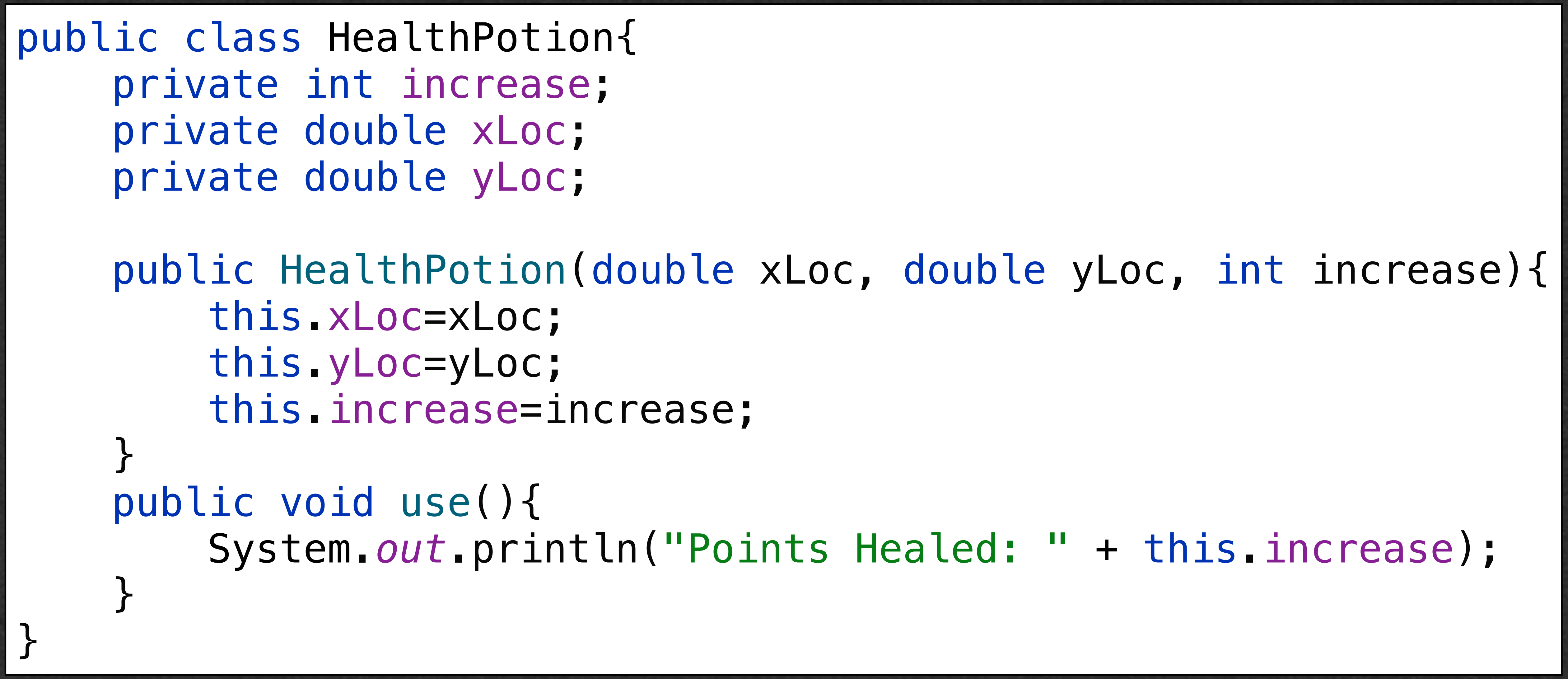
Inheritance

Overview

- Suppose we're making a game and we want to various Items that a Player can use
    - A HealthPotion that will heal a Player when used
    - A Weapon that Players can equip

- Note: We won't build this full game, but we will build some of the game mechanics

HealthPotion Class

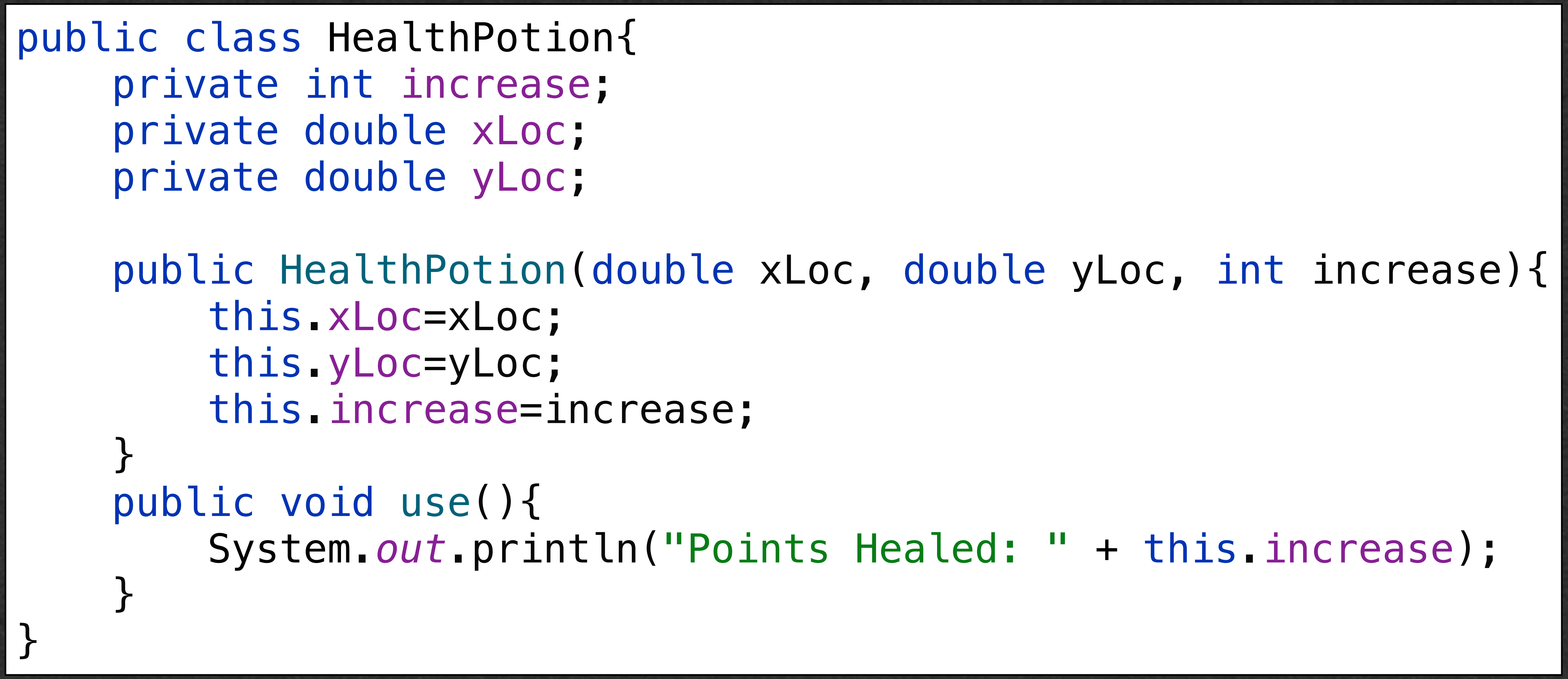


```java
public class HealthPotion{
    private int increase;
    private double xLoc;
    private double yLoc;

    public HealthPotion(double xLoc, double yLoc, int increase){
        this.xLoc=xLoc;
        this.yLoc=yLoc;
        this.increase=increase;
    }
    public void use(){
        System.out.println("Points Healed: " + this.increase);
    }
}
```

- Let's start with the HealthPotion class
- This class has:
  - A constructor that takes three parameters
    - The (x, y) location of the potion as 2 doubles
    - An int representing the amount of health restored by consuming the potion
  - A use method that will heal the Player (Simulated with a println for now)

