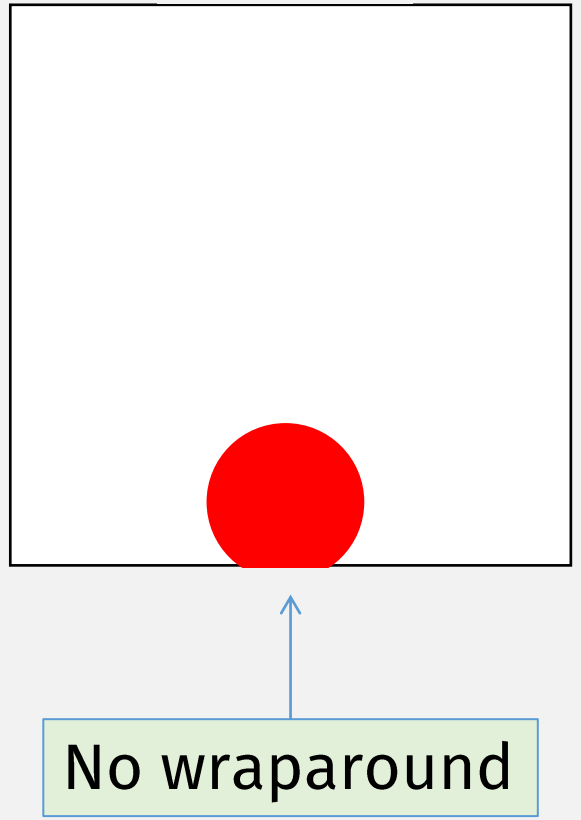

Some Student Examples (sorry)

```
;; next-worldstate : WorldState -> WorldState
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(define (next-worldstate w)
