

# Object-Oriented Programming

Methods and Constructors

Lecture 12

# Announcements

- Worksheet Out Today - Due Wednesday 10/16 at 11:59pm
  - Office hours close Wednesday 10/16 at 5pm, so hand-in early!

# Object-oriented Programming

- So far we've used objects as compound data types
  - i.e. to model a row of data in a spreadsheet
- We've written functions, *separate from classes*, that operate on objects
- The only thing we've been able to *do* with an "object" is access and assign values to its properties
- Object-oriented programming allows us to give objects *capabilities*
  - We'll do this with two special kinds of functions: methods and constructors

# Review of **Classes** and **Objects**

- A class defines a new **Data Type**
  - The class definition specifies properties
- Instances of a class are called **objects**
  - To create an object you must use the **new** keyword: **new <Classname>()**
- *Every object of a class* has the **same properties** but has **its own values**
- Objects are reference-types
  - variables do not hold objects, but rather *references to objects*

# Follow-along: Simple Method App

- Let's implement and call the sayHello method example from previous slides in 00-simple-method-app.ts

```
class Person {  
    // ... properties elided...  
  
    sayHello(): void {  
        print("Hello, world");  
    }  
}
```

```
let aPerson = new Person();  
aPerson.sayHello();
```

# Introducing: Methods

- A **method** is a special function defined in a class.
  - Everything you know about a function's parameters, return types, and evaluation rules are the same with methods.
  - *Syntactically*, you'll notice there *are* some minor differences. No `let` keyword, no assignment operator, and no arrow.
- Once defined, you can call a method on any object of that class using the dot operator.
  - Just like how properties were accessed except followed by parenthesis and any necessary arguments

```
class ClassName {  
  
    // Properties Elided  
  
    <name>(<parameters>): <returnType> {  
        <method body>;  
    }  
  
}
```

```
let a = new ClassName();  
a.methodName();
```

# Functions vs. Methods

1. Let's define a *silly* **function**.

```
let sayHello = (): void => {  
    print("Hello, world");  
};
```

2. Once defined, we can then call it.

```
sayHello();
```

3. Now, let's define that same function as a **method** *of the Person class*.

```
class Person {  
    // ... properties elided...  
  
    sayHello(): void {  
        print("Hello, world");  
    }  
}
```

4. Once defined, we can call the method on any Person object:

```
let a = new Person();  
a.sayHello();
```

# Hands-on: Practice with the **this** keyword

- In 01-this-keyword-app.ts...
  1. At TODO #1, define the **toString** method to the right.
  2. In the main function, at TODO's #2 , call the **toString** method on **Points a** and **b** respectively.

```
class Point {  
  
    // ... Properties Elided ...  
  
    toString(): string {  
        return this.x + ", " + this.y;  
    }  
  
}
```



Method's Special Feature:

Methods can *refer* to the object the method was called on.

Consider this plain **function**.  
Notice that its parameter **p** is  
*a reference* to a Point object.

```
let toString = (p: Point): string => {  
    return p.x + ", " + p.y;  
};
```

To call it, we would pass a  
reference to a Point object as an  
argument.

```
let a = new Point();  
print(toString(a));
```

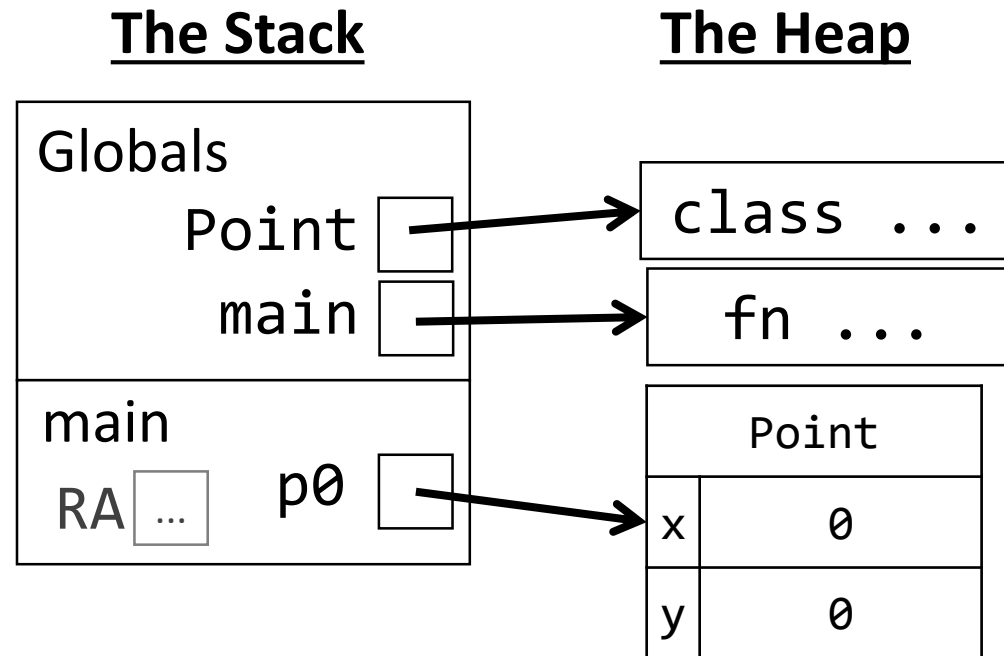
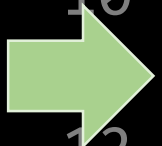
It turns out we *can* write a method  
that does the same thing and it can  
be called like the example to the  
right.

```
let a = new Point();  
print(a.toString());
```


