Object-Oriented Programming

Methods and Constructors

Lecture 18 - Fall 2018

BEFORE **`npm run pull`** -- RUN: **`npm i --save introcs`**

Announcements

- Build Your Own Bracket – PS5 Due Weds 11/28 at 11:59pm
- Apply to be a UTA this Spring! Applications due LDOC at 11:59pm.
- Final Exam – Good news! No more cramped quarters.
  - We found another classroom that will allow us to spread out and avoid feeling so cramped.
  - Half of the class will be seated in Chapman 211, the other half in our usual classroom.

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**

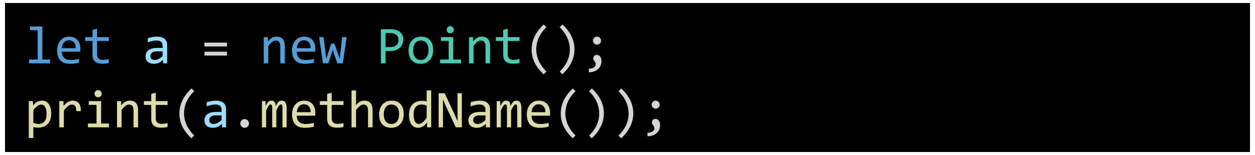
- Objects are reference-types
  - variables do not hold objects, but rather ***references to objects***

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 Point {

    // Properties Elided

    <name>(<parameters>): <returnType> {
        <method body>;
    }

}
```



```
let a = new Point();
print(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 `Point` class*.

```
class Point {
    // ... properties elided...

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

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

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

Follow-along: Simple Method App

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

```
class Point {
    // ... properties elided...

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

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

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.

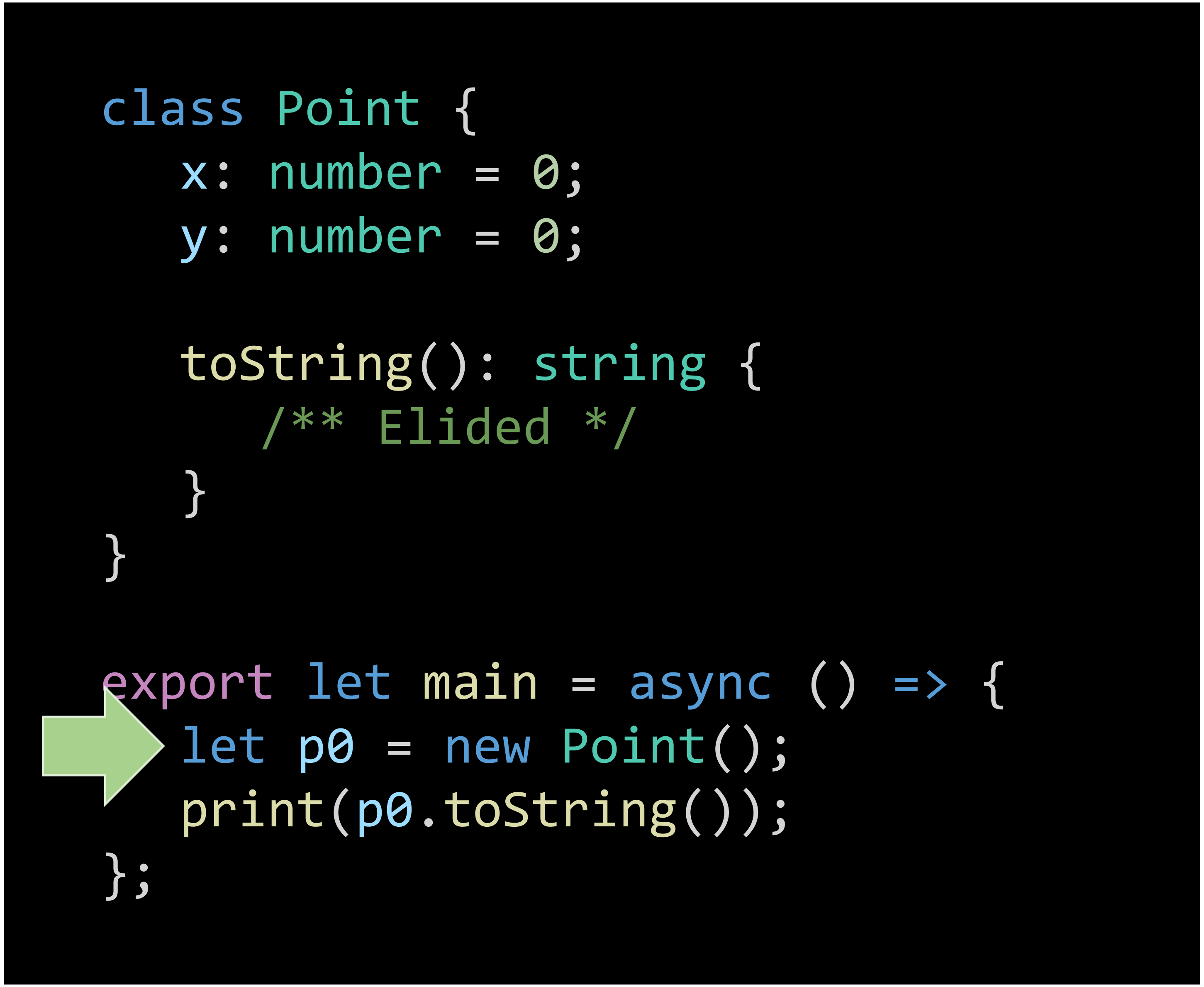
```
let a = new Point();
print(toString(a));
```

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

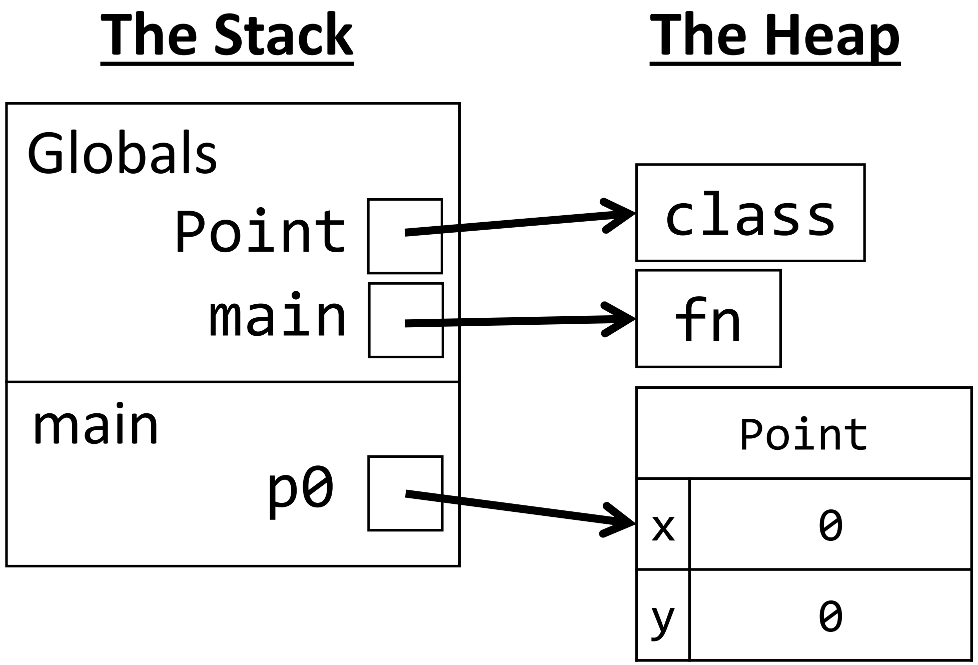
```
let a = new Point();
print(a.toString());
```

How does this magic work???