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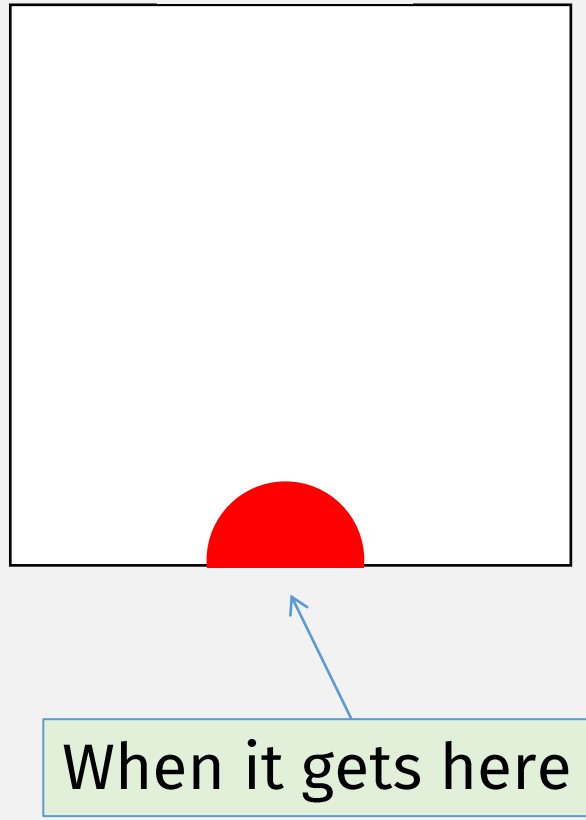
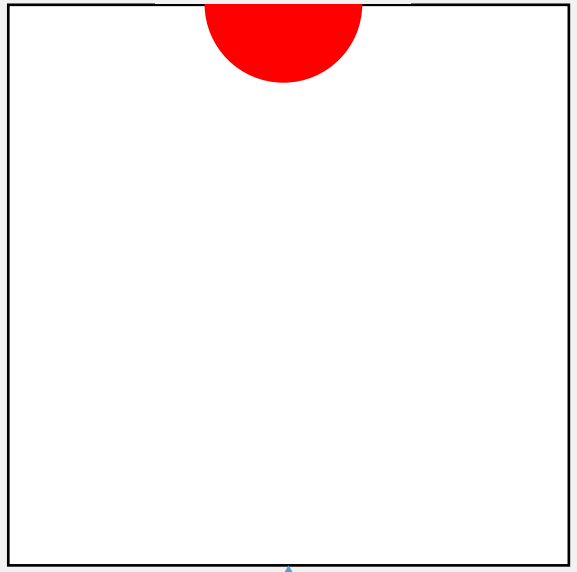


Some Student Examples (sorry)

Will jump back to here

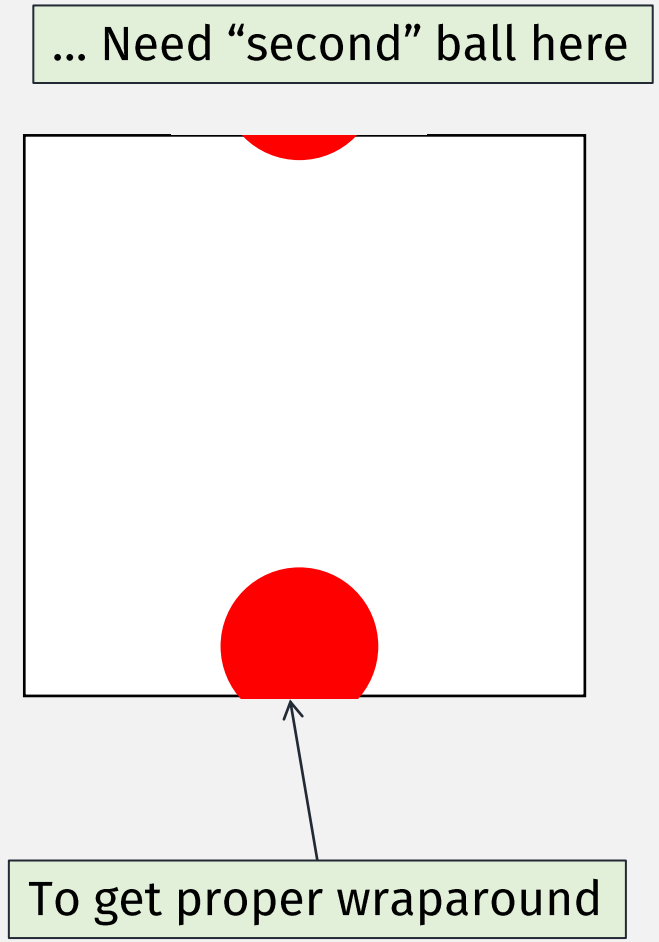
```
;; next-worldstate : WorldState -> WorldState