*How does this magic work???*

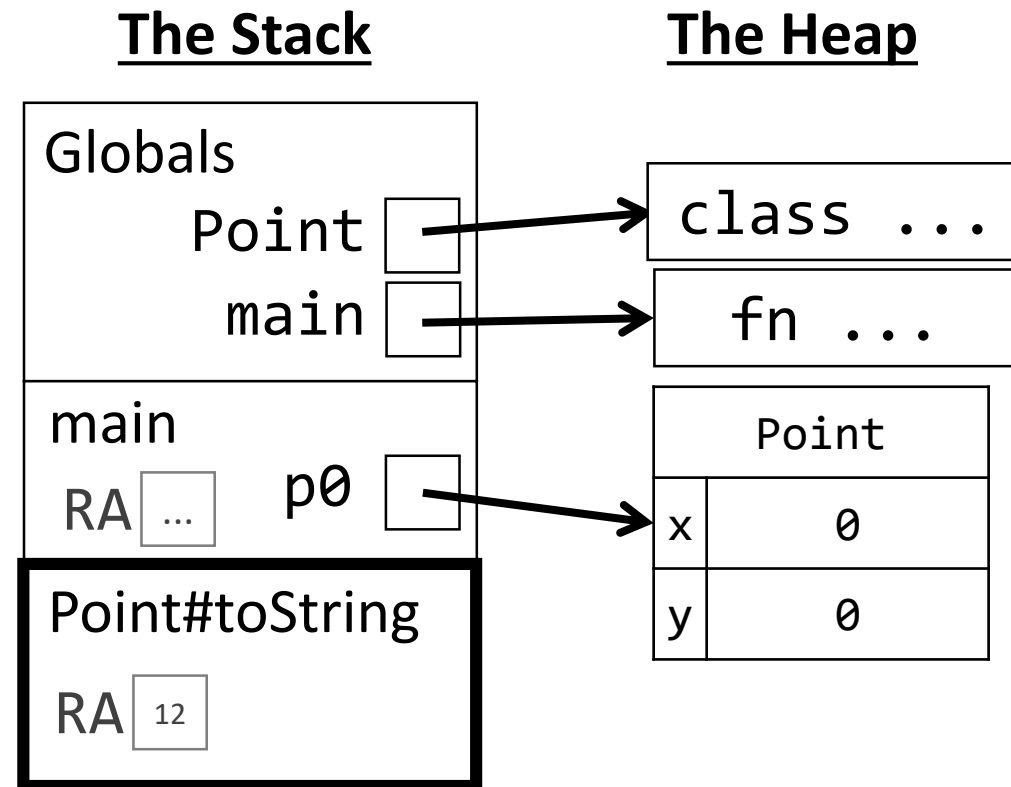
Suppose the processor *just* completed this line...

```
01 class Point {  
02   x: number = 0;  
03   y: number = 0;  
04  
05   toString(): string {  
06     /** Elided */  
07   }  
08 }  
09  
10 export let main = async () => {  
11   let p0 = new Point();  
12   print(p0.toString());  
13 };
```



How is this *method call* processed? First, a frame is added...