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



```
class Point {
   x: number = 0;
   y: number = 0;

   toString(): string {
      /** Elided */
   }
}

export let main = async () => {
   let p0 = new Point();
   print(p0.toString());
};
```



The Stack

Globals
Point
main

main
p0

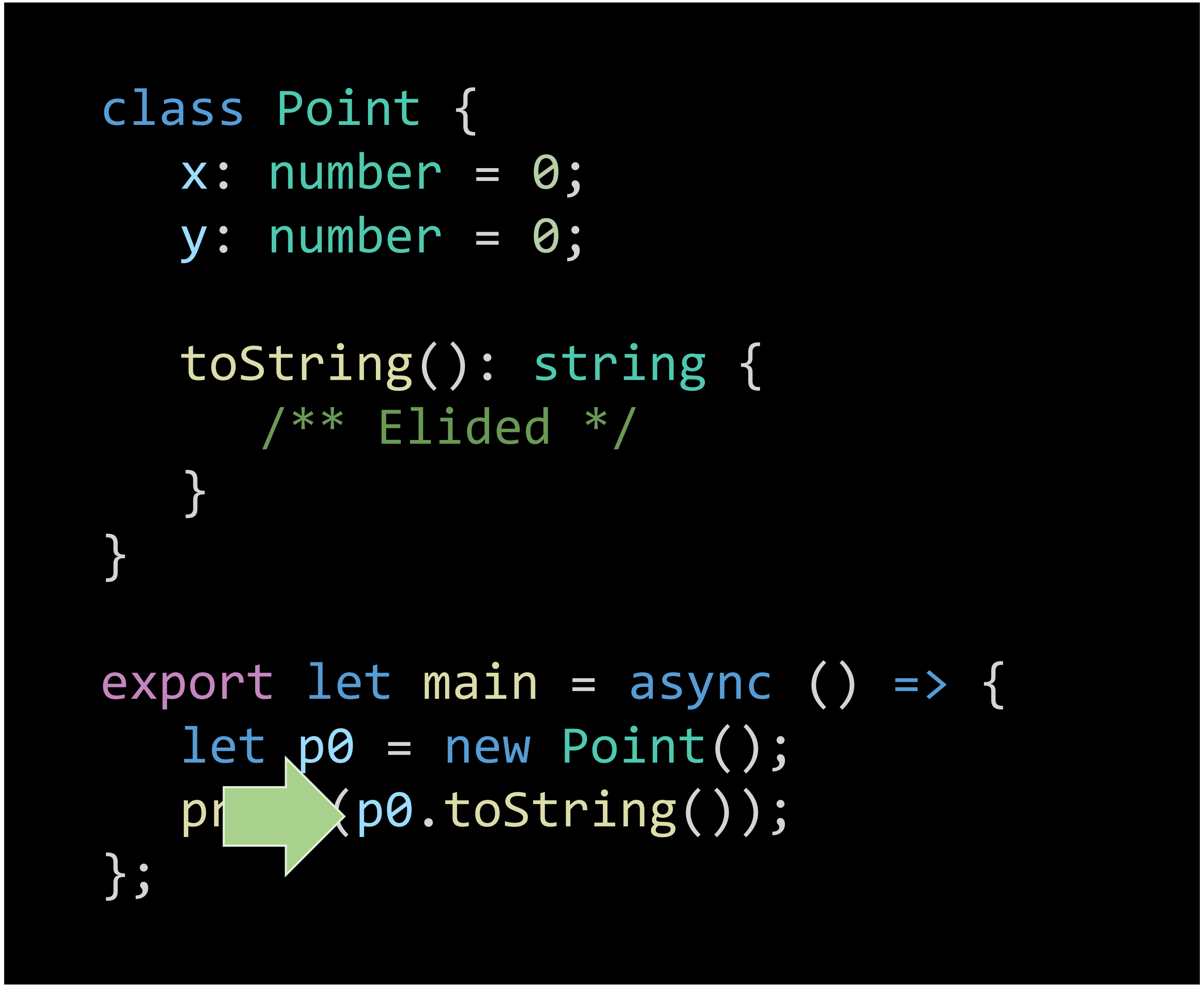
The Heap

class

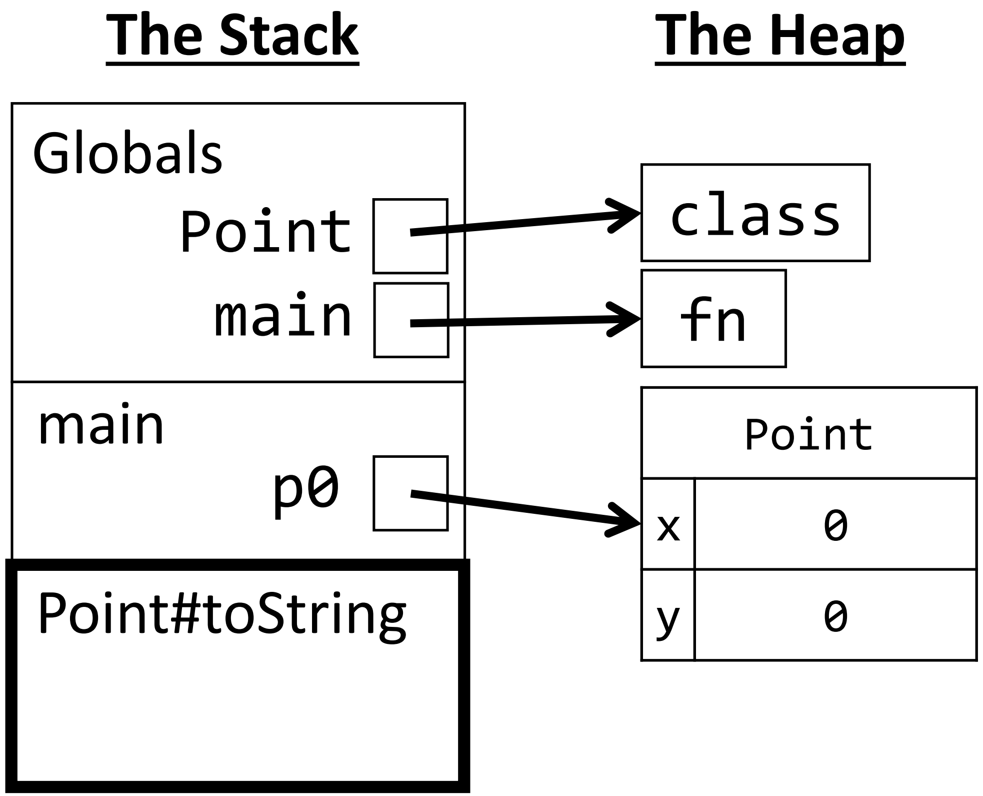
fn

Point	
x	0
y	0

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

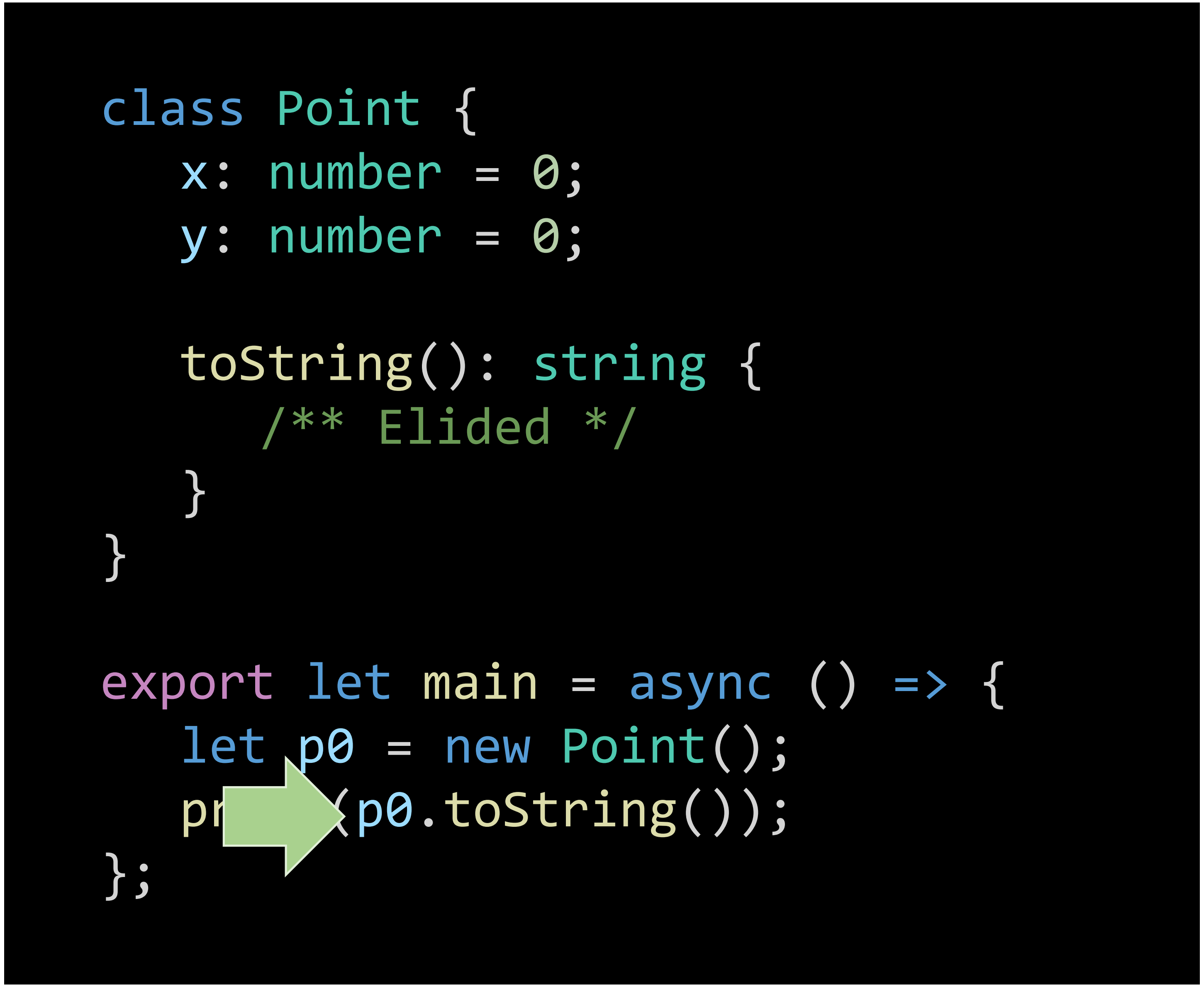


```
class Point {
   x: number = 0;
   y: number = 0;

   toString(): string {