;; Each tick increments y pos by 1
(define (next-worldstate w)
  (if (= w WORLD-HEIGHT)
      0
      (add1 w)))
```



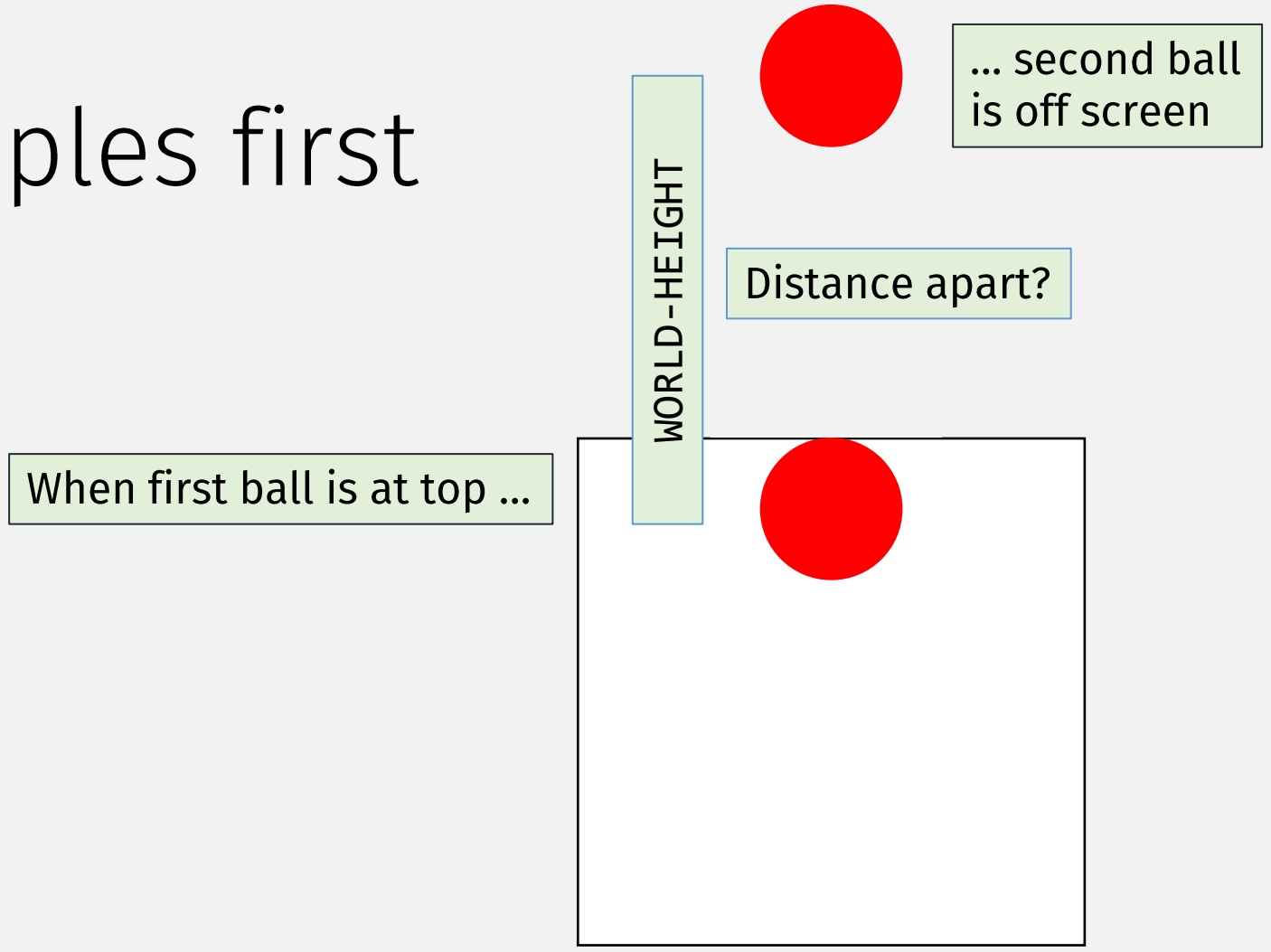
… but part of ball should still be here