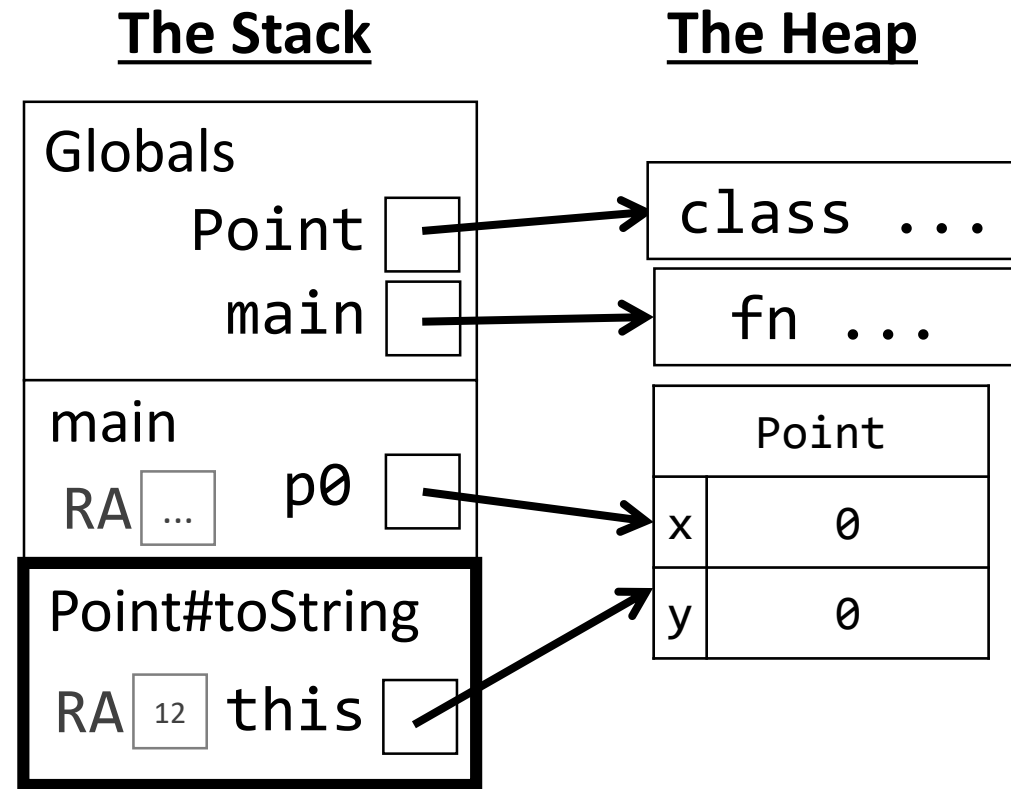
```
01 class Point {  
02   x: number = 0;  
03   y: number = 0;  
04  
05   toString(): string {  
06     /** Elided */  
07   }  
08 }  
09  
10 export let main = async () => {  
11   let p0 = new Point();  
12    print(p0.toString());  
13 };
```



What's up with this pound sign? It's conventional across many programming languages to identify a method by **ClassName#method**.

THEN, a reference named **this** is established TO the object the method was called on... and *this is all the magic* of a **method call**.

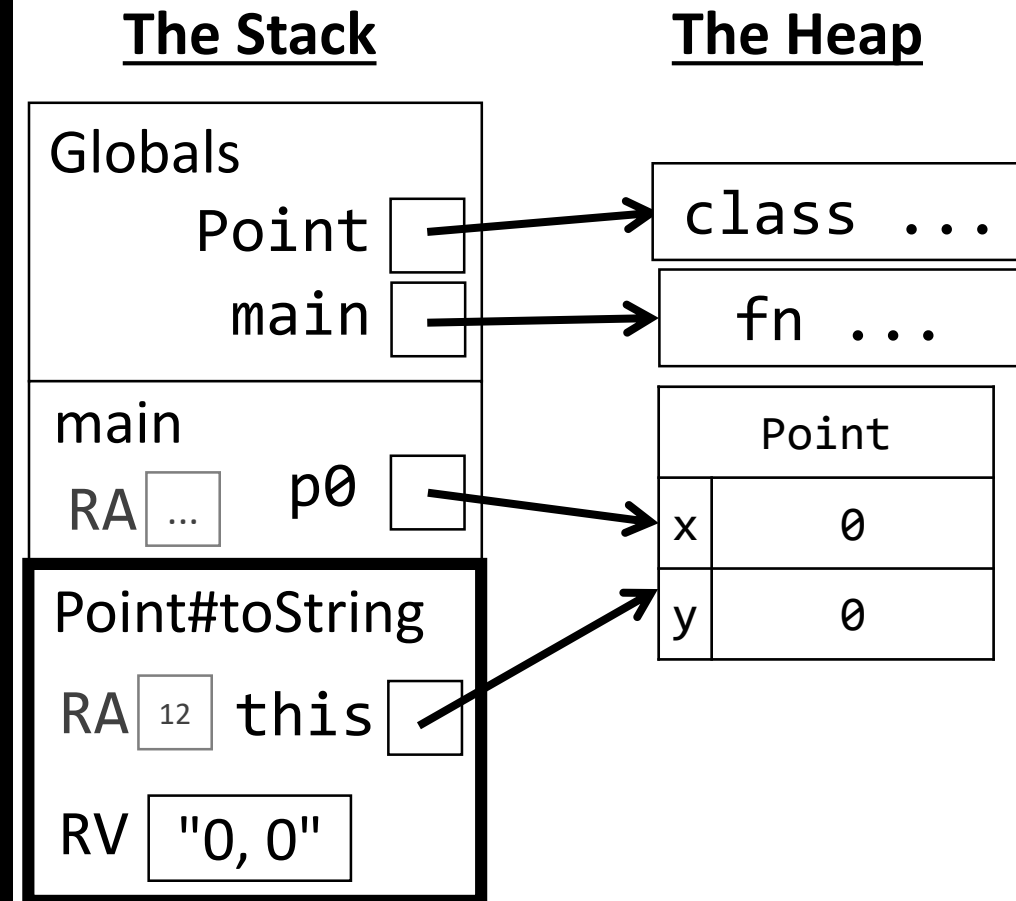
```
01 class Point {
02   x: number = 0;
03   y: number = 0;
04
05   toString(): string {
06     /** Elided */
07   }
08 }
09
10 export let main = async () => {
11   let p0 = new Point();
12   print(p0.toString());
13 };
```