HealthPotion Class



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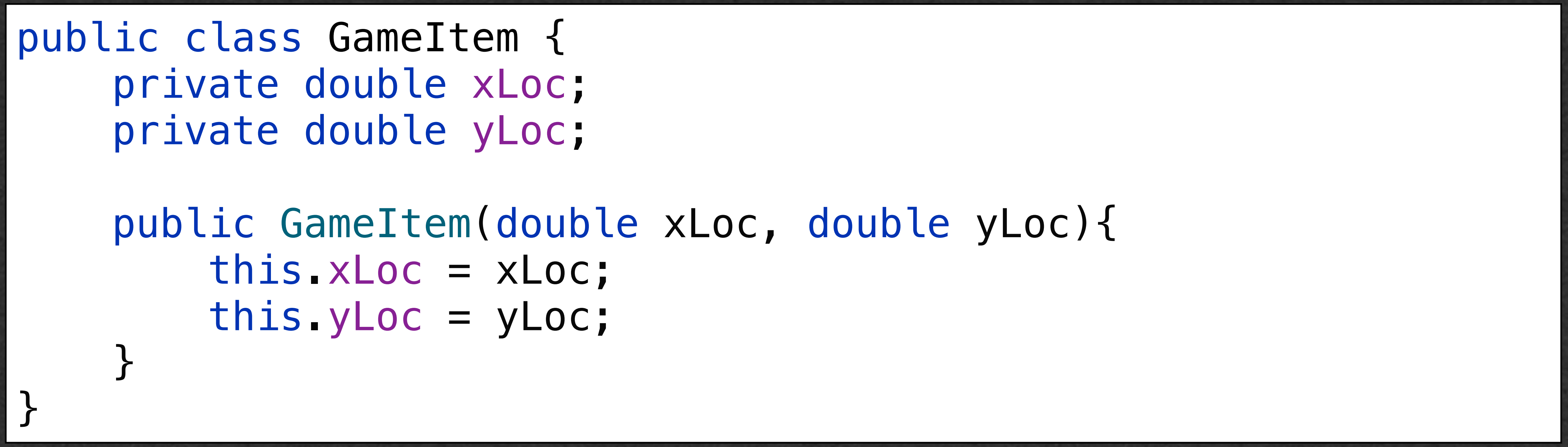
    }
    public void use(){
        System.out.println("Points Healed: " + this.increase);
    }
}
```

- Cool.. but we already know how to do all that
  - What are we learning today?

Inheritance!

Inheritance



```java
public class GameItem {
    private double xLoc;
    private double yLoc;

    public GameItem(double xLoc, double yLoc){
        this.xLoc = xLoc;
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    }
}
```
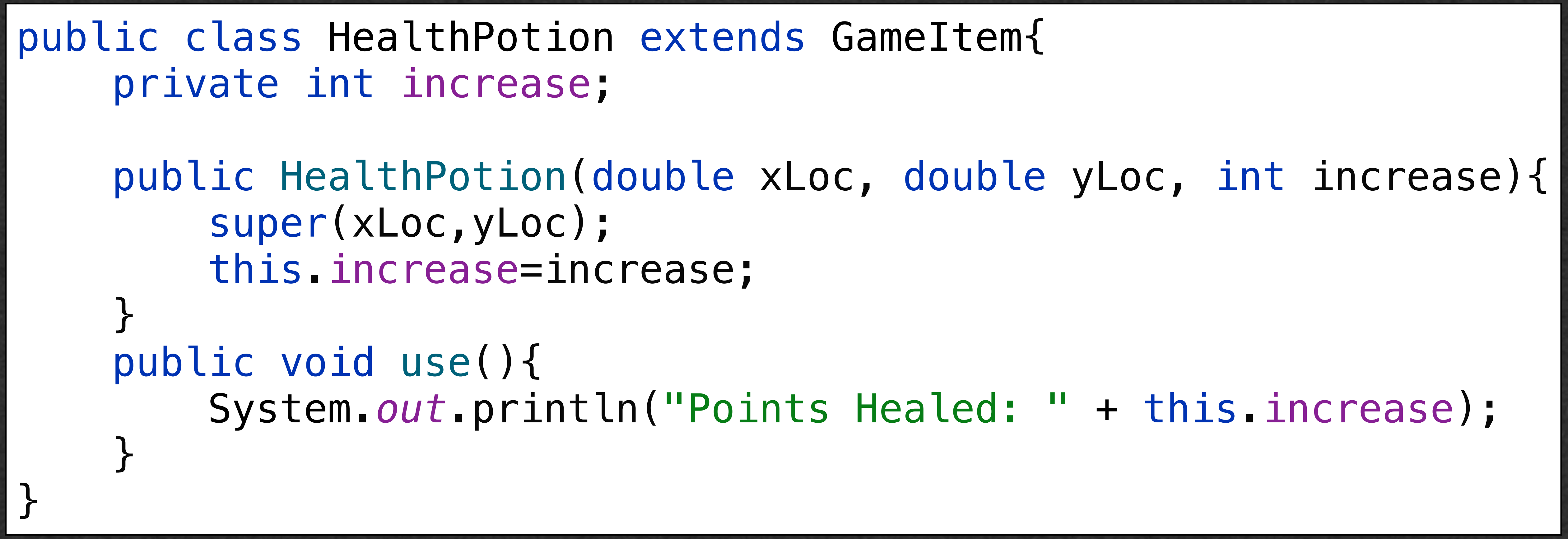
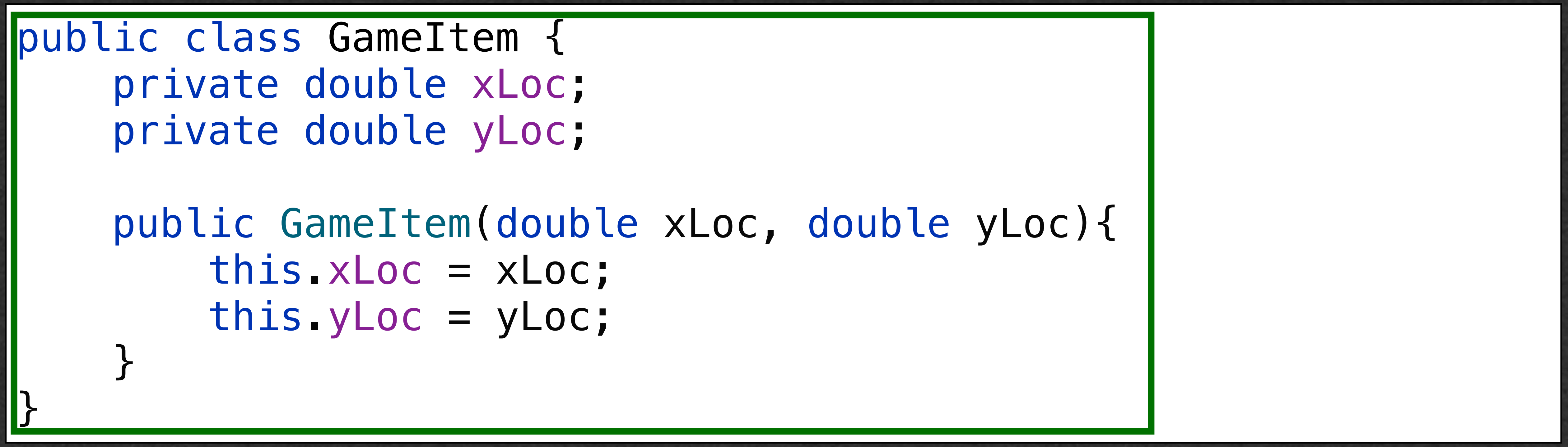



```java
public class HealthPotion extends GameItem{
    private int increase;