(Guess how many students worked through examples before jumping to code???)

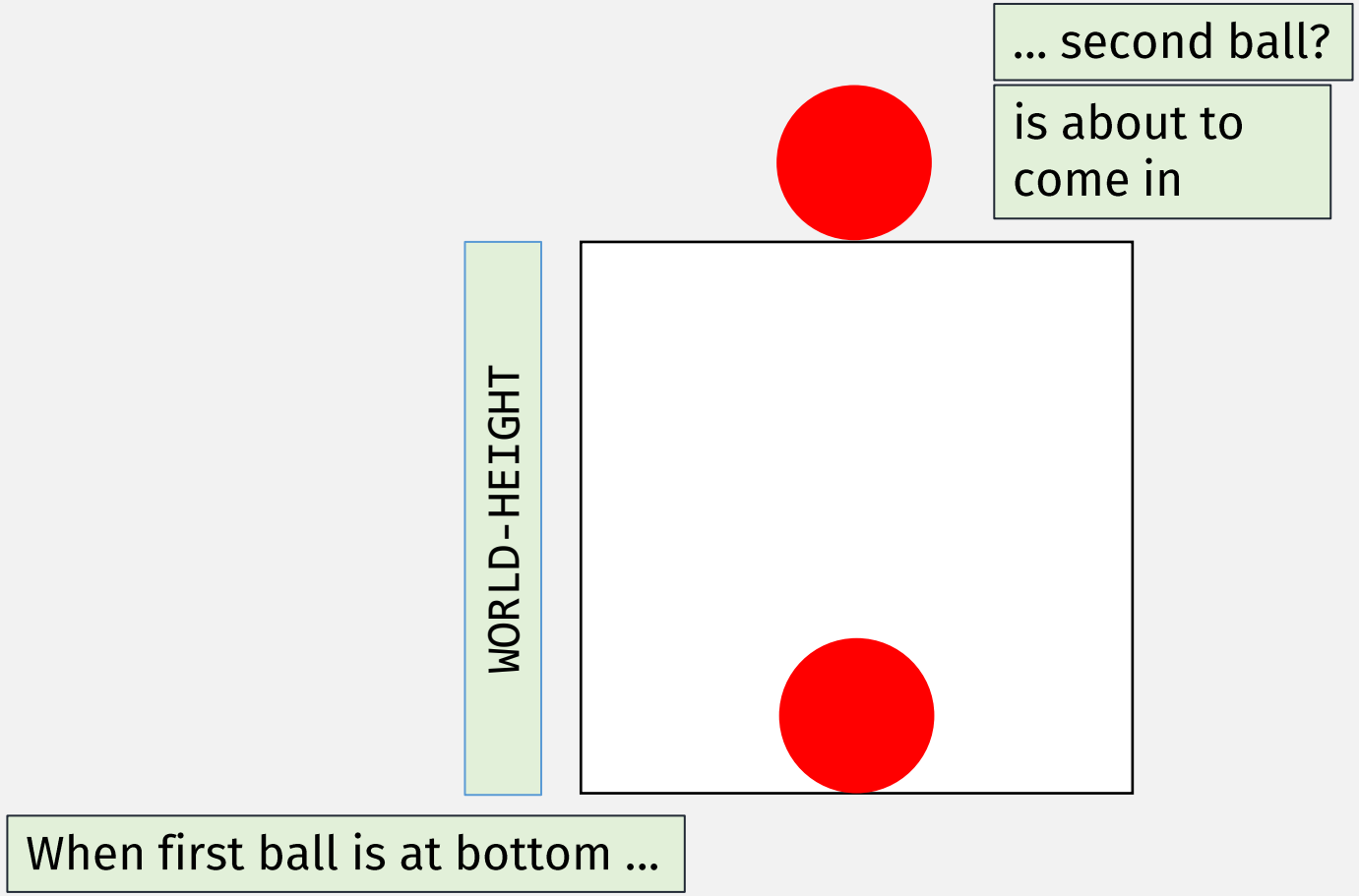
Start over … examples first



Start over … examples first

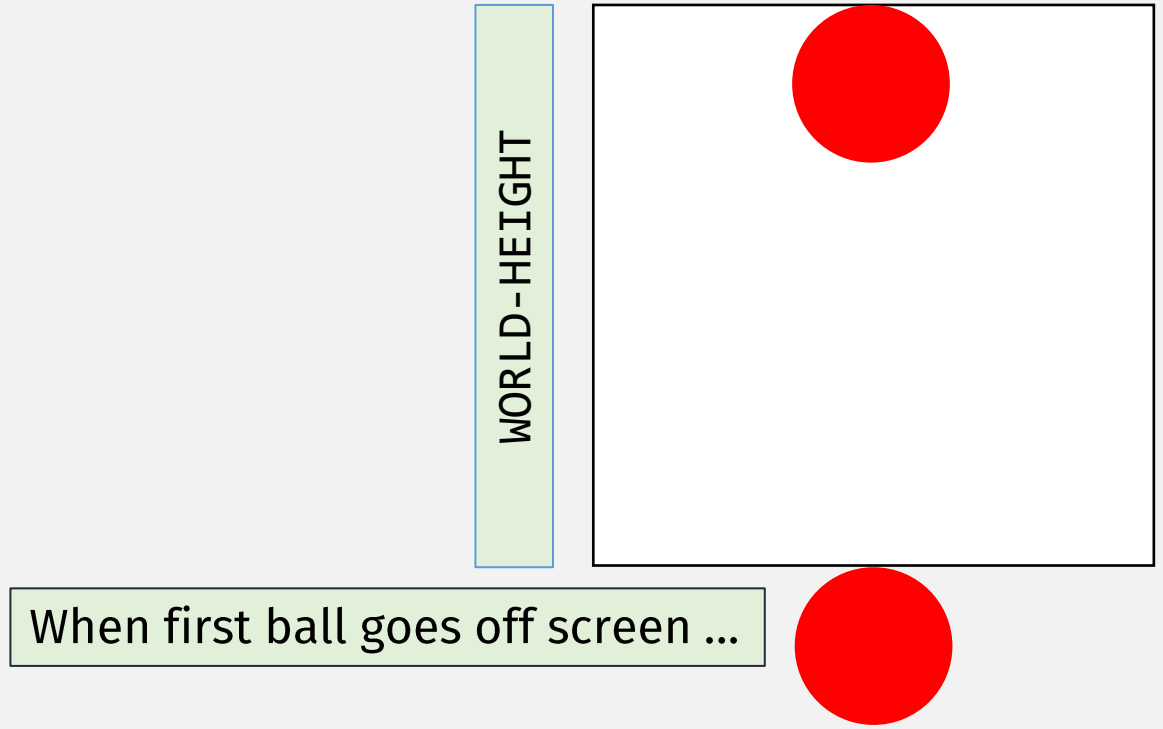


Examples: Corner cases