The processor is performing this step magically behind the scenes.

When name resolution occurs inside of a method, the special variable *this* always refers to the object the method was called on.

```
01 class Point {  
02   x: number = 0;  
03   y: number = 0;  
04  
05   toString(): string {  
06     return this.x + ", " + this.y;  
07   }  
08 }  
09  
10 export let main = async () => {  
11   let p0 = new Point();  
12   print(p0.toString());  
13 };
```



Method's Special Feature:

# Methods can refer to the object the method was called on.

When a method is called, inside of the function, a special "variable" is initialized named **this**

The **this** keyword *refers to* the object the method was called upon.

```
let a = new Point();  
a.x = 110;  
a.y = 110;  
print(a.toString());
```

When the above code jumps to *toString*, **this** will refer to the same Point object **a** refers to.

```
class Point {  
    // ... Properties Elided ...  
  
    toString(): string {  
        return this.x + ", " + this.y;  
    }  
}
```

```
let b = new Point();  
b.x = 401;  
b.y = 401;  
print(b.toString());
```

When the above code jumps to *toString*, **this** will refer to the same Point object **b** refers to.

# Hands-on: Practice with the **this** keyword

- In 02-stateful-object-app.ts, let's make it easy to move a Point relative to its current position.
  1. At #1, increase the **x** property of the object **translate** is called on by **dx**. Then, increase the **y** property of the object **translate** is called on by **dy**.
    - Hint: reassign **this.x** and **this.y** by adding dx, dy respectively.
  2. Call **translate** on **Point a** in the main function using any values you'd like at each of the TODOS # 2 and #3.
  3. Once you've tested that it works, check-in on [PollEv.com/compunc](https://pollev.com/compunc)

```
translate(dx: number, dy: number): void {  
    this.x += dx;  
    this.y += dy;  
}
```



# Follow-Along: Distance Method

- Let's add a method to compute the distance between two points.
- We'll specify the 2<sup>nd</sup> point as a parameter named *other*.
- We'll also make use of the special Math function:
  - Math.sqrt(x) computes square root

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

```
class Point {  
  // ... elided ...  
  distanceTo(other: Point): number {  
    let xDelta2 = (other.x - this.x) ** 2;  
    let yDelta2 = (other.y - this.y) ** 2;  
    return Math.sqrt(xDelta2 + yDelta2);  
  }  
}
```

```
// Calling the distanceTo method  
print(a.distanceTo(b));
```

# Why have both functions and methods?

- Different schools of thought in *functional programming-style (FP)* versus *object-oriented programming-style (OOP)*.
  - Both are equally **capable**, but some problems are better suited for one style vs. other.
- FP tends to shine with *data processing* problems
  - Data analysis programs like processing *stats* and are natural fits
- OOP is great for stateful systems like *user interfaces, simulations, graphics*
- Methods allow objects to have "built-in" functionality
  - You don't need to import extra functions to work with an object, they are bundled.
  - As programs grow in size, methods and OOP have some extra capabilities to help teams of programmers avoid accidental errors. You'll see this in 401!

# Method Call Tracing Steps

When a method call is encountered on an object,

1. The processor will determine the class of the object and then confirm it:
  1. Has the method being called defined in it.
  2. The method call's arguments agree with the method's parameters.
2. Next it will initialize the RA, parameters, *and* the **this** keyword
  - The **this** keyword is assigned a reference to the object the method is called on
3. Finally, when the method completes, processor returns back to the RA.