      /** Elided */
   }
}

export let main = async () => {
   let p0 = new Point();
   print(p0.toString());
};
```

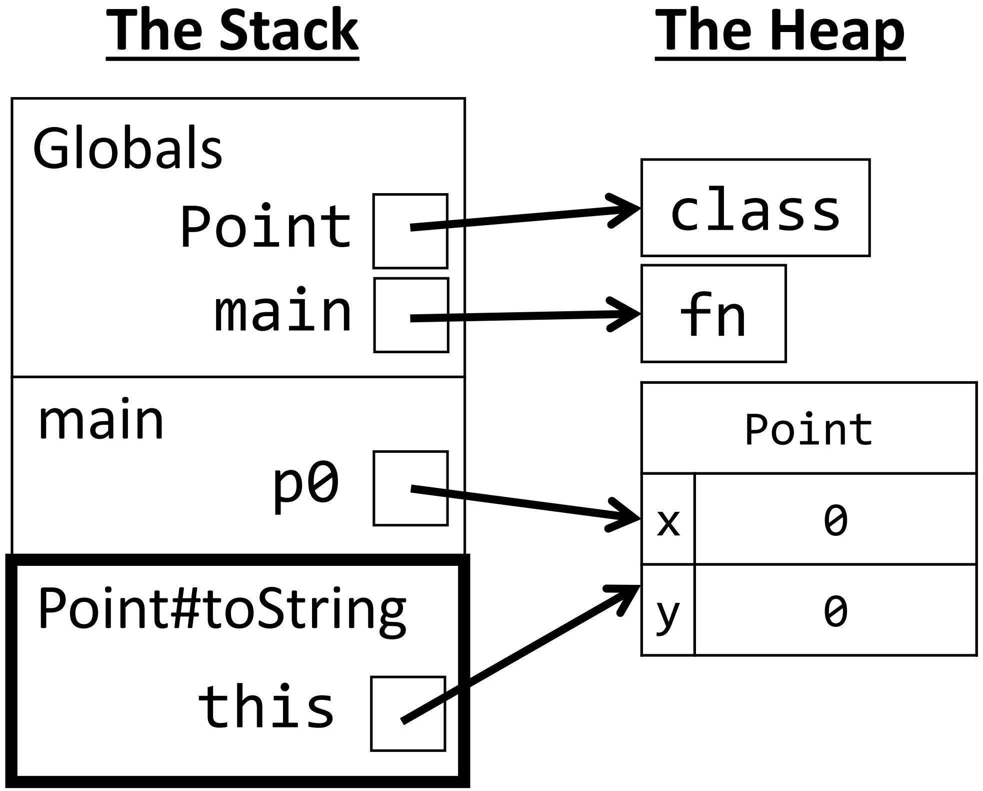


What's up with this pound sign? It's conventional across many programming languages to identify a method by **`ClassName#method`**.

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**.

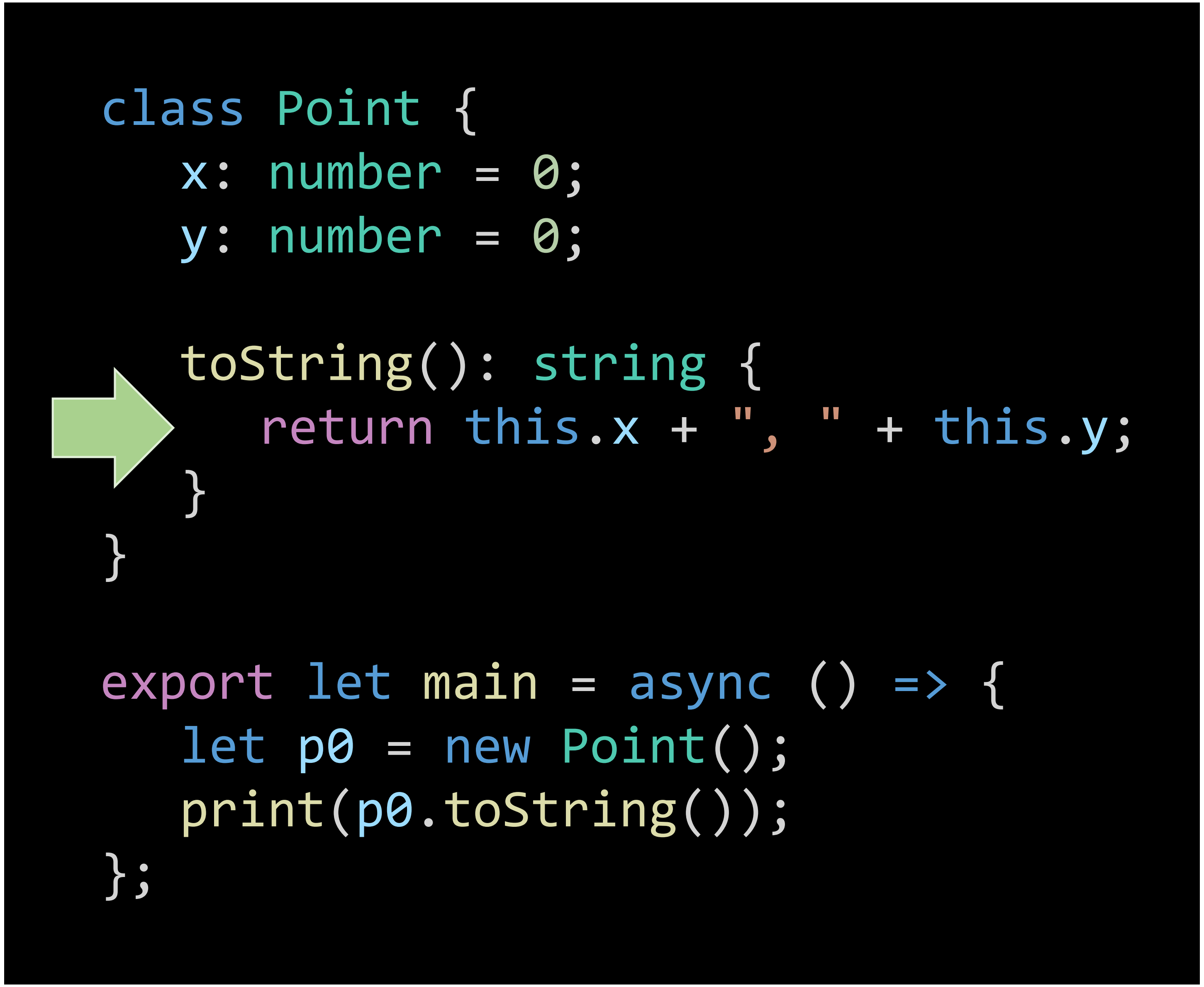


```
class Point {
   x: number = 0;
   y: number = 0;

   toString(): string {
      /** Elided */
   }
}

export let main = async () => {
   let p0 = new Point();
   pr    (p0.toString());
};
```