Examples: Corner cases

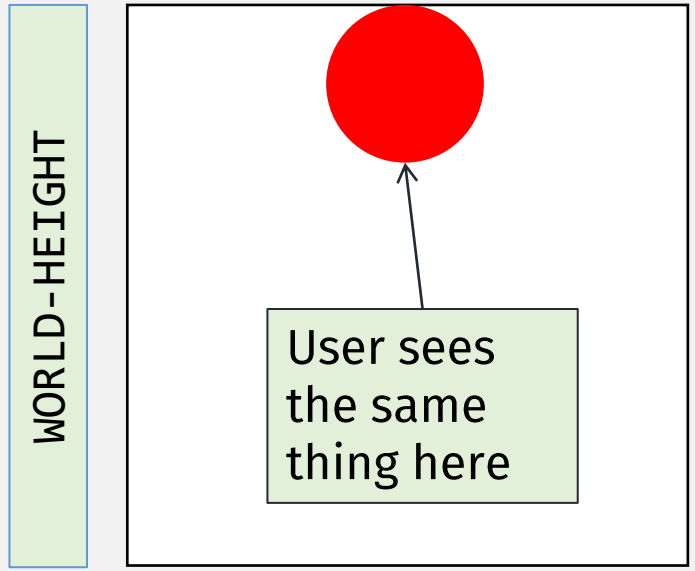
… second ball is fully in



When first ball goes off screen …

Examples: Corner cases

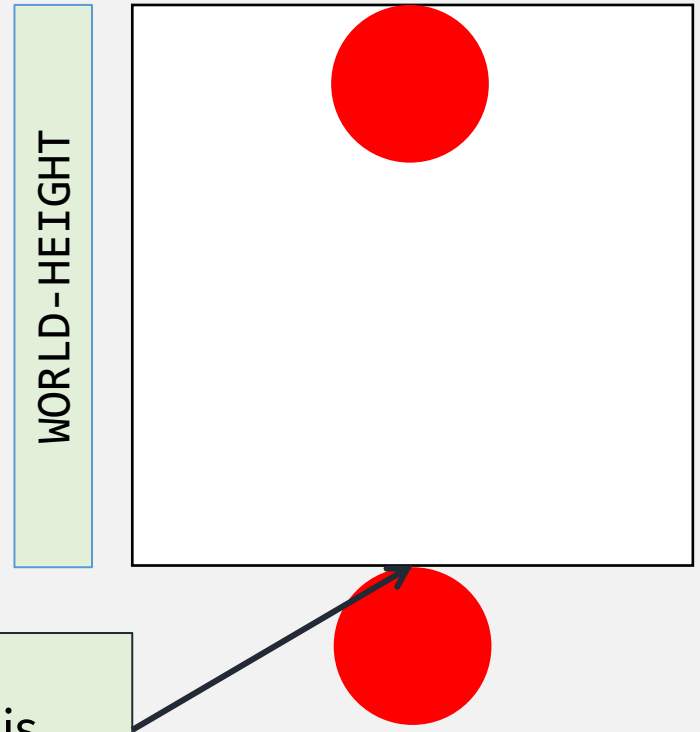
… So we can reset



Examples: Corner cases