# Constructors

- An object's properties must be initialized before the object is usable
- A constructor allows you to
  1. Specify initial values of properties upon construction of an object
  2. Require certain properties be specified
- A constructor is just a special method
  - Name is **constructor**
  - Also has a variable named **this**
  - Return type is an object of its class
- A class' constructor is called each time the **new <Classname>** expression is evaluated.

Before

```
let a = new Point();  
a.x = 10;  
a.y = 0;
```

Defining a constructor

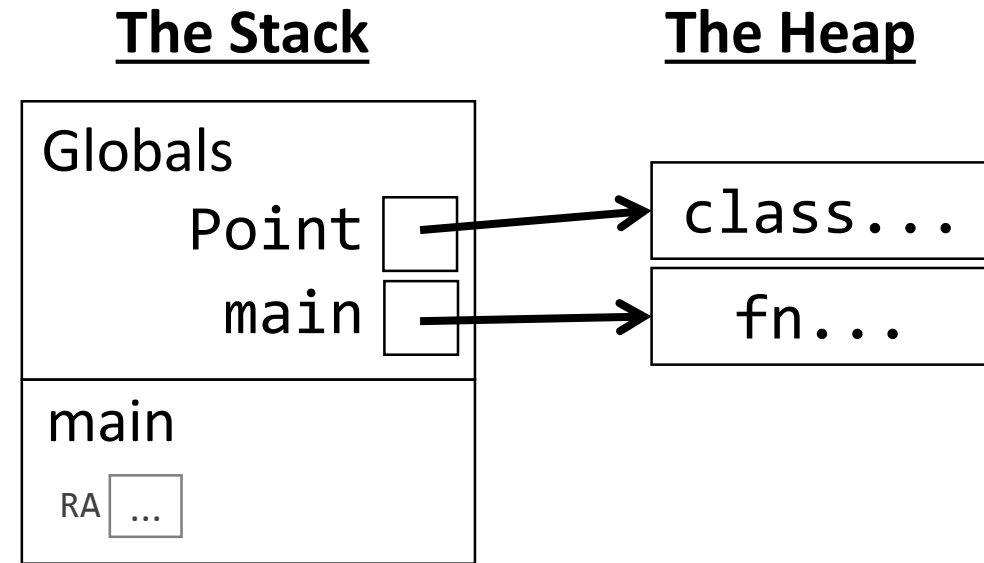

```
class Point {  
  
    x: number;  
    y: number;  
  
    constructor(x: number, y: number) {  
        this.x = x;  
        this.y = y;  
    }  
  
}
```

After

```
let a = new Point(10, 0);
```

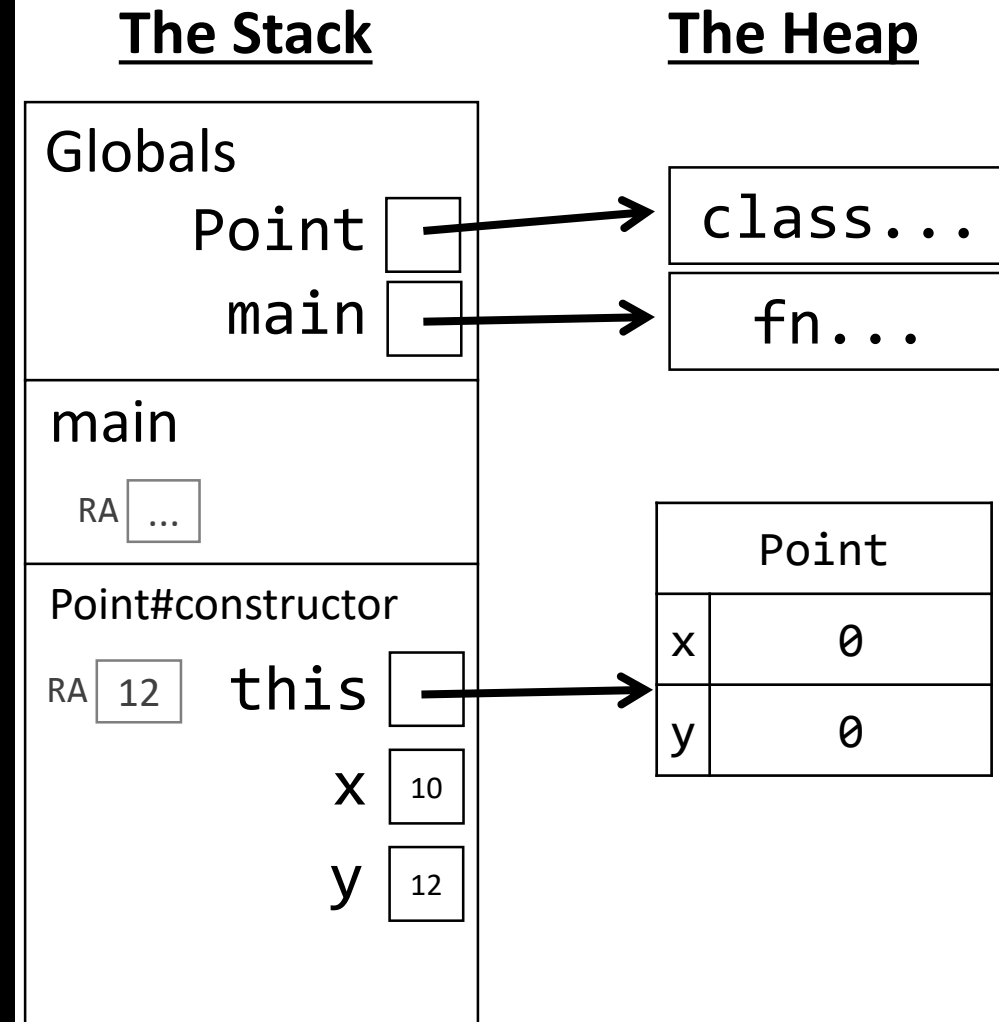
# Tracing a **constructor**. Suppose we're about to construct!

```
01 class Point {  
02   x: number = 0;  
03   y: number = 0;  
04  
05   constructor(x: number, y: number) {  
06     this.x = x;  
07     this.y = y;  
08   }  
09 }  
10  
11 export let main = async () => {  
12   let p0 = new Point(10, 12);  
13 };
```



