Basics of Inheritance

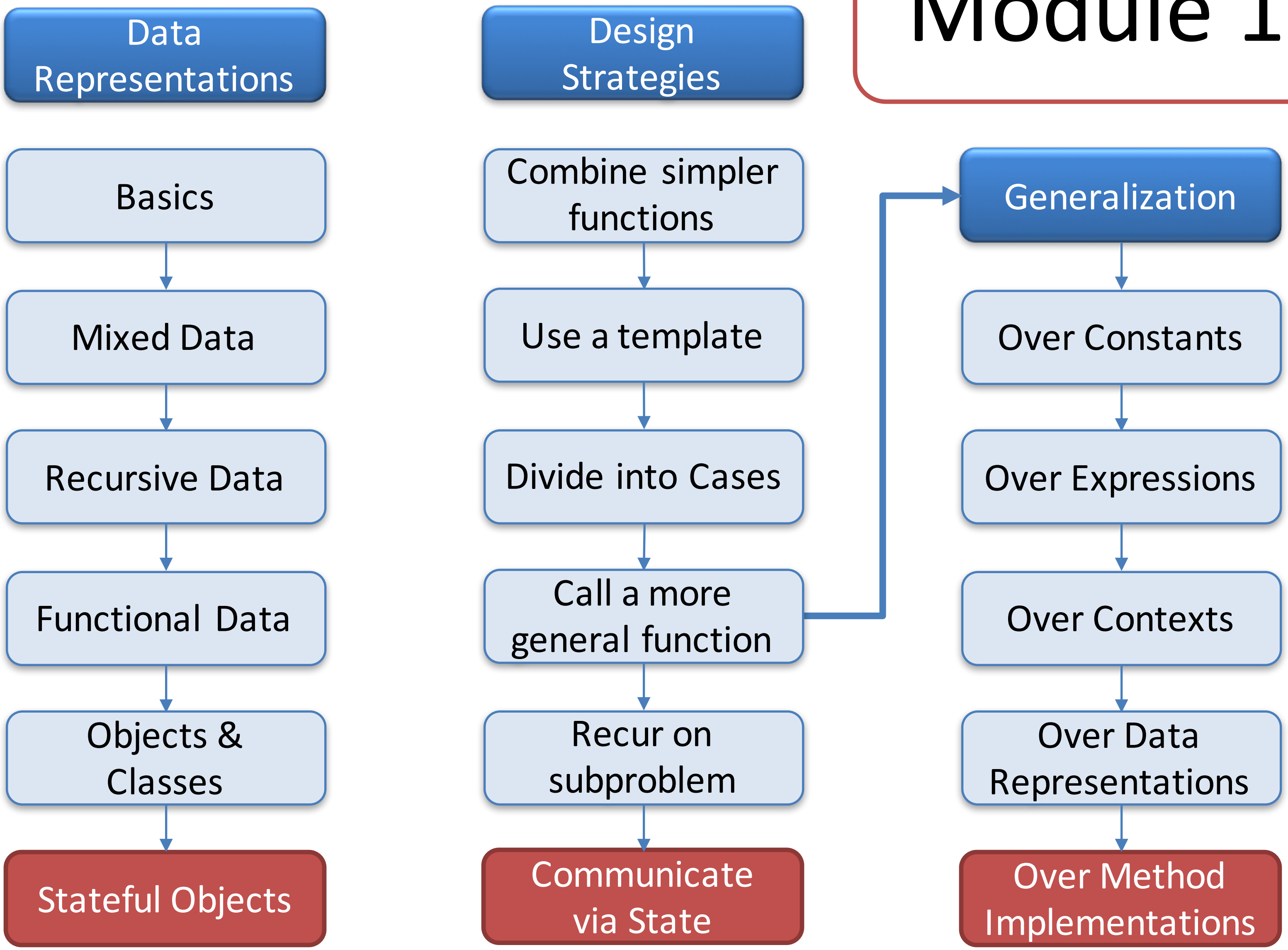
CS 5010 Program Design Paradigms "Bootcamp"

Lesson 11.1

Key Points for this Module

- Inheritance is a technique for generalizing over common parts of class implementations.
- When we create such a generalization, we specialize by subclassing.
- Languages with inheritance have many new design choices.