```
;; A WorldState is a Non-negative Integer
;; Interp: Represents the y Coordinate of the center
;;         of a ball in a `big-bang` animation.
```

Top!



So we want to “reset” when **top** of first ball is just off screen

```
;; A Coordinate is a Non-Negative Integer
;; Interp: represents x or y coordinate in a big-bang animation
;;         where (0,0) origin is to left
```

```
;; A BallTop is a Coordinate Integer between [0 WORLD-HEIGHT]
;; Interp: Represents y coordinate of (the top of) a ball image.
;;         When any part of ball "falls off" bottom, it re-appears at the top.
```

```
;; A WorldState is a BallTop
(define INITIAL-WORLD 0)
```

original

```
;; next-world : WorldState -> WorldState
;; the next world state = prev worldstate + 1;
(define (next-world w)
  (add1 w))
```

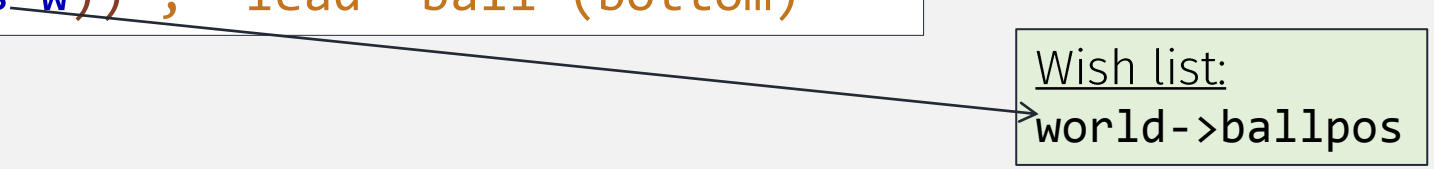
function description is still wrong

```
;; next-world : WorldState -> WorldState
;; the next world state = prev worldstate + 1;
(define (next-world w)
  (modulo (add1 w) WORLD-HEIGHT))
```

Reset to top

```
;; next-world : WorldState -> WorldState
;; the next world state = prev worldstate + 1;
;; reset to zero when the state gets to WORLD-HEIGHT
(define (next-world w)
  (modulo (add1 w) WORLD-HEIGHT))
```

```
;; render-world: WorldState -> Image
;; Draws a WorldState as a 2htdp/image Image
;; - Ball starts flush at top; wraps back to top when it “falls off” bottom.
;; - Use two ball imgs (“lead” and “follow” ball) to simulate "wraparound"
;; - when not wrapping, only "lead" ball is visible
(define (render-world w)
  (define lead-y
    (world->ballpos w)) ; "lead" ball (bottom)
```



Wish list:
`world->ballpos`

```
(define (render-world w)
  (define lead-y
    (world->ballpos w)) ; "lead" ball (bottom)
```

Wish list:
`world->ballpos`

```
;; world->pos: WorldState -> Coordinate
;; Computes y coordinate for ball center from the current WorldState (ball top)
```

```
(check-equal? (world->ballpos 0) BALL-RADIUS)
```

```
(define (world->ballpos w)
  (+ w BALL-RADIUS))
```

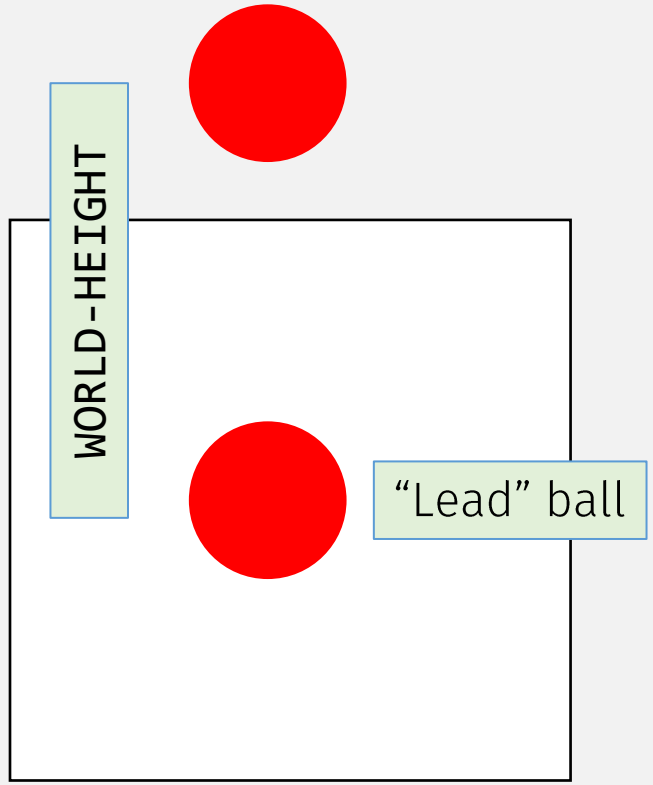
```
;; render-world: WorldState -> Image
;; Draws a WorldState as a 2htdp/image Image
;; - Ball starts flush at top; wraps back to top when it “falls off” bottom.
;; - Use two ball imgs (“lead” and “follow” ball) to simulate "wraparound“
;; - when not wrapping, only "lead" ball is visible
(define (render-world w)
  (define lead-y
    (world->ballpos w)) ; "lead" ball (bottom)
  (define follow-y
    (lead->follow lead-y)) ; "follow" ball
```

Wish list:

~~world->ballpos~~

lead->follow

Example