When the frame is established, a new Point object is referred to by **this**. Arguments are assigned to parameters in the constructor's frame.

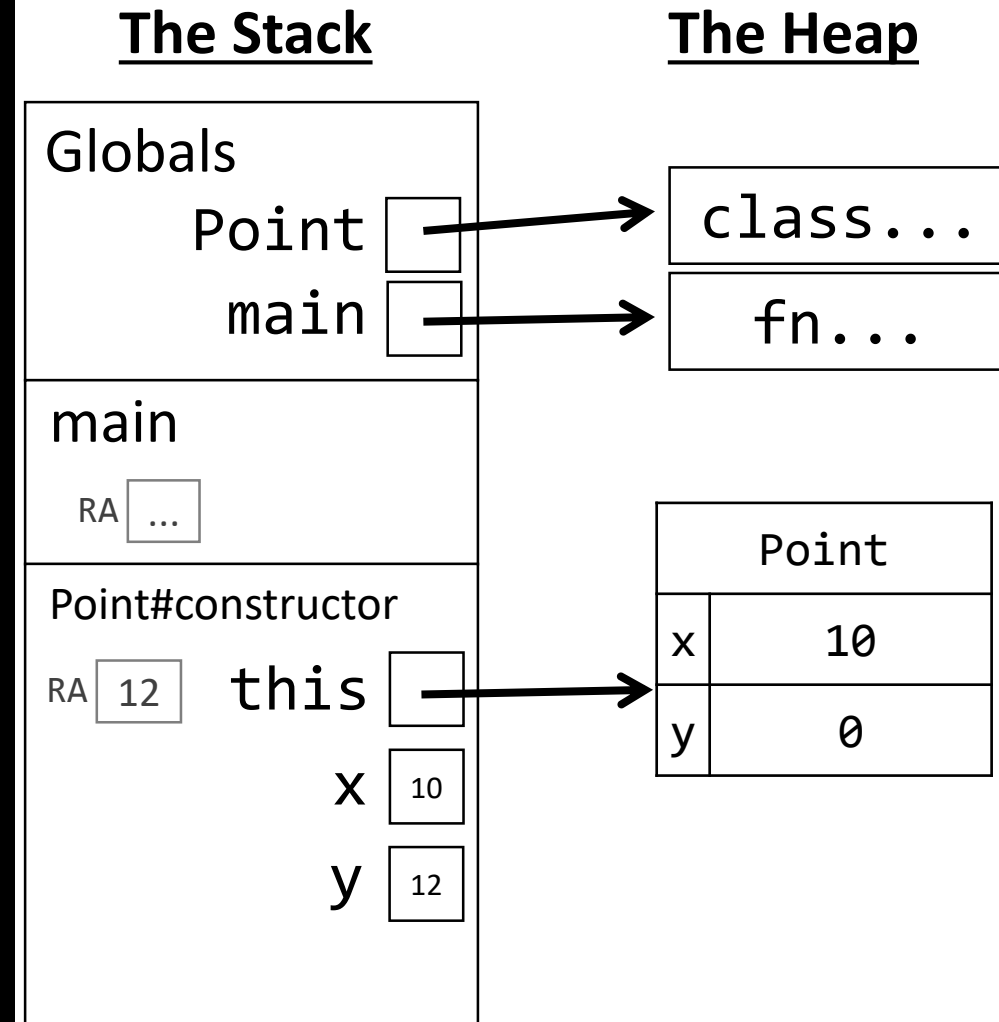
```
01 class Point {  
02   x: number = 0;  
03   y: number = 0;  
04  
05   constructor(x: number, y: number) {  
06     this.x = x;  
07     this.y = y;  
08   }  
09 }  
10  
11 export let main = async () => {  
12   let p0 = new Point(10, 12);  
13 };
```