Module 11



Data Representations

Basics

Mixed Data

Recursive Data

Functional Data

Objects & Classes

Stateful Objects

Design Strategies

Combine simpler functions

Use a template

Divide into Cases

Call a more general function

Recur on subproblem

Communicate via State

Generalization

Over Constants

Over Expressions

Over Contexts

Over Data Representations

Over Method Implementations

Key Points for Lesson 11.1

- By the end of this lesson you should be able to explain how objects find methods by searching up the inheritance chain.
- Use the overriding-defaults pattern to introduce small variations of a class.

Example: 11-1-flashing-balls

- Sometimes we want to define a new class that is just a small variation of an old class.
- For example, we might want to make a ball that flashes different colors.
- To do this, create a subclass that inherits from the old class (the "superclass").
- We call this the "overriding defaults" pattern.
- Let's look at some code.

FlashingBall%

```
;; FlashingBall% is like a Ball%, but it displays
;; differently: it changes color on every fourth tick

(define FlashingBall%
  (class* Ball%  ; inherits from Ball%
    (SBall<%>)   ; implements same interface
```

FlashingBall% inherits from Ball%. FlashingBall% is the subclass; Ball% is the superclass

```
    ;; number of ticks between color changes
    (field [color-change-interval 4])

    ;; time left til next color change
    (field [time-left color-change-interval])

    ;; the list of possible colors, first elt is
    ;; current color
    (field [colors (list "red" "green")])

    ;; here are fields of the superclass that we need.
    (inherit-field radius x y selected?)

    ;; the init-field w isn’t declared here,
    ;; so it is sent to the superclass.
    (super-new)
```

inherit-fields is used to declare fields of the superclass that we want to make visible in the subclass

```
;; Scene -> Scene
;; RETURNS: a scene like the given one, but with the
;;  flashing ball painted on it.
;; EFFECT: decrements time-left and changes colors if
;;  necessary
(define/override (add-to-scene s)
  (begin
    ;; is it time to change colors?
    (if (zero? time-left)
      (change-colors)
      (set! time-left (- time-left 1)))
    ;; now paint this ball on the scene
    (place-image
      (circle radius
        (if selected? "solid" "outline")
        (first colors))
      x y s)))


;; -> Void
;; EFFECT: rotate the list of colors,
;;  and reset time-left
(define (change-colors)
  (set! colors
    (append (rest colors) (list (first colors))))
  (set! time-left color-change-interval))

))
```

define/override is used to define methods that override methods in the superclass

Features for Inheritance in Racket

- The Racket object system uses two features to implement inheritance: **define/override** and **inherit-fields**.
  - **`define/override`** is used to define methods that override methods in the superclass.
  - **`inherit-fields`** is used to declare fields of the superclass that we want to make visible in the subclass.
    - eg: **x**, **y**, **selected?**, **radius** in **`FlashingBall%`**.
    - values are automatically supplied to the superclass on initialization.

Other languages do this differently, so watch out!

What fields are in the subclass?

- The init-fields of a subclass are the init-fields of the superclass plus any additional init-fields declared in the subclass.
- FlashingBall% doesn't declare any new init-fields, so its init-fields are the same as those of Ball%.
- init-fields of the subclass are automatically sent to the superclass, so when we create a FlashingBall%, we write

```
(new FlashingBall% [x ...][y ...][speed ...])
```

- Those values become the values for the fields in Ball%, so they can be used by the methods in Ball%.
- x and y are also inherited fields, so they are visible to the methods in FlashingBall% as well.