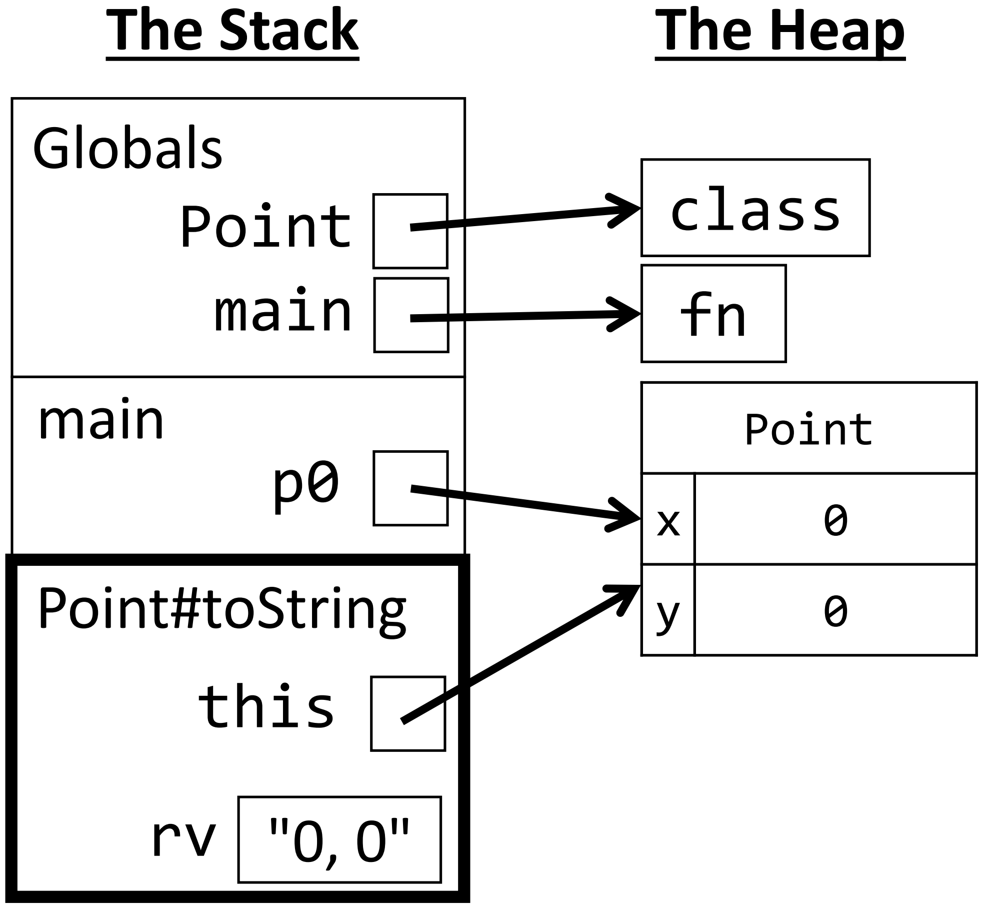


The processor is performing this step magically behind the scenes.

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



```
class Point {
    x: number = 0;
    y: number = 0;

    toString(): string {
        return this.x + ", " + this.y;
    }
}

export let main = async () => {
    let p0 = new Point();
    print(p0.toString());
};
```



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.

```
class Point {

   // ... Properties Elided ...

   toString(): string {
      return this.x + ", " + this.y;
   }

}
```

```
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.

```
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 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;
   }

}
```

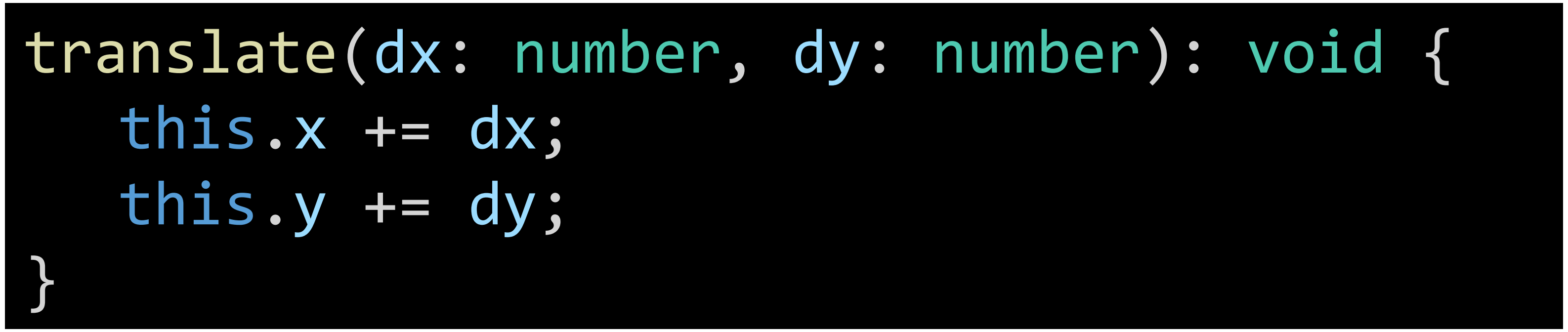
Hands-on: Practice with the **this** keyword

- 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`**

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



```typescript
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 2nd 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 Steps

When a method call is encountered on an object,

1. The processor will determine what class of object it is.
2. It will then go look to confirm the class:
   1. Has the method being called defined in it.
   2. The method call's arguments are in agreement with the method's parameters.
3. Next it will initialize the method's parameters *and* the **`this`** keyword
   1. Arguments will be assigned to parameters, just like a function call
   2. The **`this`** keyword is assigned a reference to the object the method is called on
4. A bookmark is dropped at the method call and processor jumps into the method.
5. Finally, when the method completes, processor returns back to the bookmark.

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

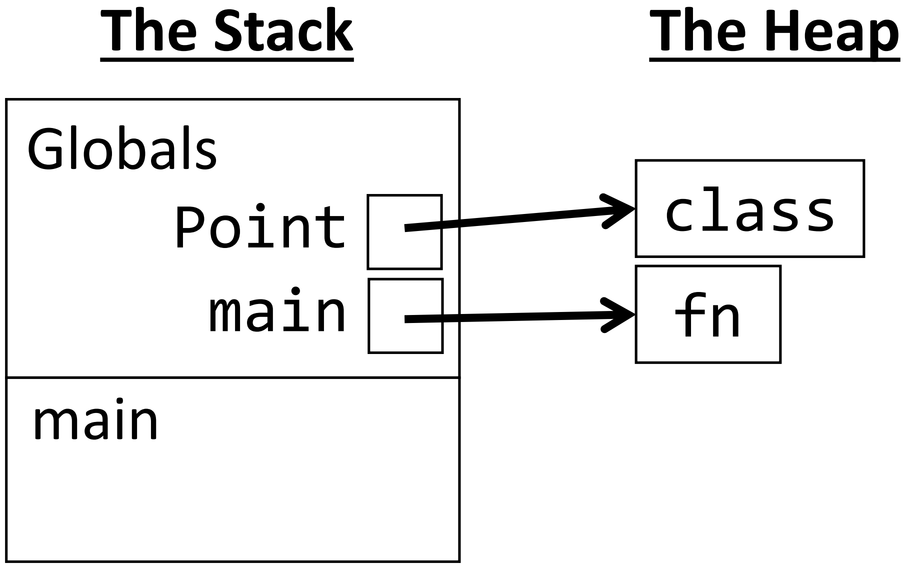
```
class Point {

    x: number;
    y: number;

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


}
```