    public HealthPotion(double xLoc, double yLoc, int increase){
        super(xLoc,yLoc);
        this.increase=increase;
    }
    public void use(){
        System.out.println("Points Healed: " + this.increase);
    }
}
```

- Instead of defining all of the HealthPotion functionality in its own class:
    - Have it inherit from another class
- Let's breakdown how this works

Inheritance



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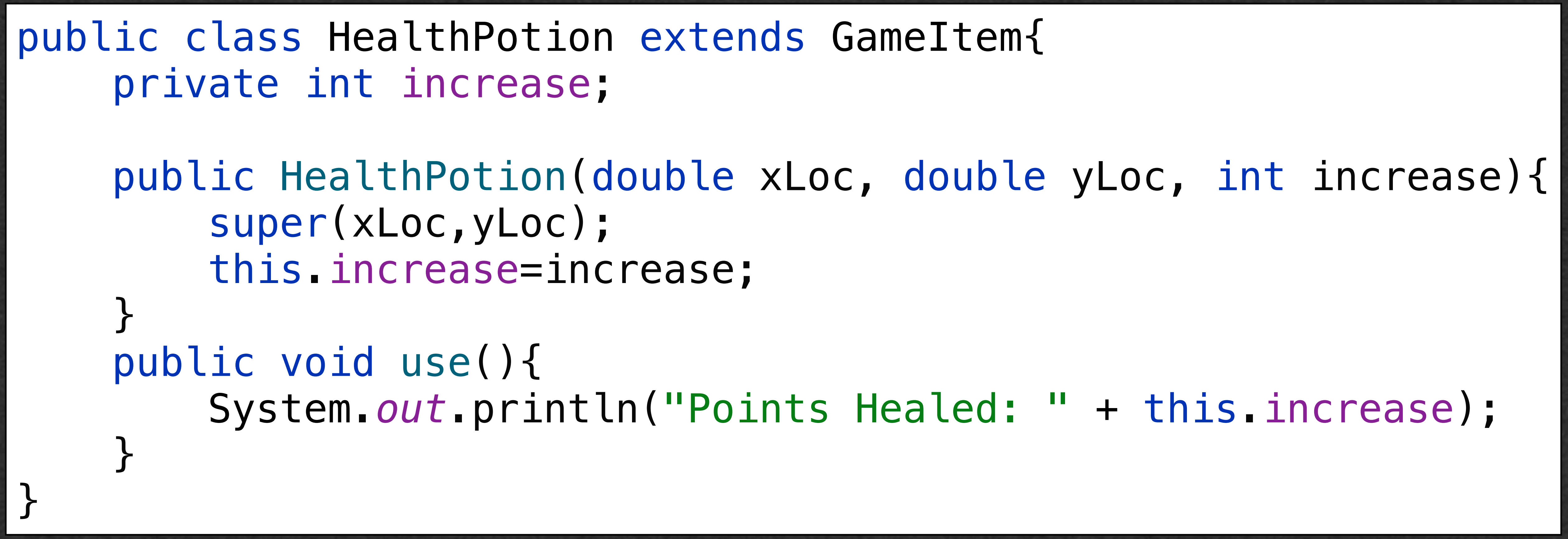

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    }
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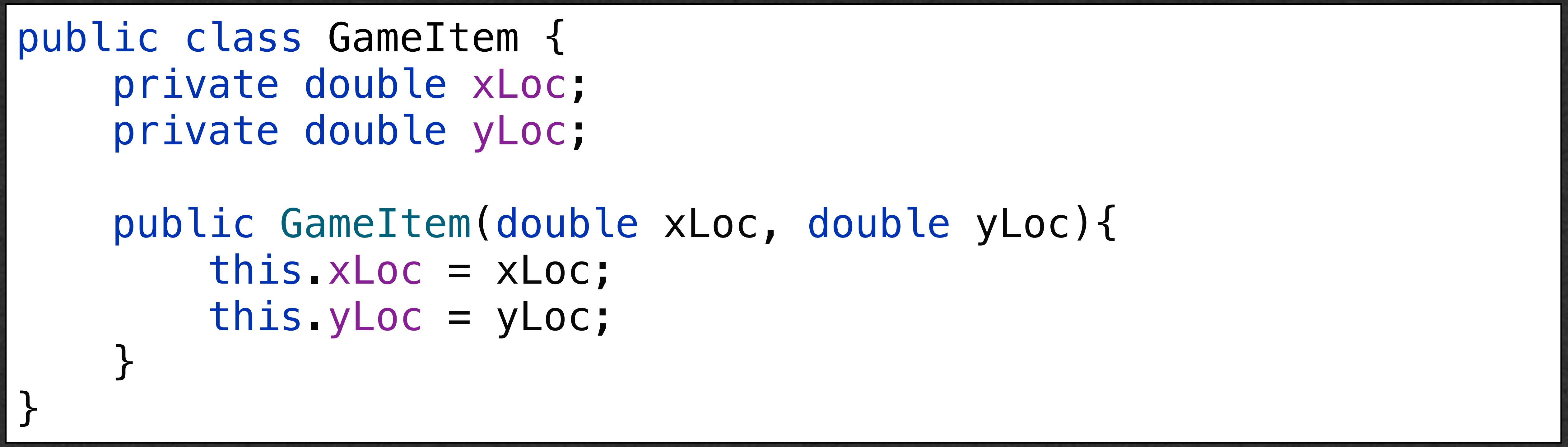
}
```

- First, we'll write a separate class, GameItem
- GameItem will contain all the state and behavior common to every item in our game
    - Every item will have a location

Inheritance



```java
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    private double xLoc;
    private double yLoc;

    public GameItem(double xLoc, double yLoc){
        this.xLoc = xLoc;
        this.yLoc = yLoc;
    }
}
```
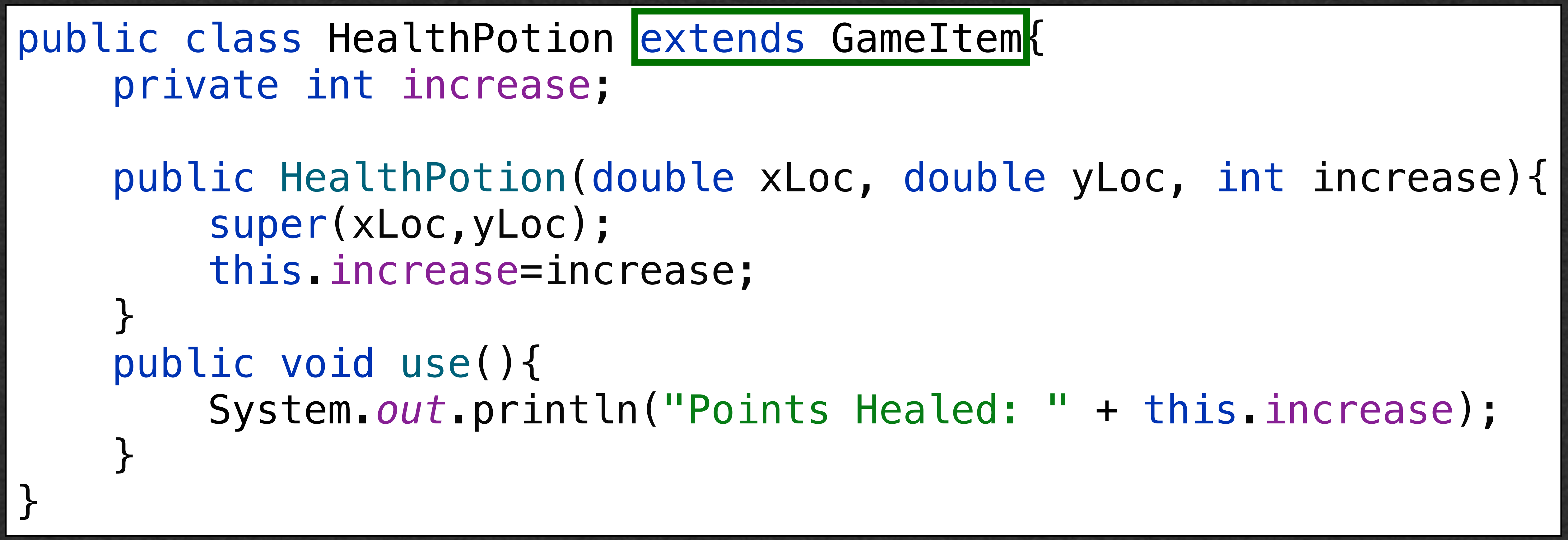

- Use the **extends** keyword to inherit from another class
- HealthPotion **inherits from** GameItem
  - or, HealthPotion **extends** GameItem



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    }
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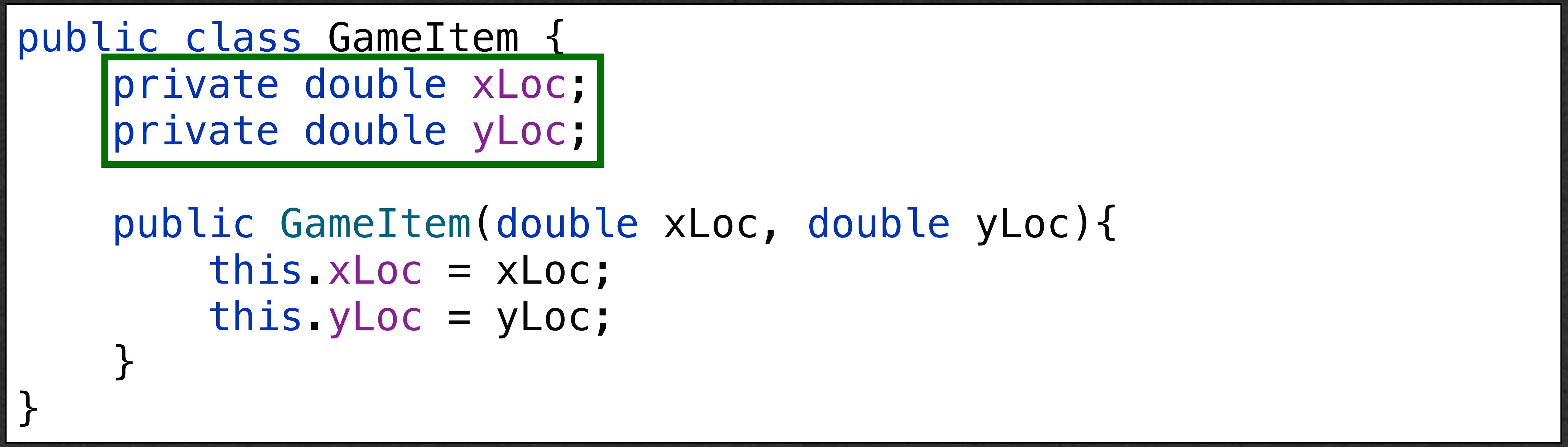
}
```

- HealthPotion *inherits* all the **state** and **behavior** of GameItem
  - -or- HealthPotion *inherits* all the **instance variables** and **methods** of GameItem

Inheritance



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}
```