The overriding-defaults pattern

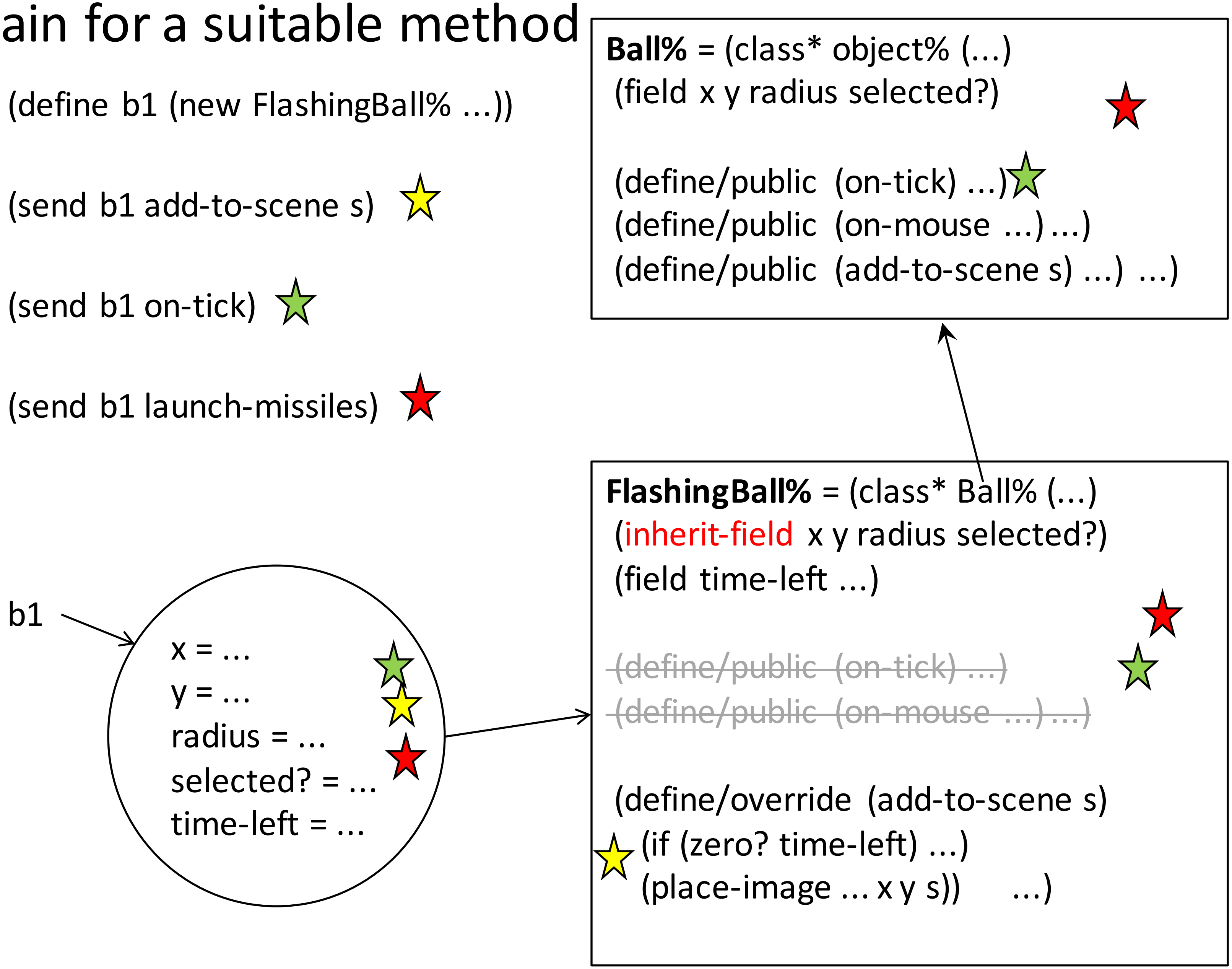
The flashing ball was an example of the *overriding-defaults* pattern. In the overriding-defaults pattern:

- The superclass has a complete set of behaviors
- The subclass makes an incremental change in these behaviors by overriding some of them.

How does inheritance work?