After

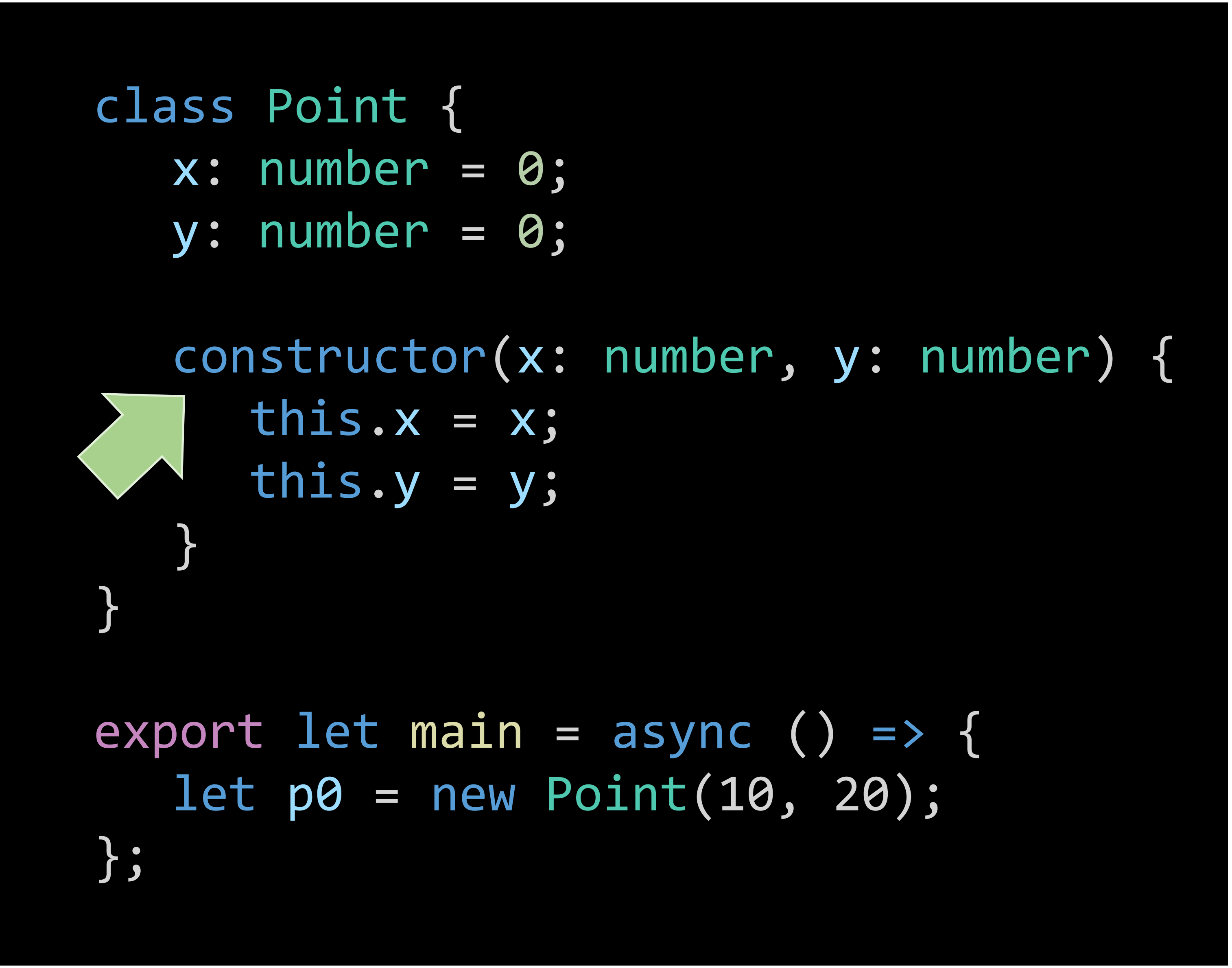
```
let a = new Point(10, 0);
```

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

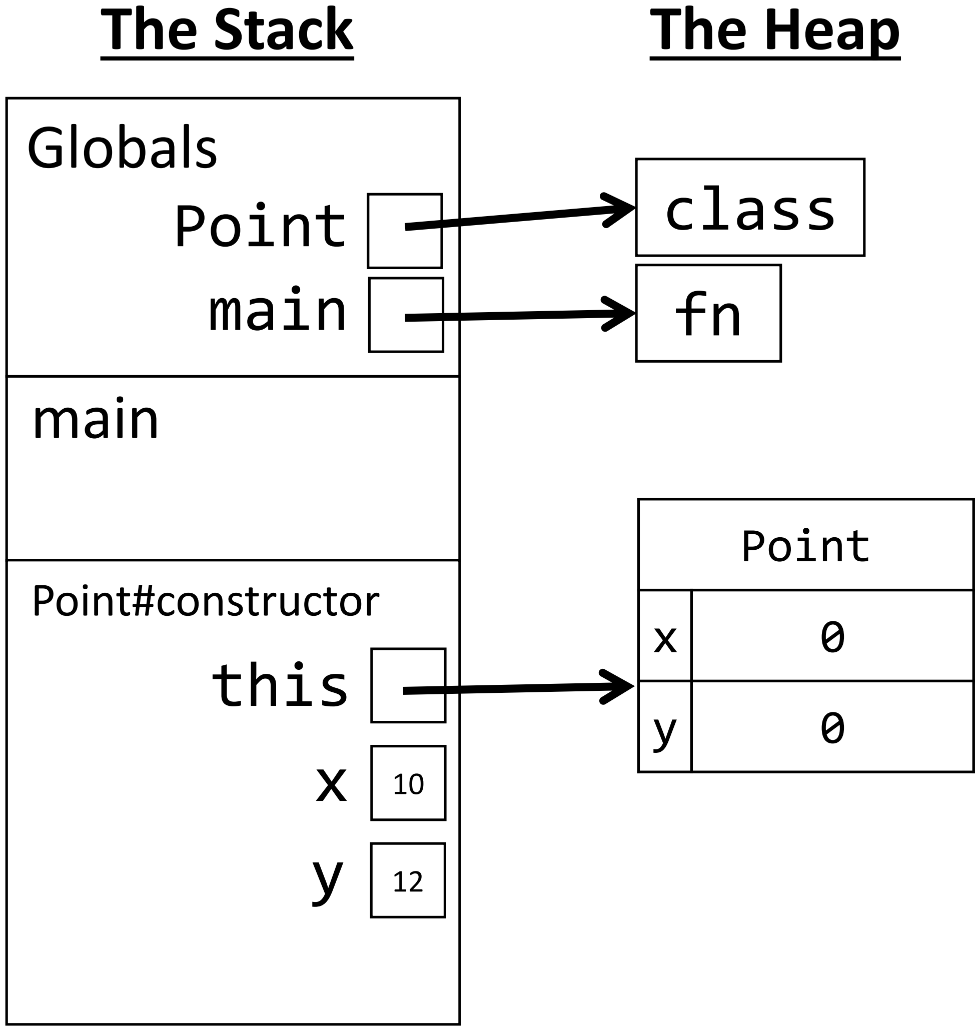
```
class Point {
   x: number = 0;
   y: number = 0;

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

export let main = async () => {
   let p0 = new Point(10, 20);
};
```