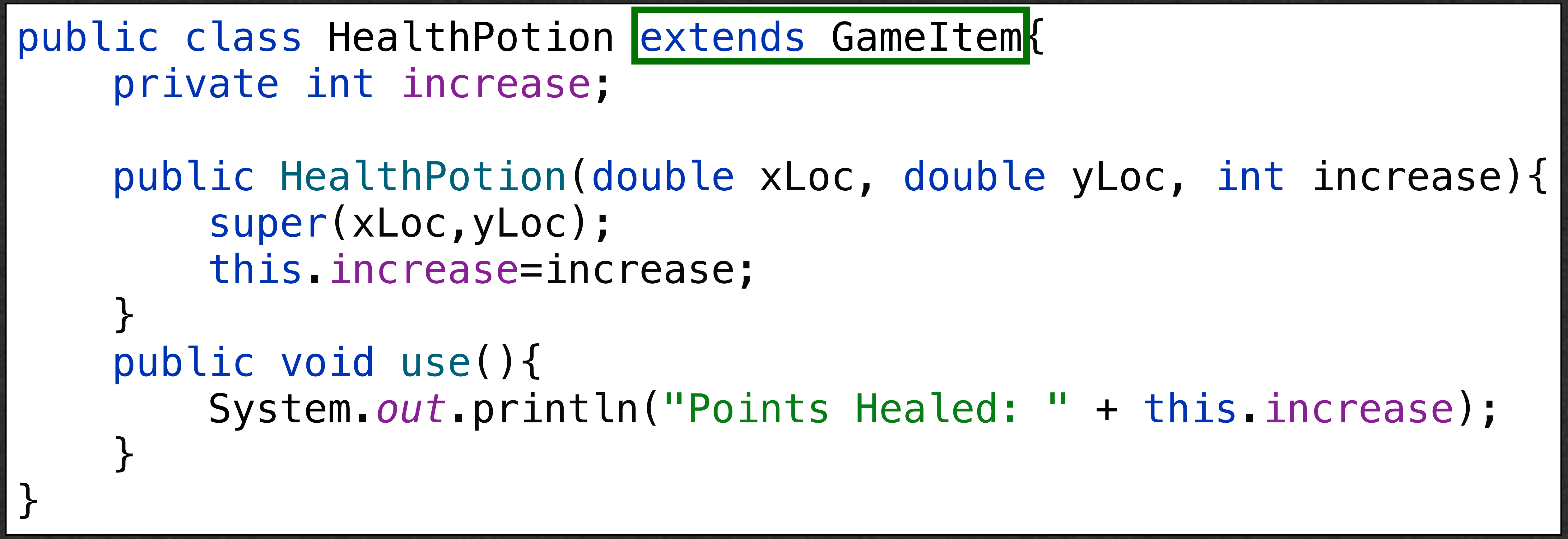

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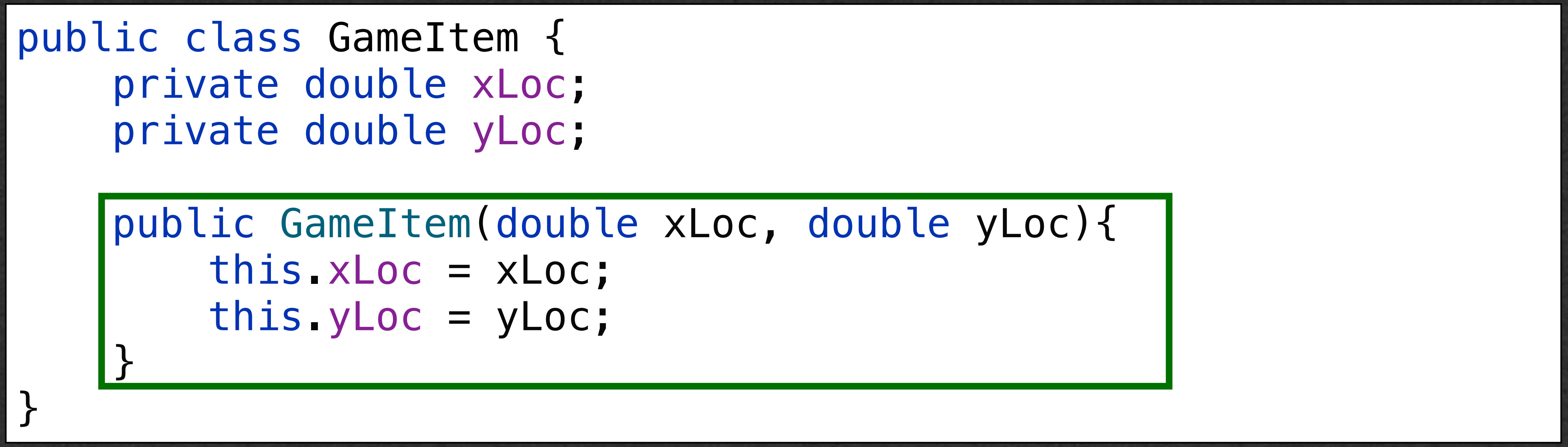
    }
    public void use(){
        System.out.println("Points Healed: " + this.increase);
    }
}
```

- HealthPotion *inherits* all the **state** and **behavior** of GameItem

- All instance variables declared in GameItem are also instance variables of every HealthPotion

- HealthPotions now have an (x, y) location as part of their state *without* declaring these variables directly

Inheritance



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    public GameItem(double xLoc, double yLoc){
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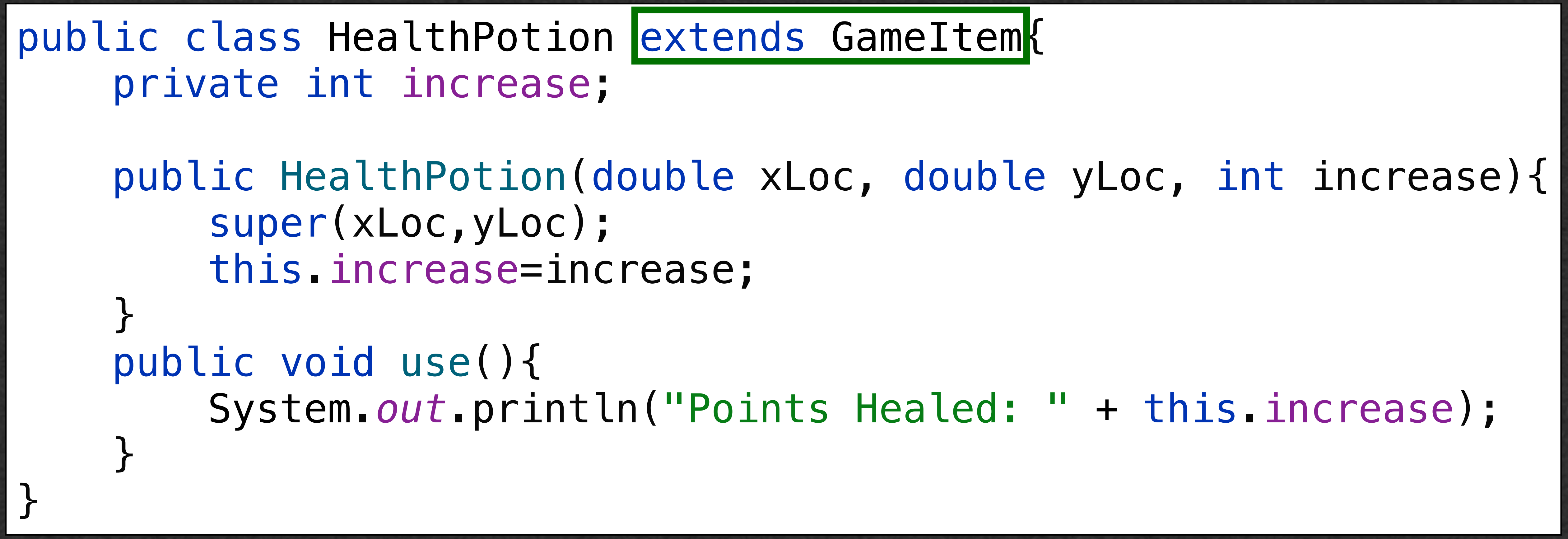

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        System.out.println("Points Healed: " + this.increase);
    }
}
```
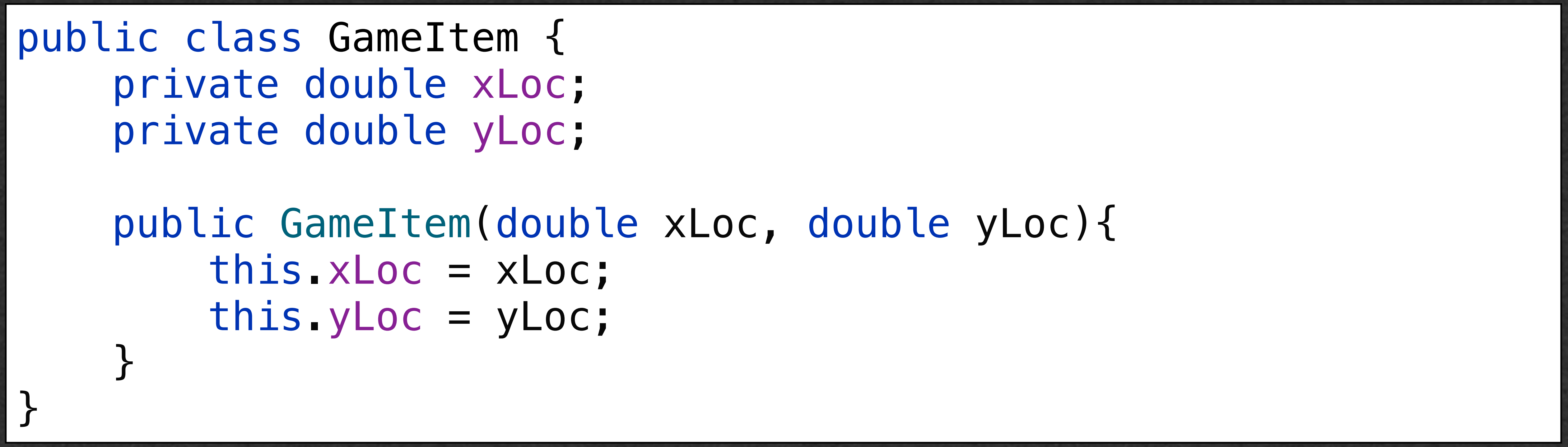