Notice the default property values are initialized just before entering the constructor.

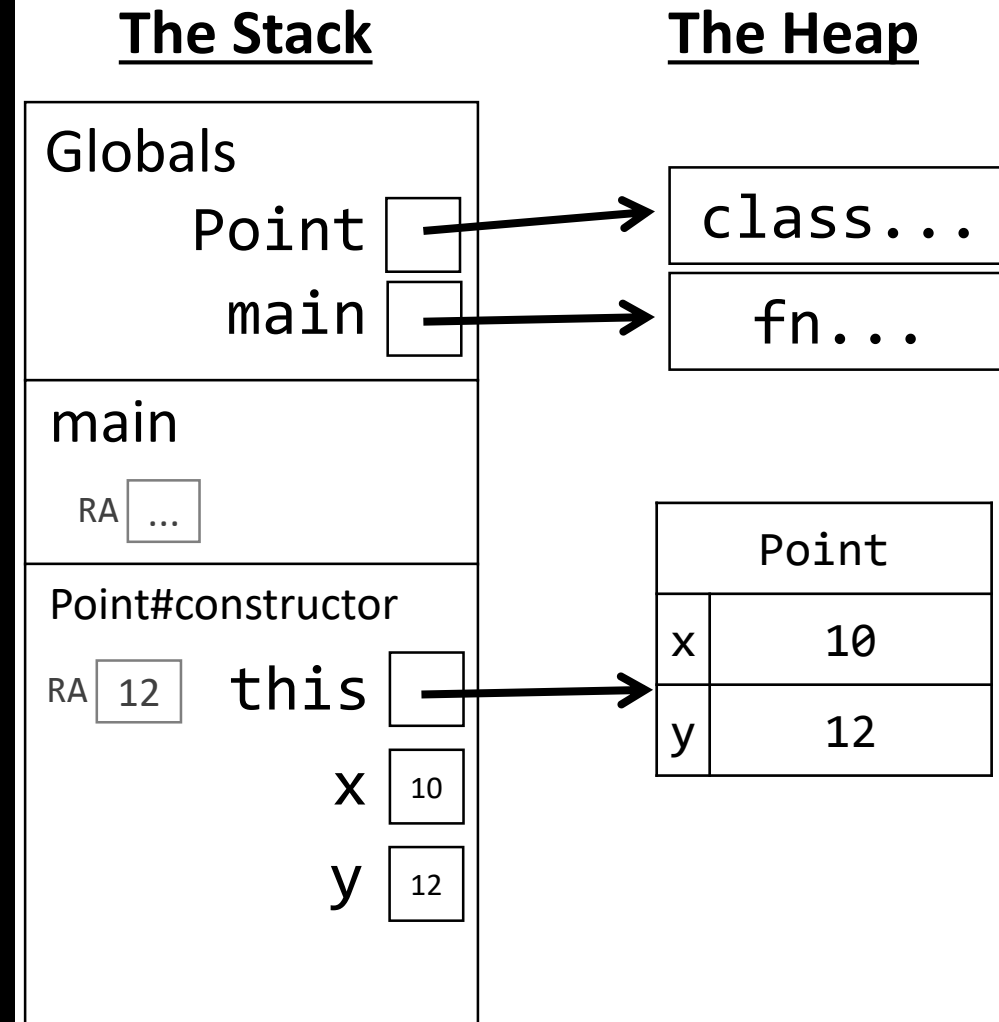
Using name resolution, the value of **x** from the constructor's frame is assigned to **this.x**, which is the new Point object's **x** property.

```
01 class Point {  
02   x: number = 0;  
03   y: number = 0;  
04  
05   constructor(x: number, y: number) {  
06     this.x = x;  
07     this.y = y;  
08   }  
09 }  
10  
11 export let main = async () => {  
12   let p0 = new Point(10, 12);  
13 };
```



Using name resolution, the value of **y** from the constructor's frame is assigned to **this.y**, which is the new Point object's **y** property.