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

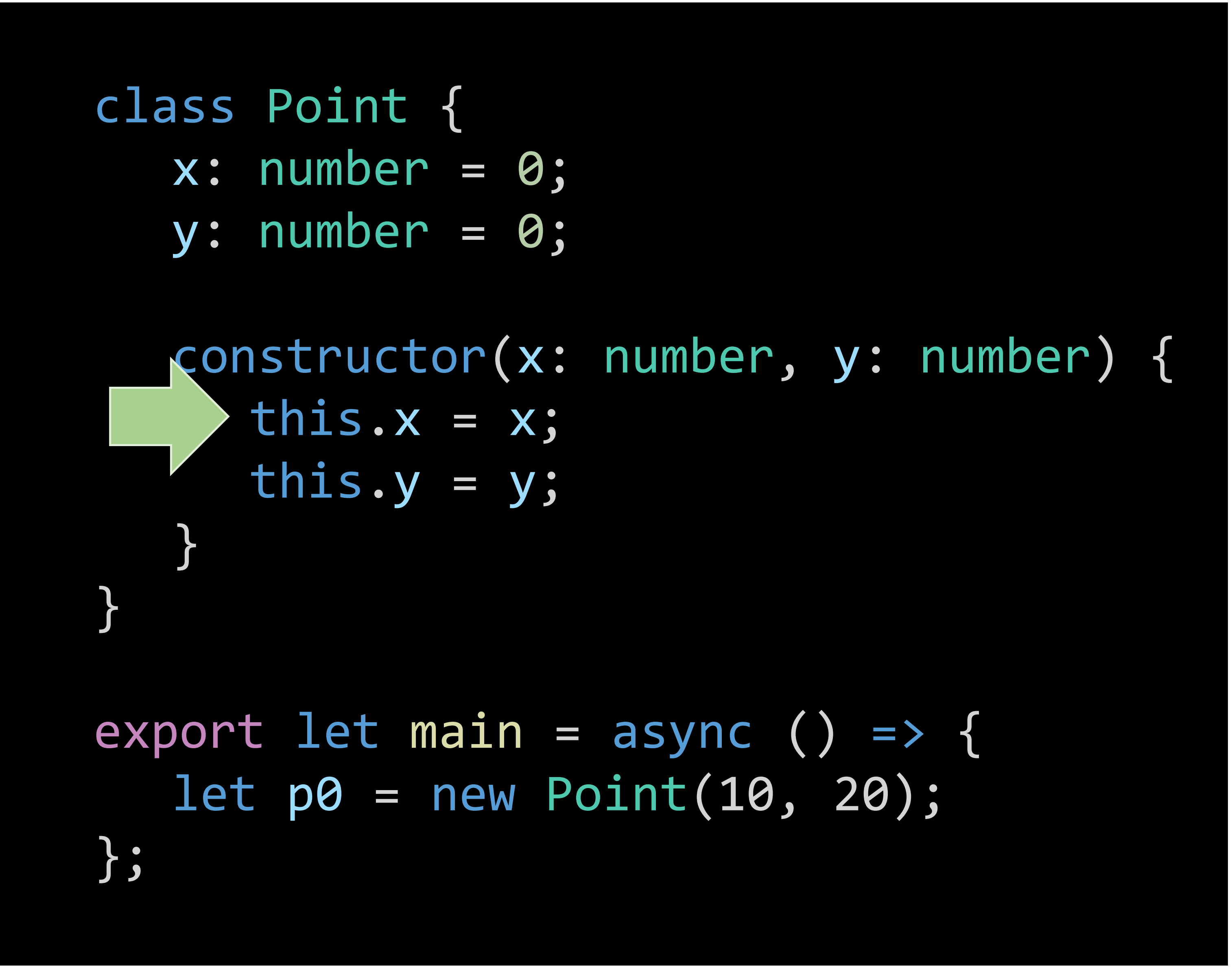


```
class Point {
   x: number = 0;
   y: number = 0;

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

export let main = async () => {
   let p0 = new Point(10, 20);
};
```

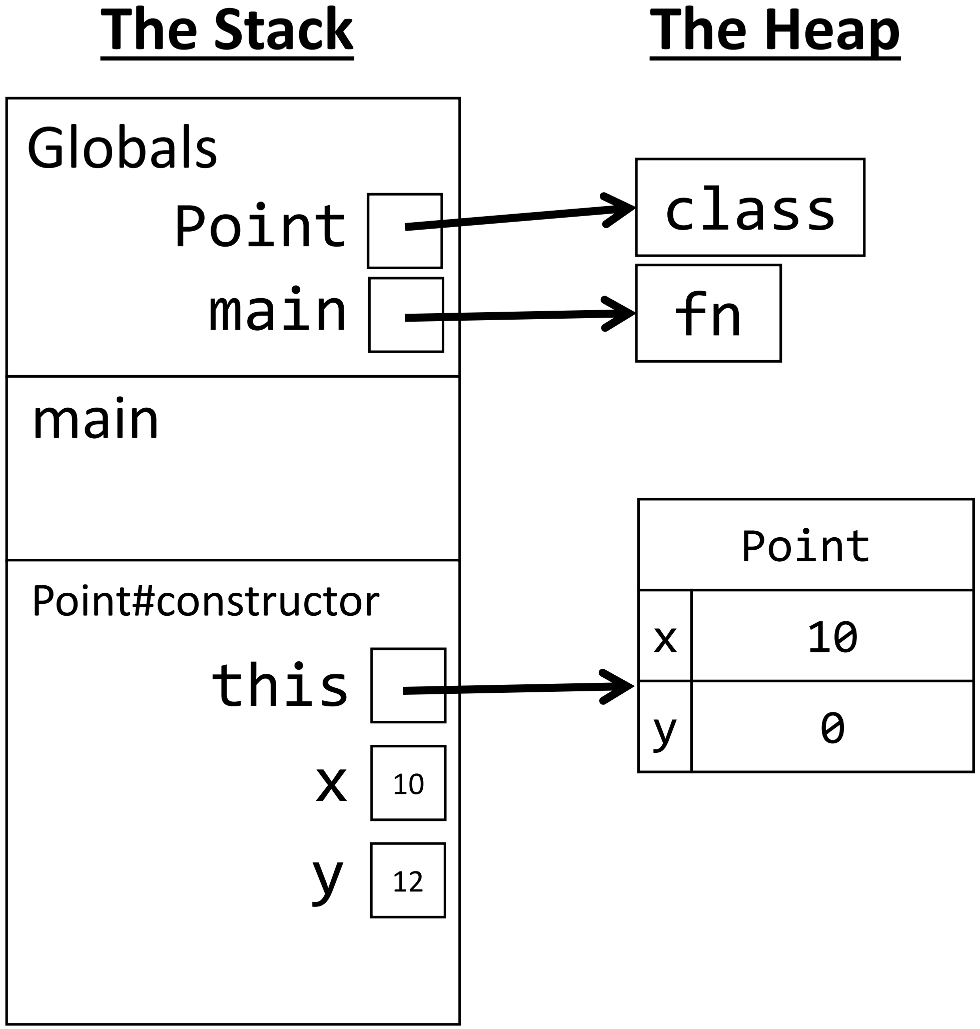


Notice the default property values are initialized just before entering the constructor.