- An object searches its inheritance chain for a suitable method.
- For FlashingBall% we have
  - FlashingBall% inherits from
  - Ball%, which inherits from
  - object%
- but the chain could be as long as you want.
- Here’s an example (be sure to watch the animation):

An object searches its inheritance chain for a suitable method



(define b1 (new FlashingBall% ...))

(send b1 add-to-scene s)

(send b1 on-tick)

(send b1 launch-missiles)

Ball% = (class* object% (...)
(field x y radius selected?)

(define/public (on-tick) ...)
(define/public (on-mouse ...) ...)
(define/public (add-to-scene s) ...) ...)

FlashingBall% = (class* Ball% (...)
(inherit-field x y radius selected?)
(field time-left ...)

~~(define/public (on-tick) ...)~~
~~(define/public (on-mouse ...) ...)~~

(define/override (add-to-scene s)
(if (zero? time-left) ...)
(place-image ... x y s)) ...)

Inheritance and **this**

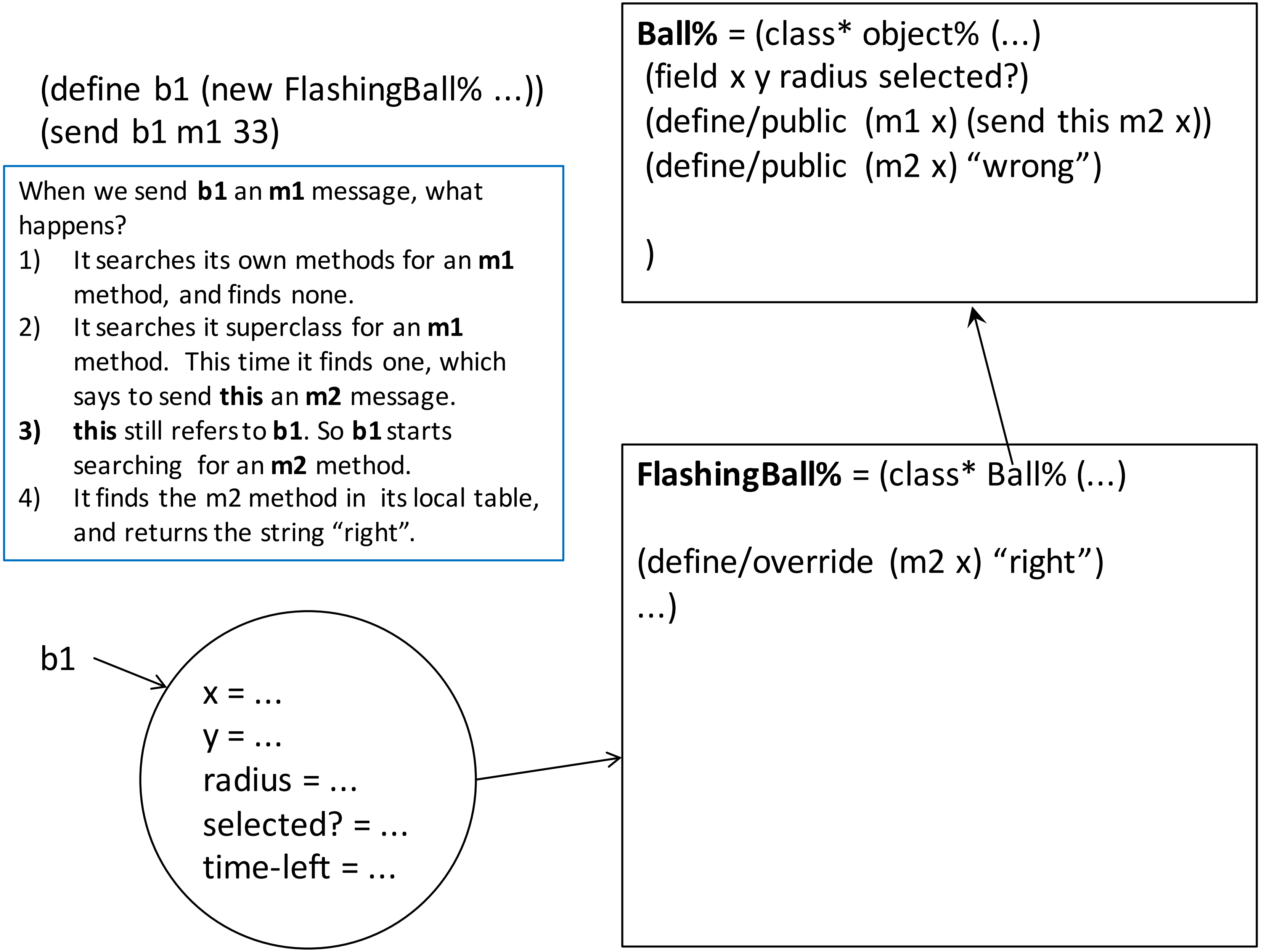
- If a method in the superclass refers to **this**, where do you look for the method?
- Answer: in the original object.
- Consider the following class hierarchy:

Searching for a method of **this**

```
(define b1 (new FlashingBall% ...))
(send b1 m1 33)
```

When we send **b1** an **m1** message, what happens?

1) It searches its own methods for an **m1** method, and finds none.
2) It searches it superclass for an **m1** method. This time it finds one, which says to send **this** an **m2** message.
3) **this** still refers to **b1**. So **b1** starts searching for an **m2** method.
4) It finds the m2 method in its local table, and returns the string “right”.



```
Ball% = (class* object% (...)
 (field x y radius selected?)
 (define/public (m1 x) (send this m2 x))
 (define/public (m2 x) “wrong”)

 )
```

```
FlashingBall% = (class* Ball% (...)

(define/override (m2 x) “right”)
...)
```

super

- Sometimes the subclass doesn’t need to change the behavior of the superclass’s method; instead it just needs to add behavior to the existing method.
- **(super** *method args* …**)** calls the method named method in the superclass of the class in which the method is defined.

Use case for **super**

```
(define the-superclass%
  (class* object% ()
   (define/public (m1 x)
     (... big-hairy function of x ...))))

(define the-subclass%
  (class* the-superclass% ()
    (define/public (m1 x)
      (... Same big hairy function,
           but now of x+1 ...))))
```

We don’t want to have to write out the big hairy function again. Can we avoid this repeated code?

Use case for **super**

```
(define the-superclass%
  (class* object% ()
   (define/public (m1 x)
     (... big-hairy function of x ...))))

(define the-subclass%
  (class* the-superclass% ()
    (define/public (m1 x)
      (super m1 (+ x 1)))))
```

This calls m1 in the superclass.

You can call any method in the **super**

```
(define the-superclass%
  (class* object% (...)
   (define/public (m1 x)
     (... big-hairy function of x ...))))

(define the-subclass%
  (class* the-superclass% (...)
    (define/public (m2 x)
      (super m1 (+ x 1)))
    (define/public (m1 x) "this is noise")) ))
```

Here method **m2** in the subclass calls method **m1** in the superclass.

In Racket, you can't call **(super m1 ...)** unless **m1** is already defined in the current class. This is a wart in the Racket object system. If we were in a different system, this would not be necessary. Sorry about that.

this and **super**, summarized

- The rules for this and super can be summarized as:

  this is dynamic, **super** is static

- This simple rule can lead to interesting behavior
  - Do Guided Practices 11.1 and 11.2 to learn more about this.
- We will take great advantage of the dynamic nature of **this** in the next lesson.

Summary of Lesson 11.1

- We’ve seen how to define superclasses and subclasses in Racket, including **inherit-field** and **define/override**.
- We’ve seen the overriding-defaults pattern, in which a subclass overrides some methods of a complete superclass
- We learned how **this** works with inheritance, and what **super** does.

Next Steps

- Study 11-1-flashing-balls.rkt in the Examples folder.
- If you have questions about this lesson, ask them on the Discussion Board.
- Do the Guided Practices 11.1 and 11.2
- Go on to the next lesson