- HealthPotion *inherits* all the **state** and **behavior** of GameItem

- All methods declared in the GameItem class are methods available to every GameItem object
    - Only the constructor for now

Inheritance



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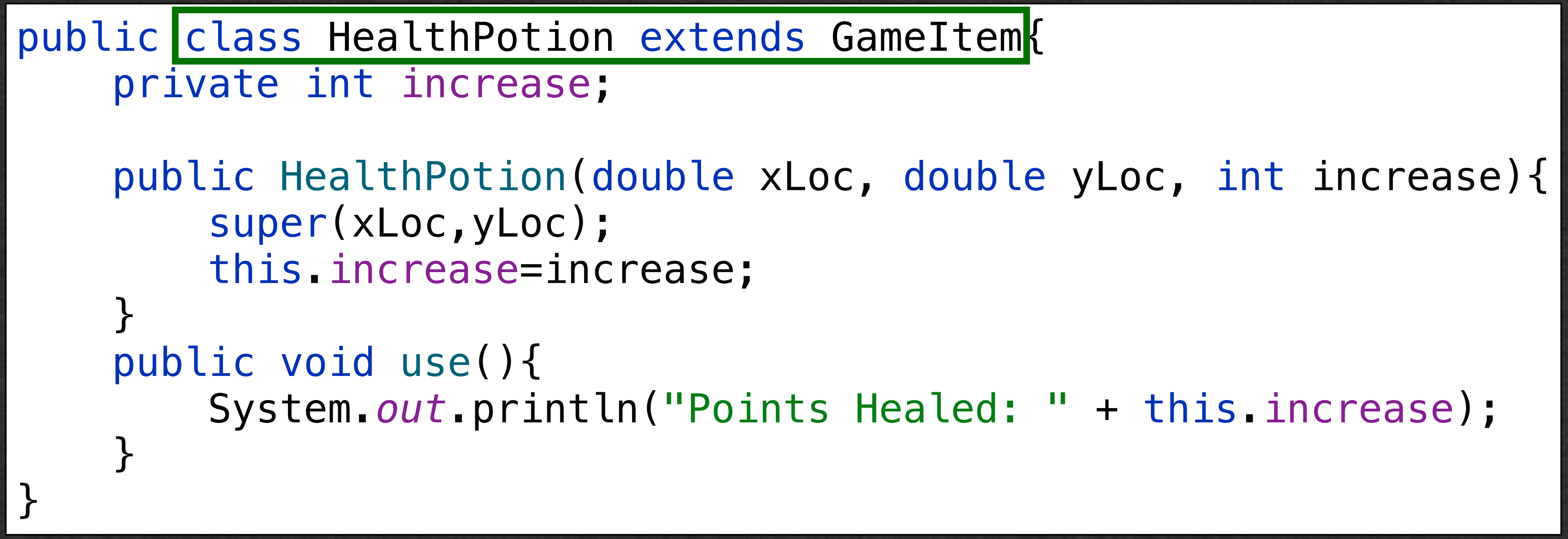