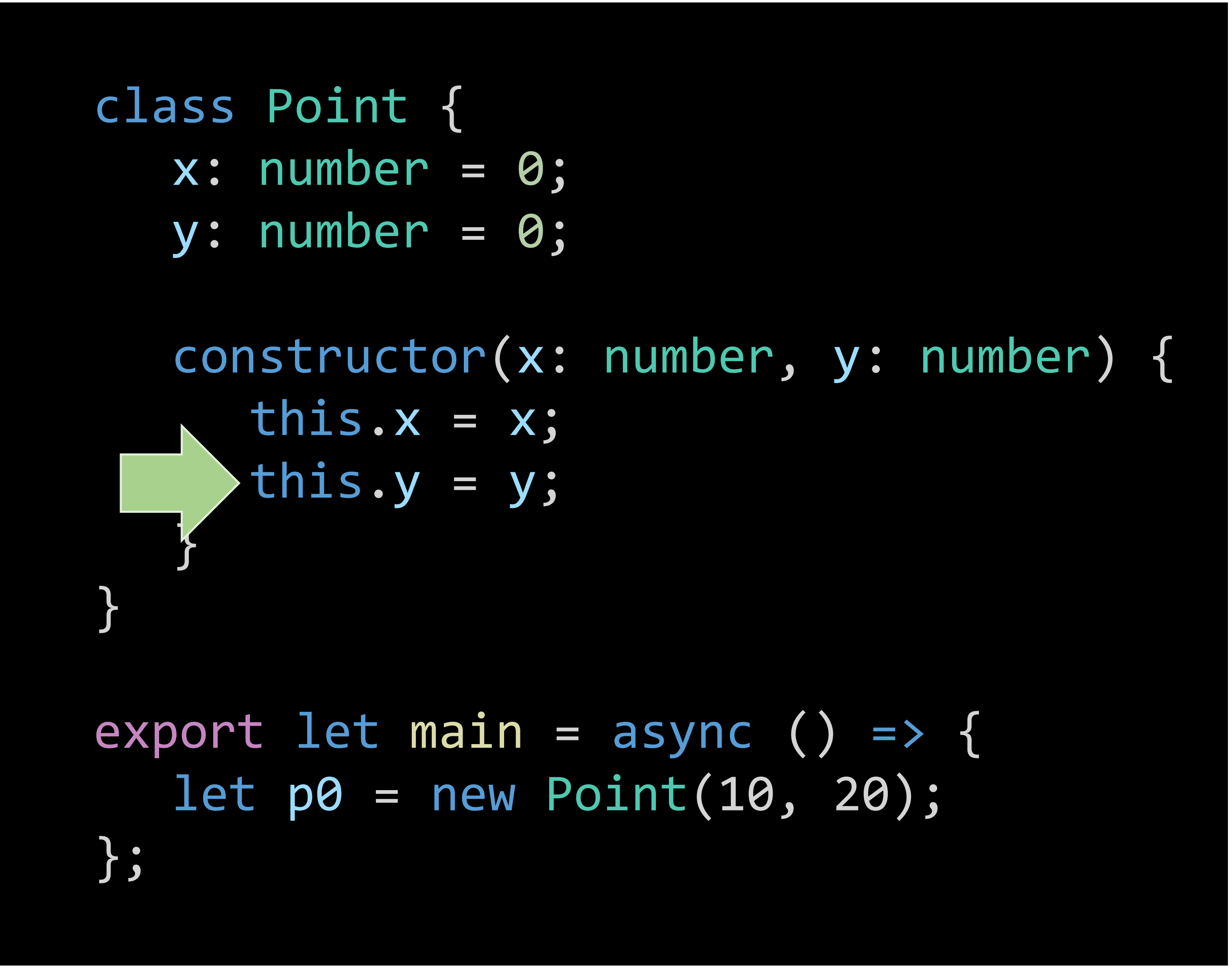
Using name resolution, the value of **x** from the constructor's frame is assigned to **this.x**, which is the new Point object's **x** property.



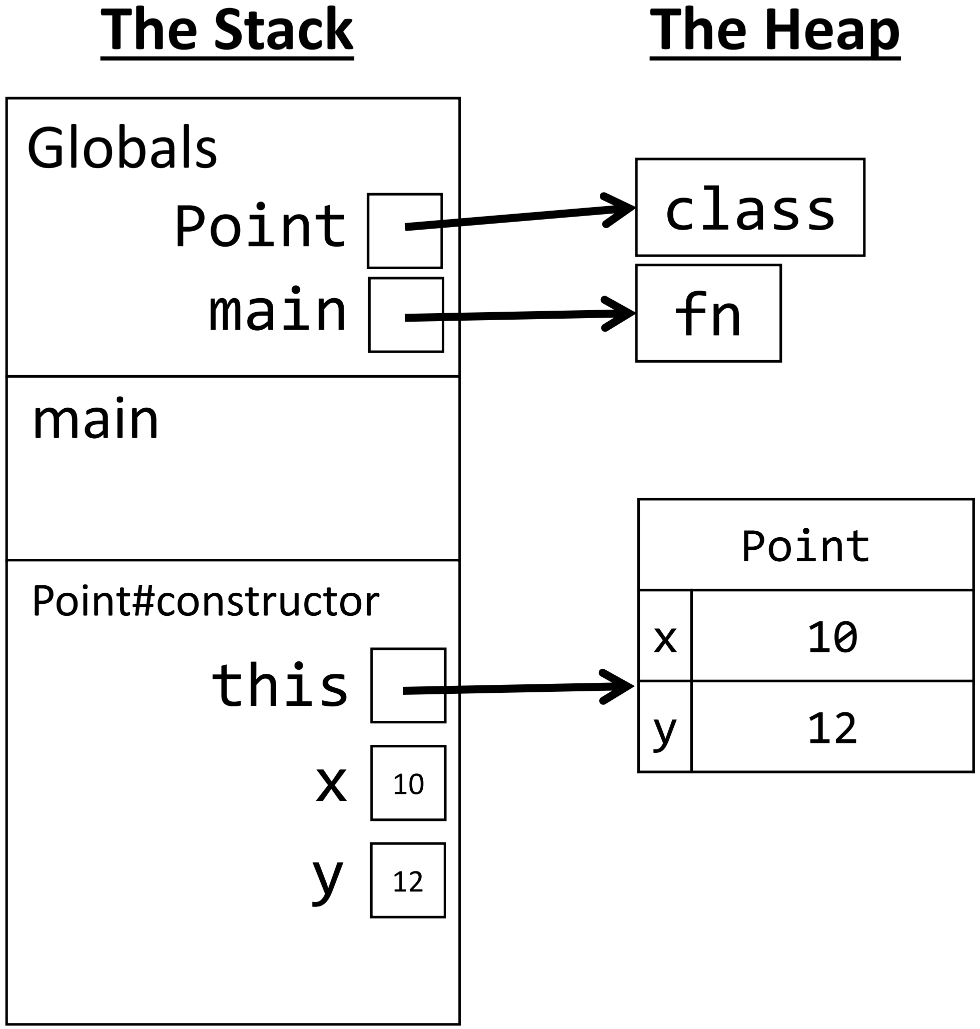
```
class Point {
    x: number = 0;
    y: number = 0;

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

export let main = async () => {
    let p0 = new Point(10, 20);
};
```



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.

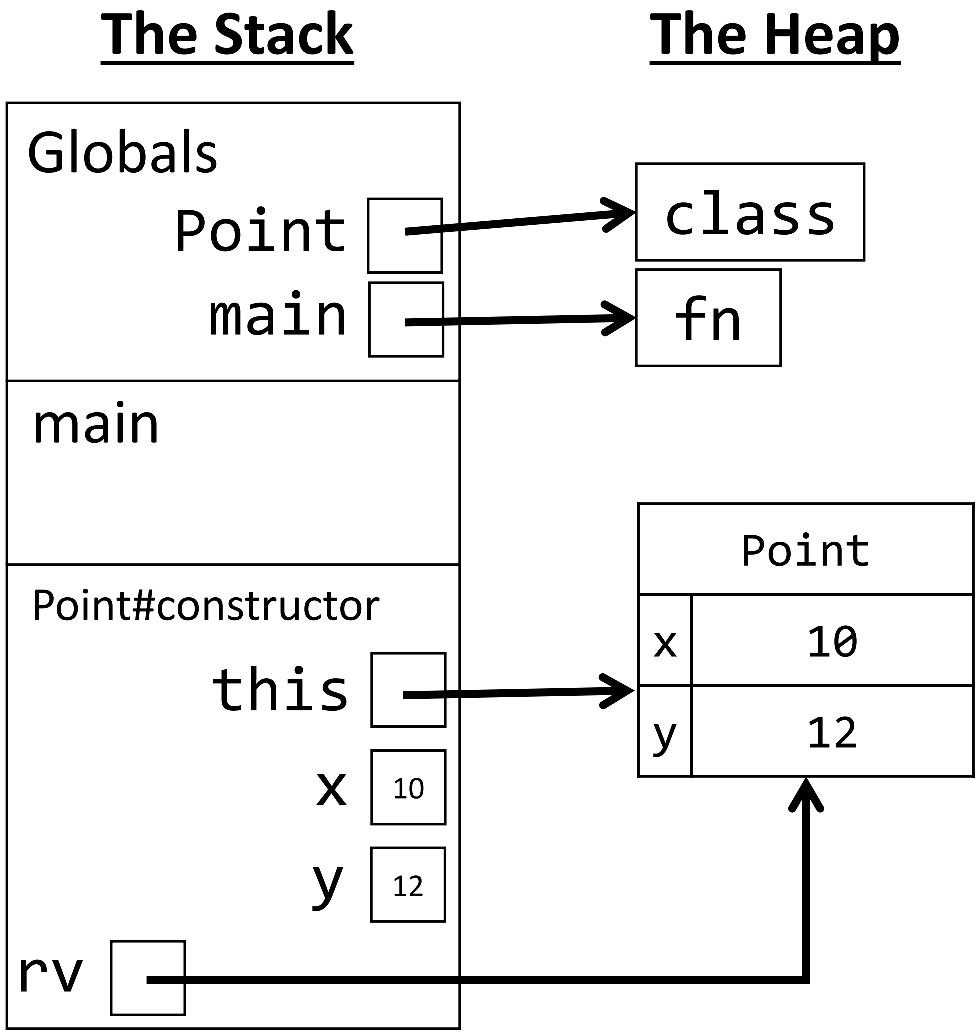


```
class Point {
    x: number = 0;
    y: number = 0;

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

export let main = async () => {
    let p0 = new Point(10, 20);
};
```