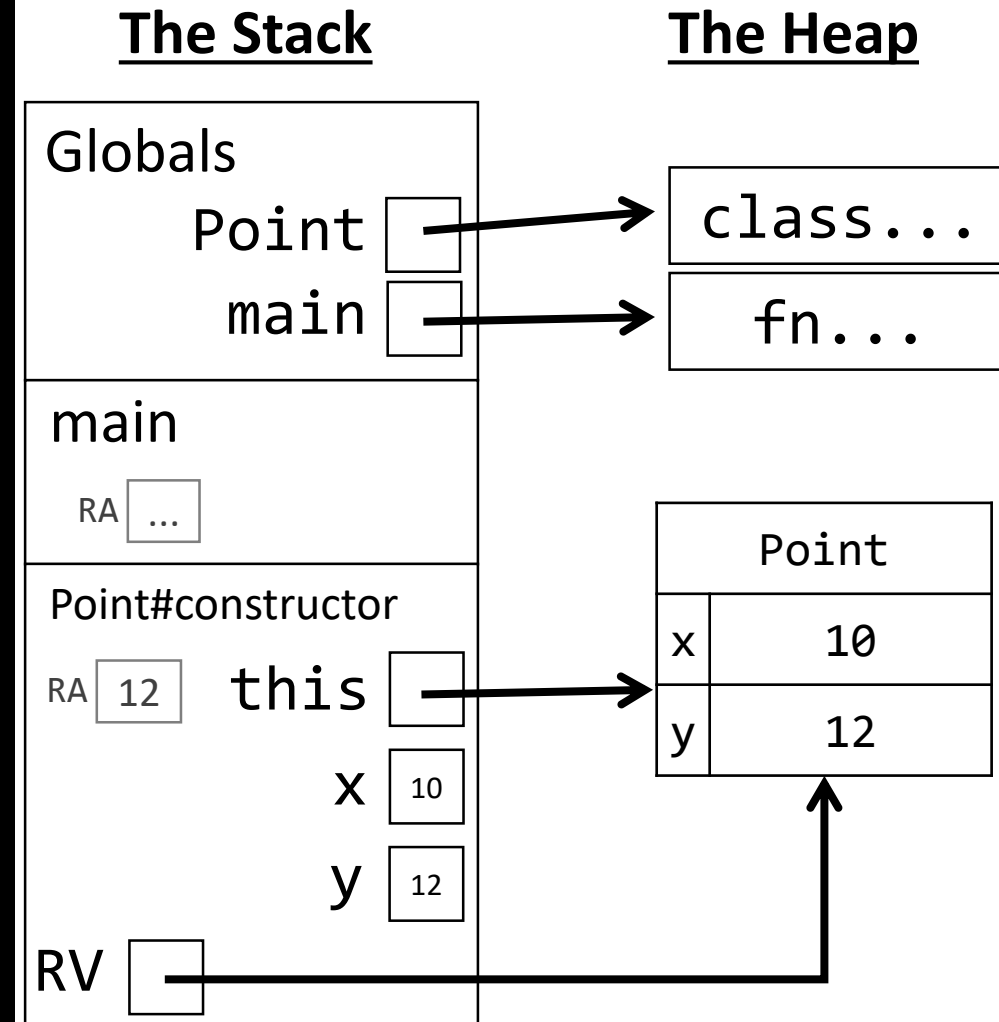
```
01 class Point {  
02   x: number = 0;  
03   y: number = 0;  
04  
05   constructor(x: number, y: number) {  
06     this.x = x;  
07     this.y = y;  
08   }  
09 }  
10  
11 export let main = async () => {  
12   let p0 = new Point(10, 12);  
13 };
```





The return value of a constructor is implicitly the same reference as **this**.

```
01 class Point {  
02   x: number = 0;  
03   y: number = 0;  
04  
05   constructor(x: number, y: number) {  
06     this.x = x;  
07     this.y = y;  
08   }  
09 }  
10  
11 export let main = async () => {  
12   let p0 = new Point(10, 12);  
13 };
```



The return value of the constructor is assigned to **p0** in **main**.

```
01 class Point {  
02   x: number = 0;  
03   y: number = 0;  
04  
05   constructor(x: number, y: number) {  
06     this.x = x;  
07     this.y = y;  
08   }  
09 }  
10  
11 export let main = async () => {  
12   let p0 = new Point(10, 12);  
13 };
```