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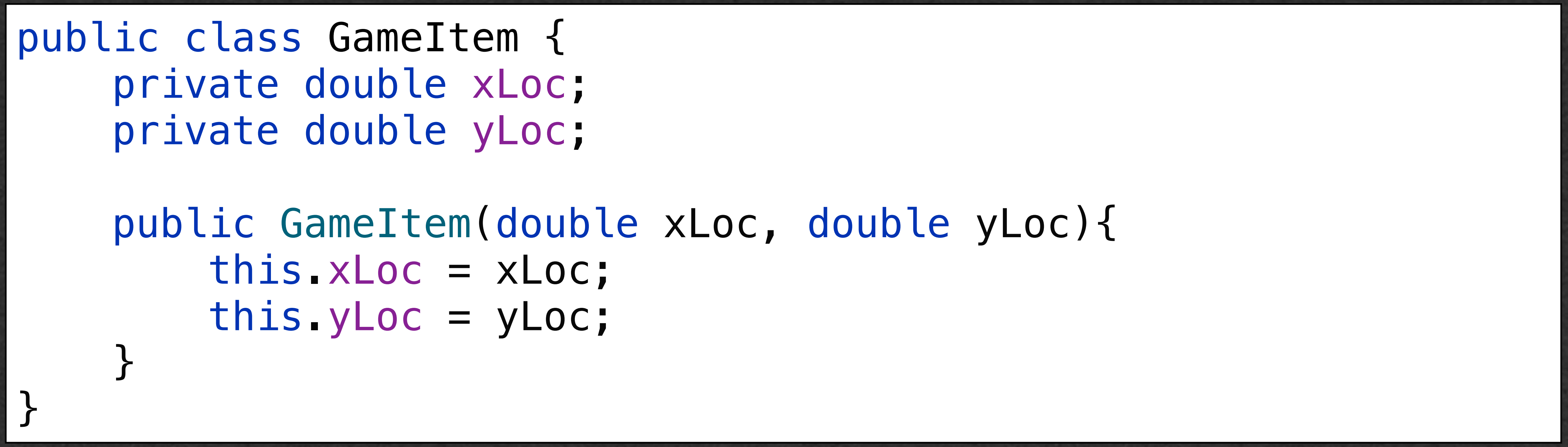
    public void use(){
        System.out.println("Points Healed: " + this.increase);
    }
}
```

- Vocab:
  - GameItem is the **super** class of HealthPotion
    - -or- GameItem is the **parent** class of HealthPotion
  - HealthPotion is a **sub-class** of GameItem
    - -or- HealthPotion is a **child** class of GameItem

Inheritance



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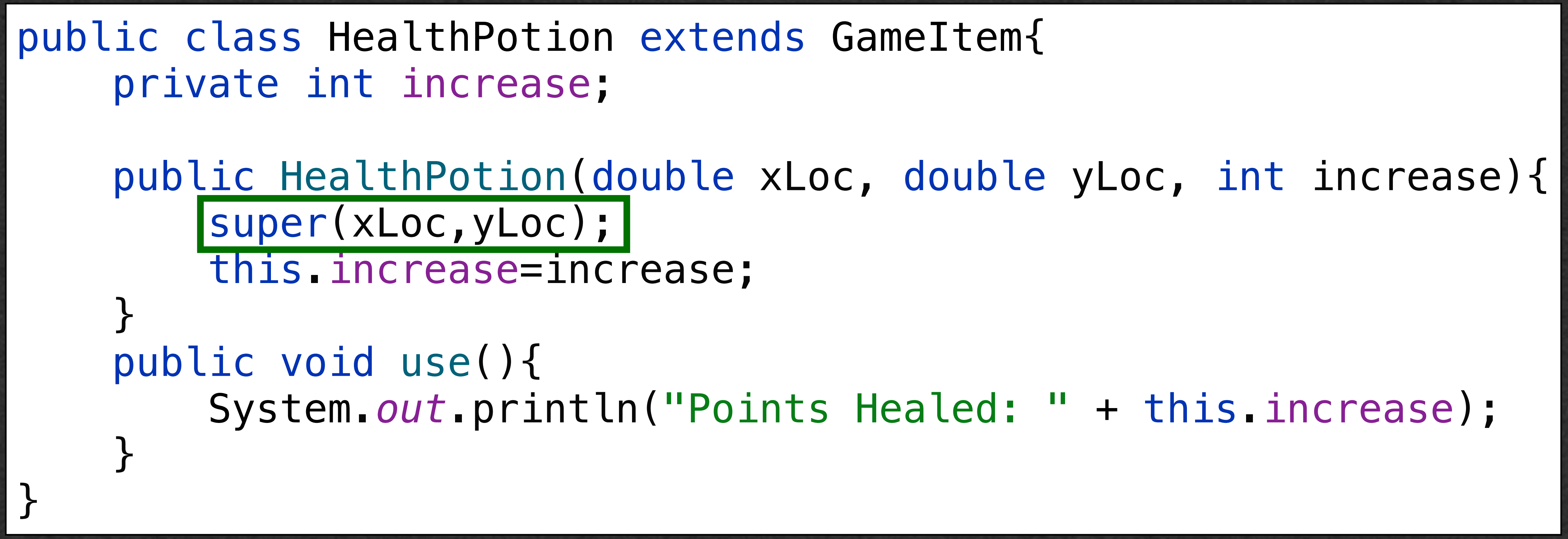

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}
```
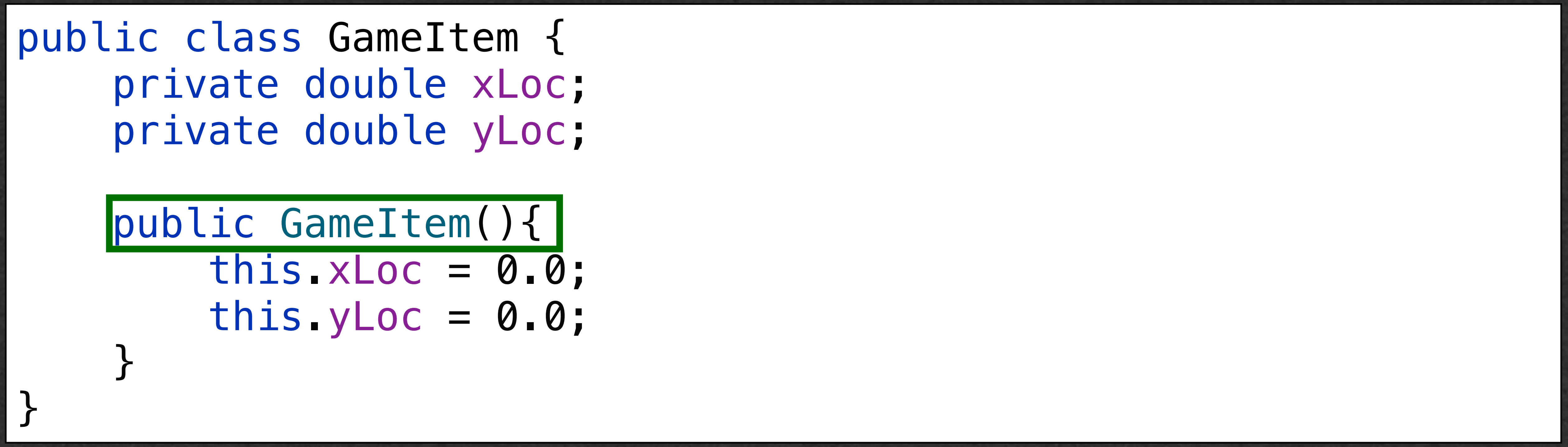
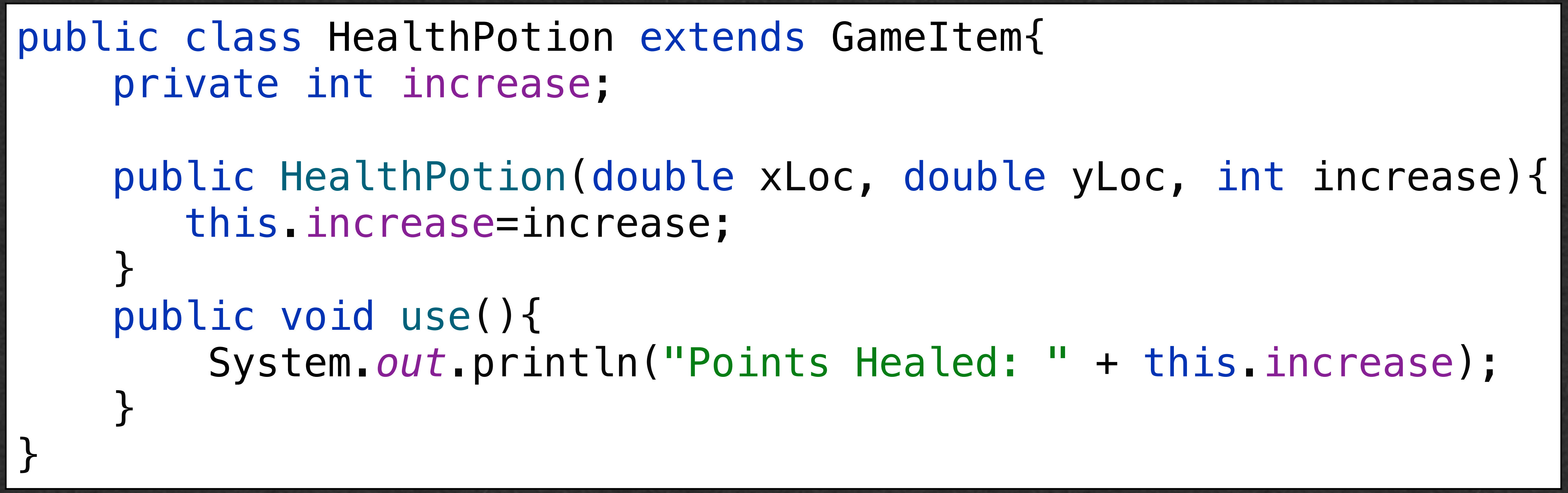

- When calling a classes constructor
  - **You must call its super class constructor**
  - Use the keyword **super** to access the super class
  - Calling super as a method will call the super class constructor
- If the super class constructor takes parameters, this call must be explicit

Inheritance



```
public class GameItem {
    private double xLoc;
    private double yLoc;

    public GameItem(){
        this.xLoc = 0.0;
        this.yLoc = 0.0;
    }
}
```