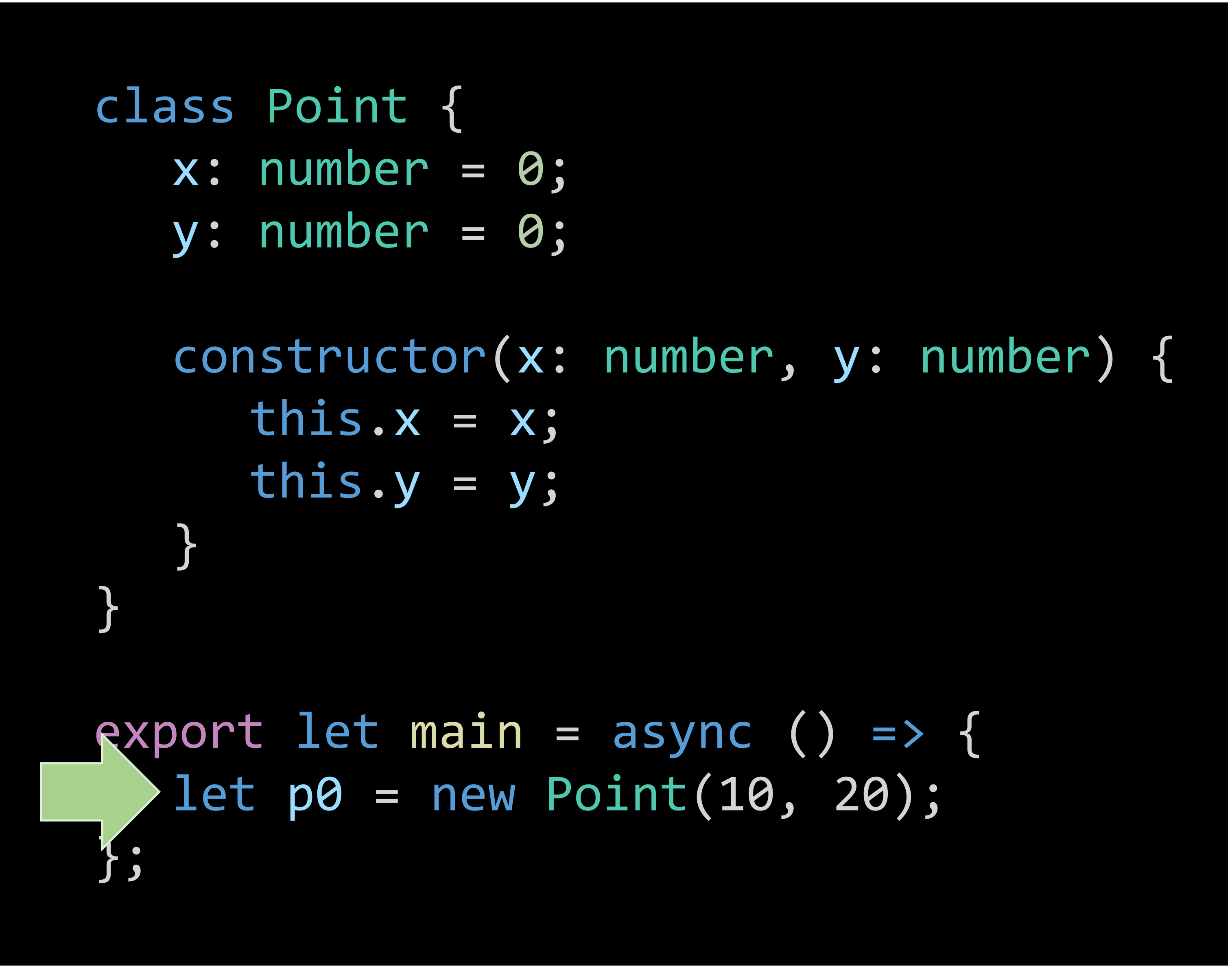


The **return value of a constructor** is implicitly the same reference as **this**.

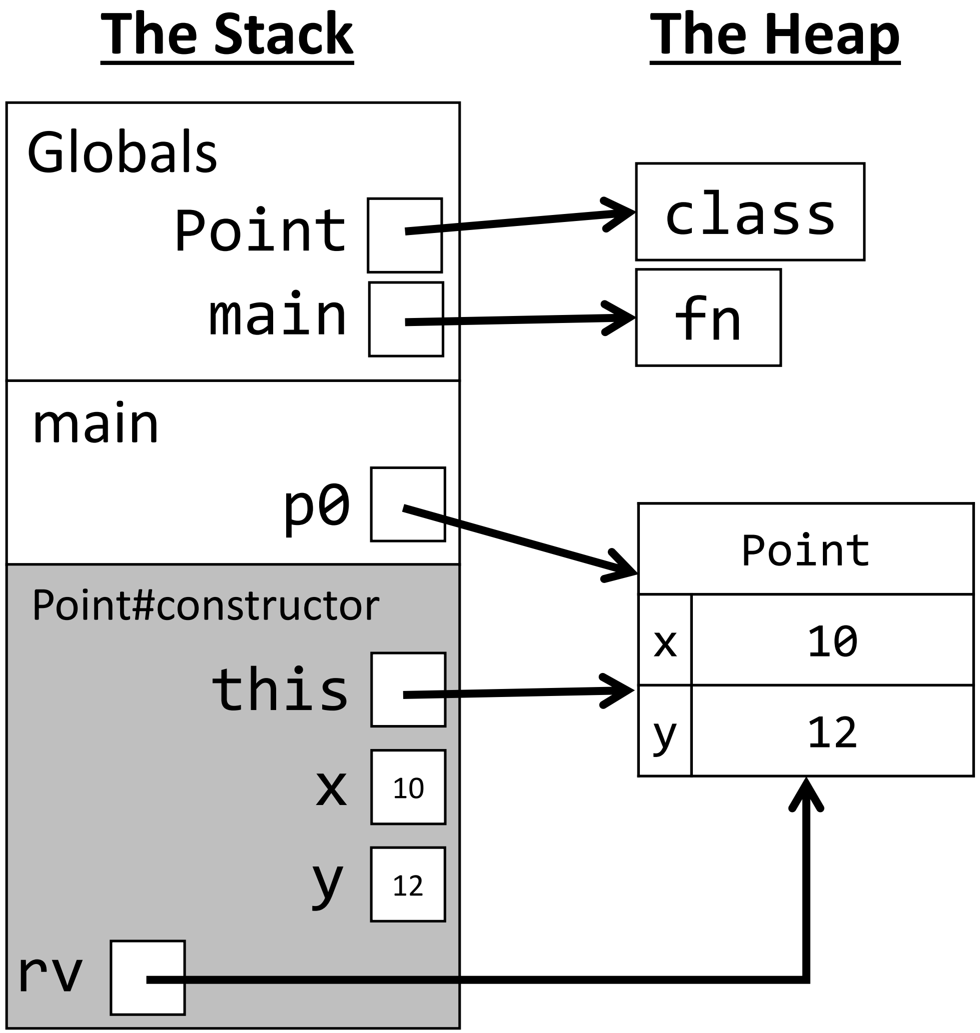
```
class Point {
   x: number = 0;
   y: number = 0;

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

export let main = async () => {
   let p0 = new Point(10, 20);
};
```



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



```
class Point {
   x: number = 0;
   y: number = 0;

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

export let main = async () => {
   let p0 = new Point(10, 20);
};
```



Technically, the Point#constructor frame would be deleted when the return value is handed back to the main frame. We see that its rv is assigned, so we assume it no longer exists, but we keep it in our diagram to illustrate work.