```
(define follow-y
  (lead->follow lead-y)) ; "follow" ball
```

lead->follow

```
;; lead->follow : Coord -> Coord
;; Given a y coord of “lead” ball, compute y
;; of “follow” ball, in wraparound animation
```

```
(define (lead->follow y)
  (- y WORLD-HEIGHT))
```

```
;; render-world: WorldState -> Image
;; Draws a WorldState as a 2htdp/image Image
;; - Ball starts flush at top; wraps back to top when it “falls off” bottom.
;; - Use two ball imgs (“lead” and “follow” ball) to simulate "wraparound“
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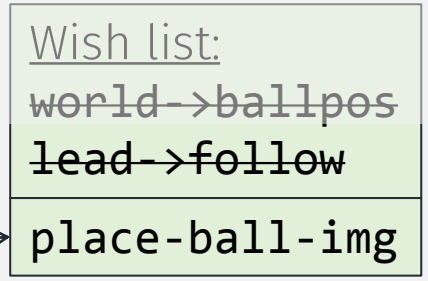
```

```
(define (render-world w)
  (define lead-y
    (world->ballpos w)) ; "lead" ball (bottom)
 (define follow-y
    (lead->follow lead-y)) ; "follow" ball
```

```
  (place-ball-img
   lead-y
   (place-ball-img
    follow-y
    EMPTY-SCENE)))
```



```
(define BALL-RADIUS 48)
(define BALL-X (/ WORLD-WIDTH 2)) ; ball only moves up/down, so x is constant
(define BALL-IMG
  (circle BALL-RADIUS "solid" "red"))
```

```
;; place-ball-img: Coordinate Image -> Image
;; Produces new img with ball img added to given Image,
;; at the specified y coord for ball center
(define (place-ball-img y img)
  (place-image BALL-IMG BALL-X y img))
```

place-ball-img

Moving on …

Predicates for Compound Data

```
;; A Ball is one of:
(struct ball [x y xvel yvel] #:transparent)
;; x : XCoord – ball center horiz coord in animation
;; y : Ycoord – ball center vert coord in animation
;; xvel : Velocity – ball horiz pixels/tick velocity
;; yvel : Velocity – ball vert pixels/tick velocity
```

Compound data predicates should be **"shallow"** checks, i.e., `ball?`

predicate?

`struct` already defines `ball?`, what about **fields?**

```
(define (Ball? arg)
  (and (ball? arg)
       (XCoord? (ball-x arg))
       (YCoord? (ball-y arg))
       (Velocity? (ball-xvel arg))
       (Velocity? (ball-yvel arg))))
```

???

This "deep" predicate checks too much …

… because it's the **job of "coordinate"** and **"velocity" processing functions** to **check those kinds of data**

Note:
Checked constructor ok

```
(define/contract (mk-ball x y xvel yvel)
  (-> XCoord? YCoord? Velocity? Velocity? ball?)
  (ball x y xvel yvel))
```

```
;; A ListofBalls is one of
;; - empty
;; - (cons Ball ListofBalls)
```

```
;; A WorldState is a ListofBalls
```

```
(define INITIAL-WORLD
  (list (random-ball)))
```

Not empty!

List Variations – Non-empty lists

```
;; A NEListofBalls (non-empty) is one of:

???
```

```
;; A WorldState is a NEListofBalls
```

List Variations – Non-empty lists

```
;; A NEListofBalls (non-empty) is one of:
;; - (cons Ball empty)
;; - (cons Ball NEListofBalls)
```

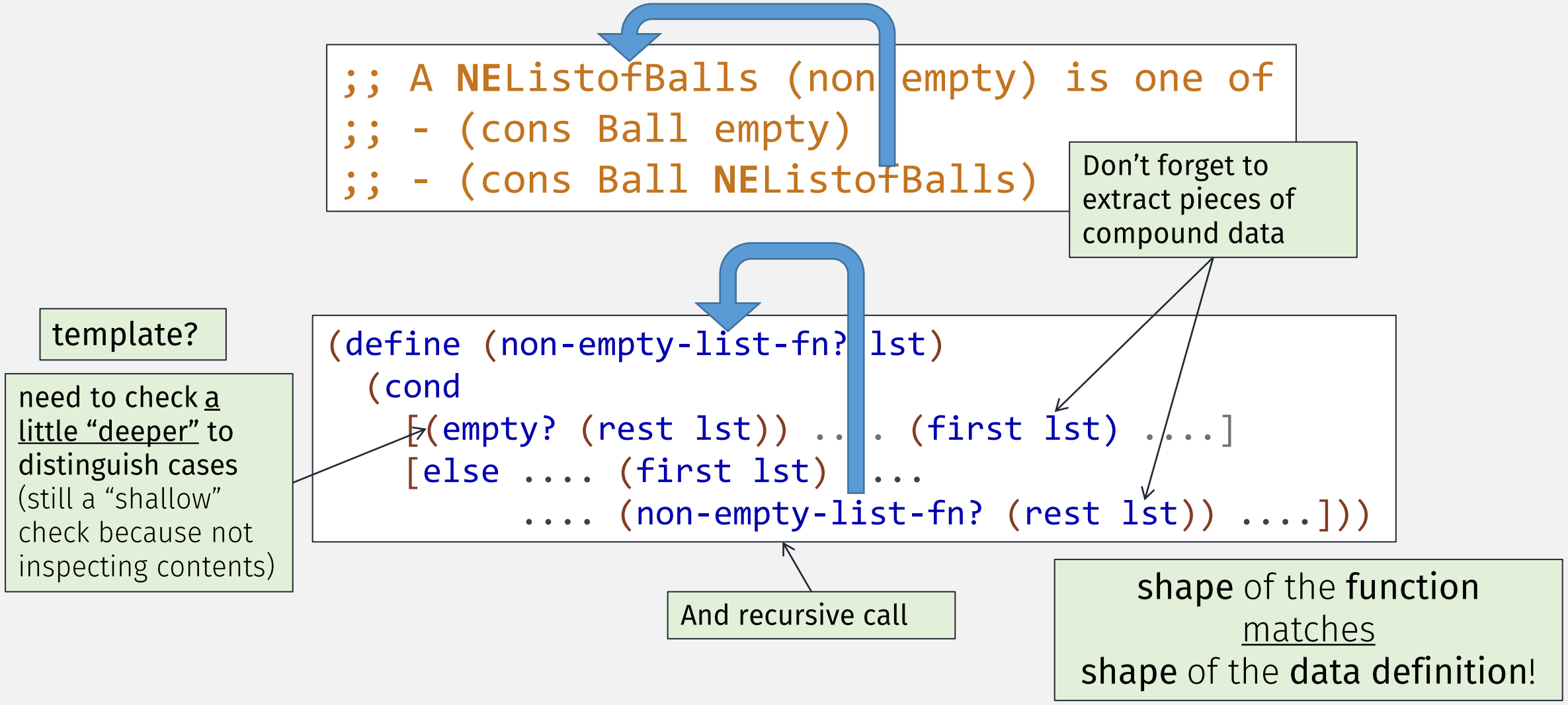
predicate?

```
(define (non-empty-list? arg)
  (and (cons? arg)

                                  )
```

Just cons? !
(shallow check)

Non-empty lists - template



Preview: Famous List Functions

- **Map**
- **Filter**
- **Fold** (reduce)

"BIG" data processing

Check-In Quiz 10/4

on gradescope

(due 1 minute before midnight)