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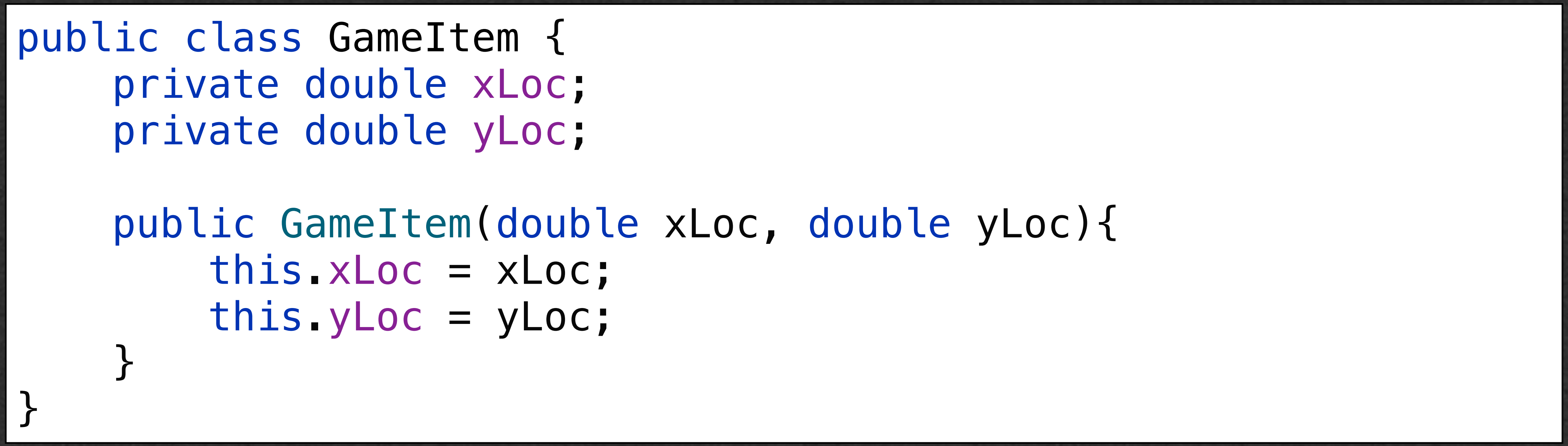
    }
}
```

- A special case:
  - *If* the super class has a constructor that takes no parameters, it will be called implicitly
  - The constructor **is still called**, you just don't have to type super()

Inheritance



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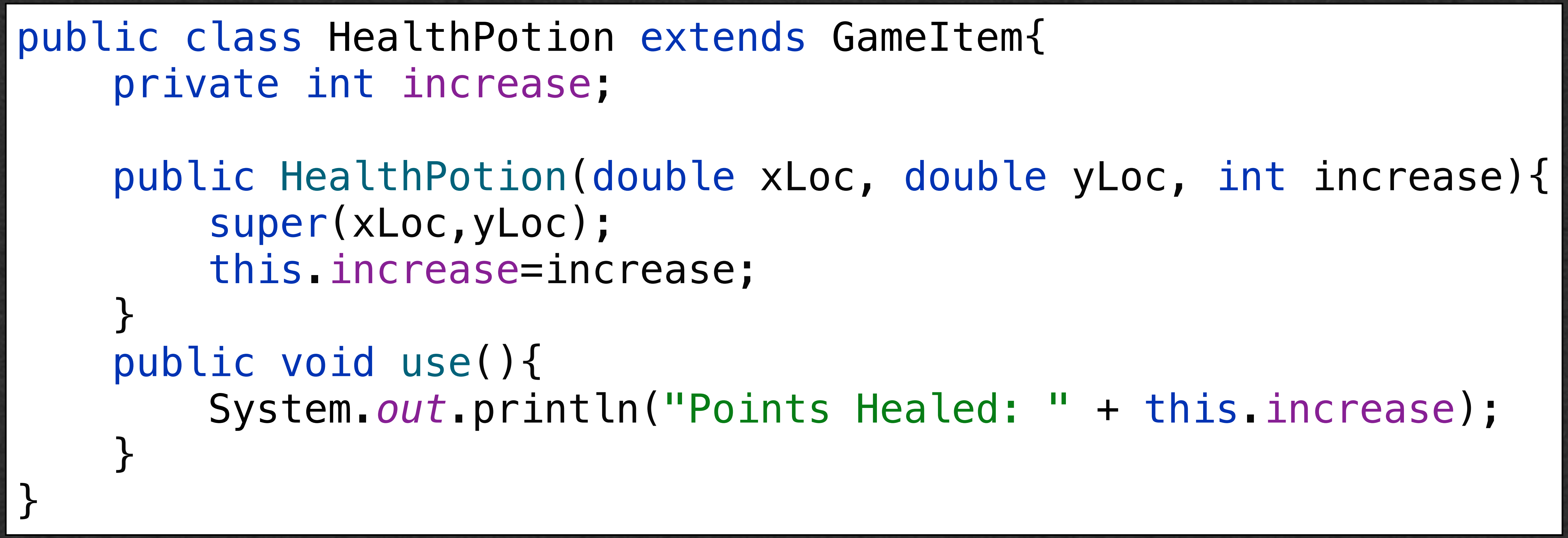

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}
```
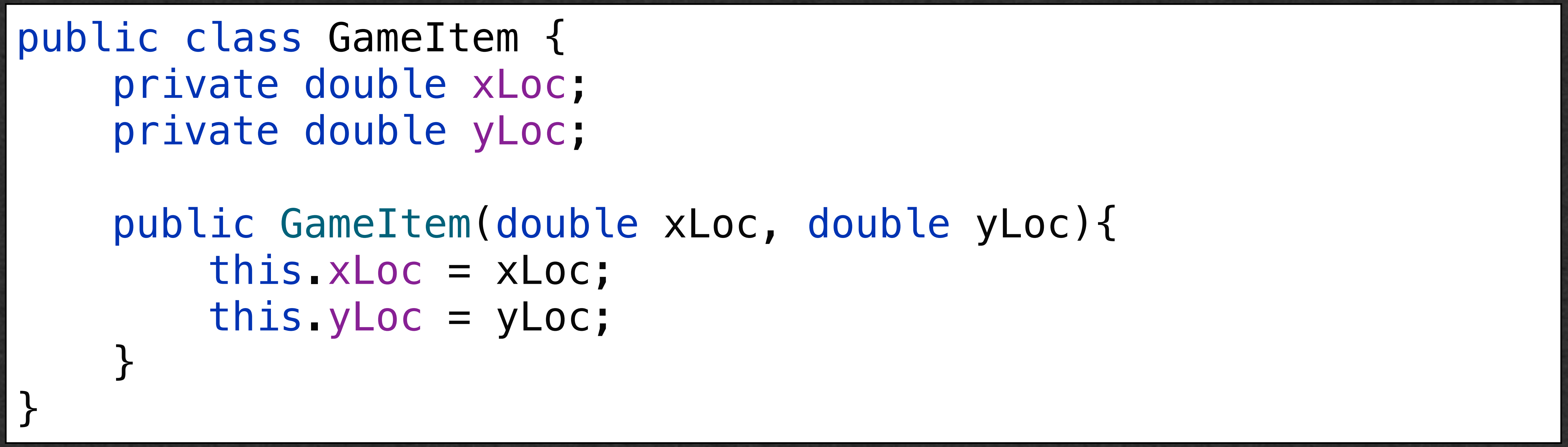

- **BUT Y THO?**

- Isn't this more work to get the same result?

Inheritance

- **BUT Y THO?**



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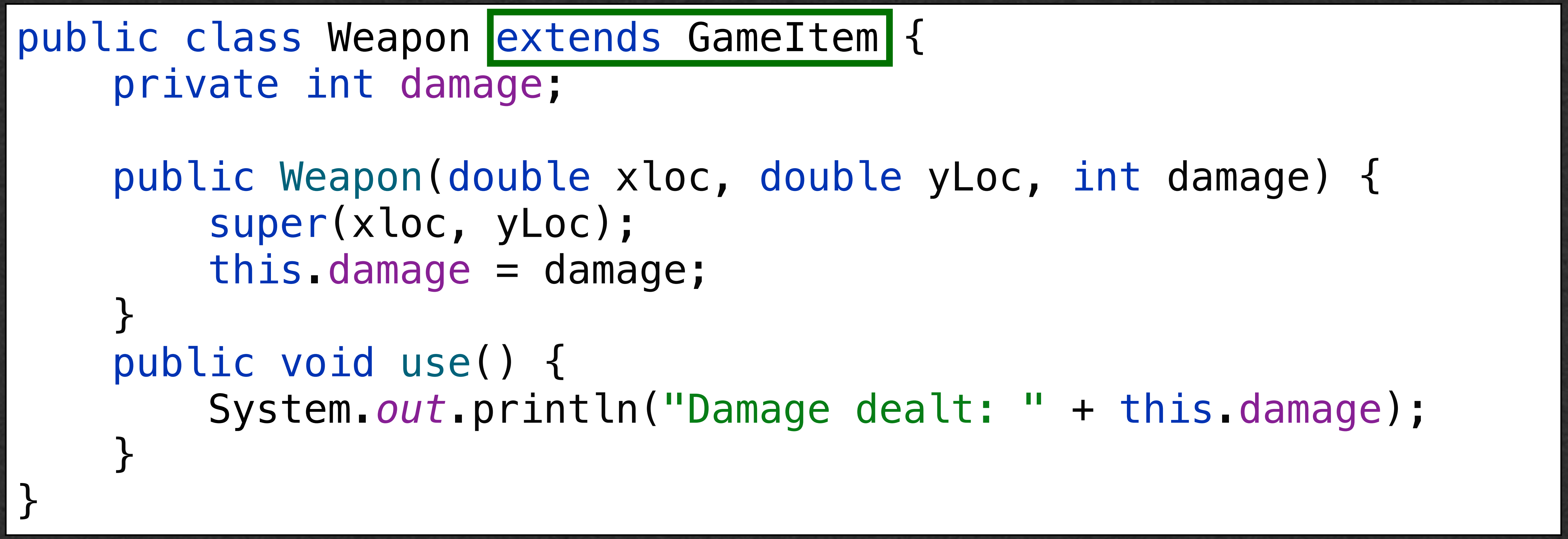
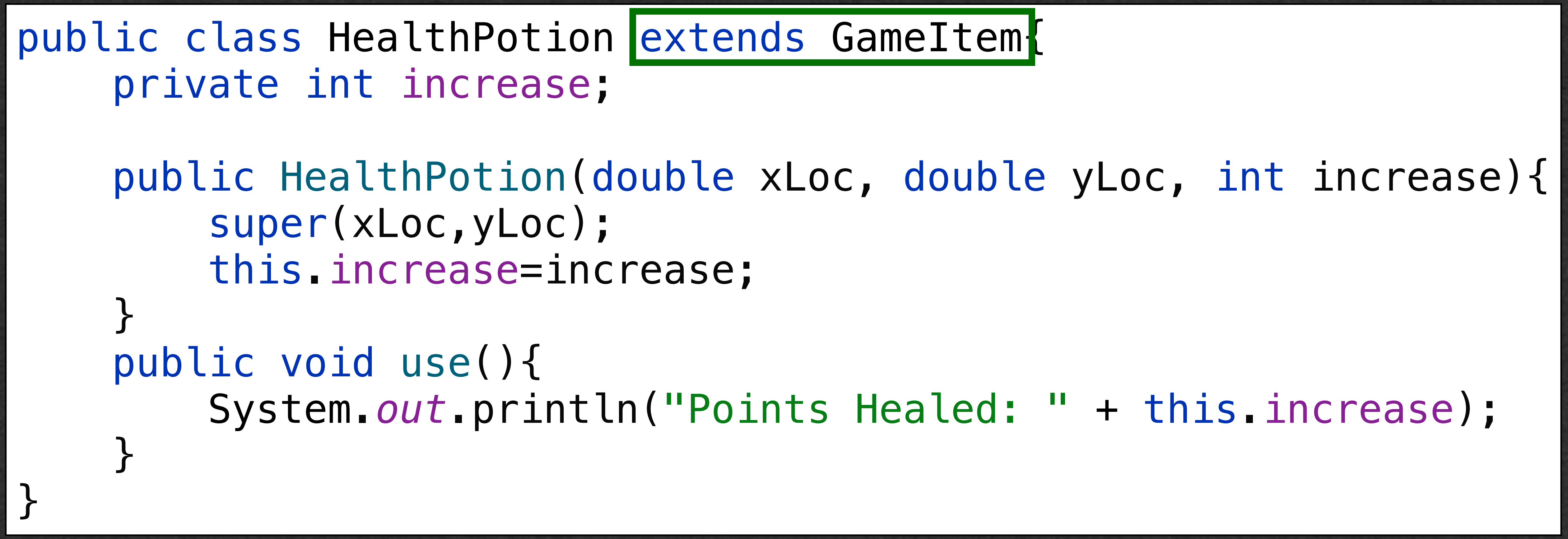


```java
public class Weapon extends GameItem {
    private int damage;

    public Weapon(double xloc, double yLoc, int damage) {
        super(xloc, yLoc);
        this.damage = damage;
    }
    public void use() {
        System.out.println("Damage dealt: " + this.damage);
    }
}
```



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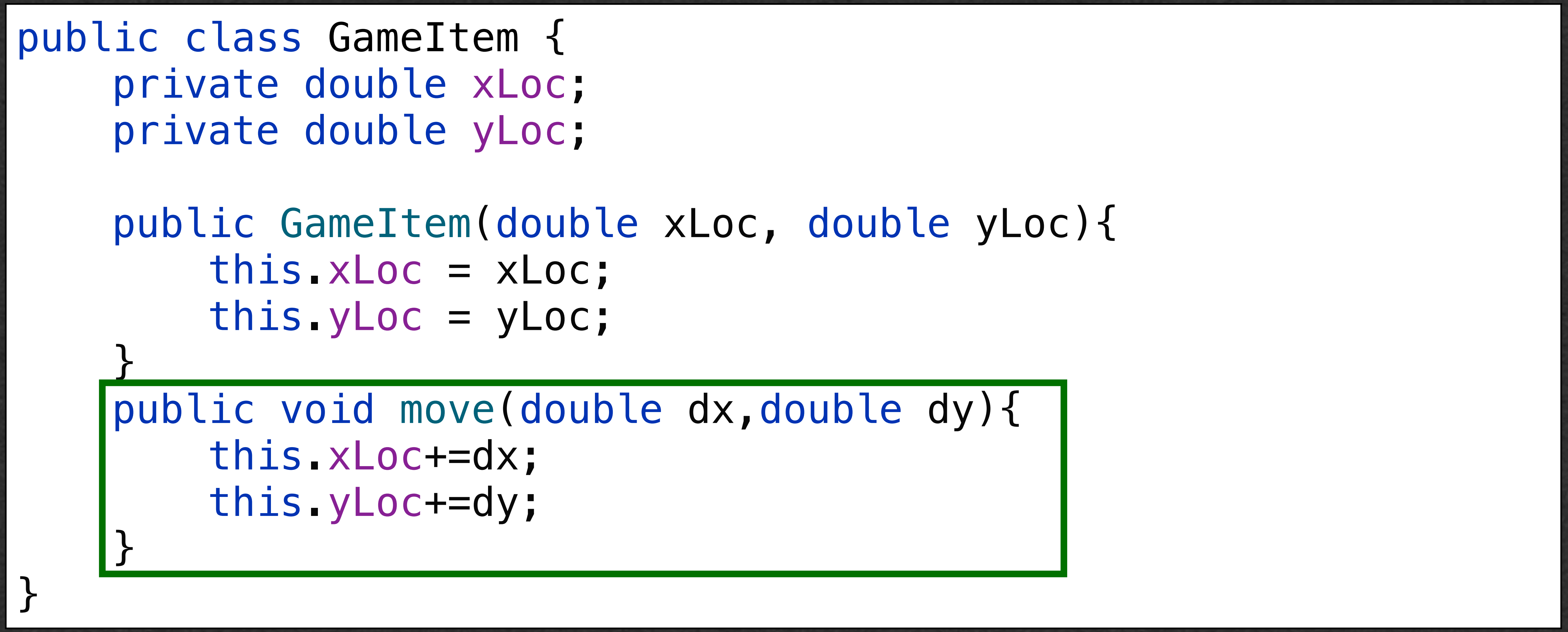
    }
}
```

- Inheritance is useful when multiple classes extend the same super class
- Every item in our game will extend GameItem
- Every item in our game has an (x, y) location without having to implement extra code (Or cut n' paste code)

Inheritance



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    private double yLoc;

    public GameItem(double xLoc, double yLoc){
        this.xLoc = xLoc;
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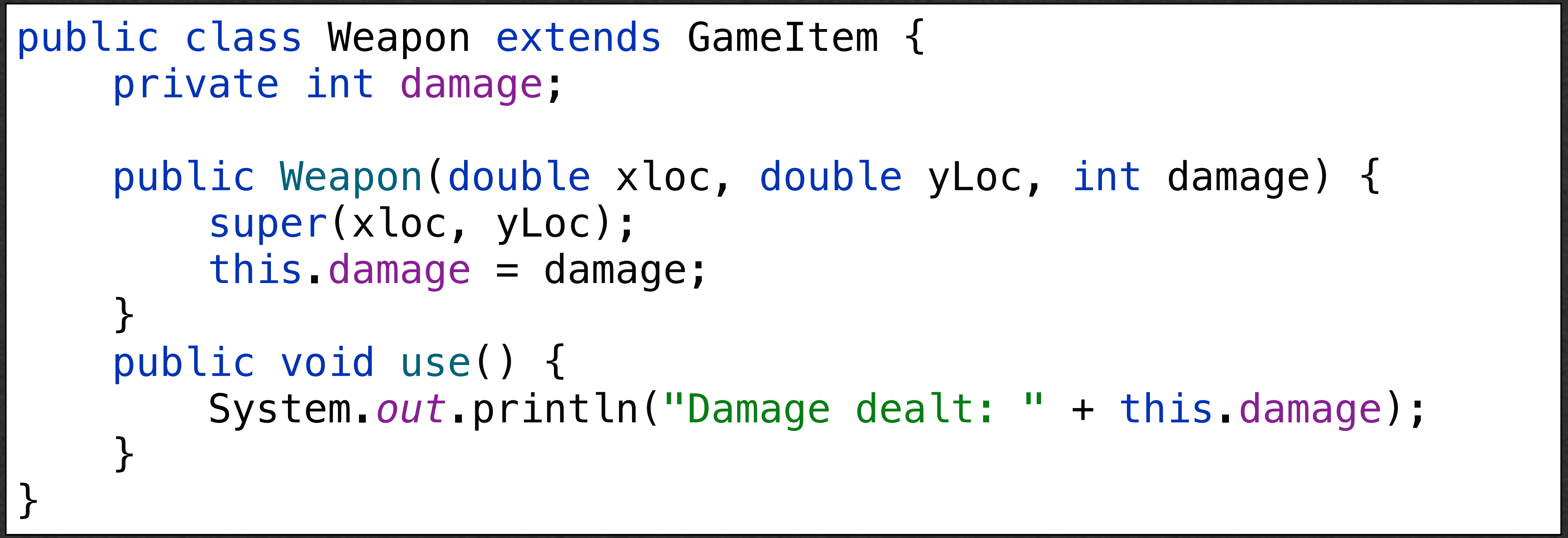
    }
    public void move(double dx,double dy){
        this.xLoc+=dx;
        this.yLoc+=dy;
    }
}
```



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    private int damage;

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        this.damage = damage;
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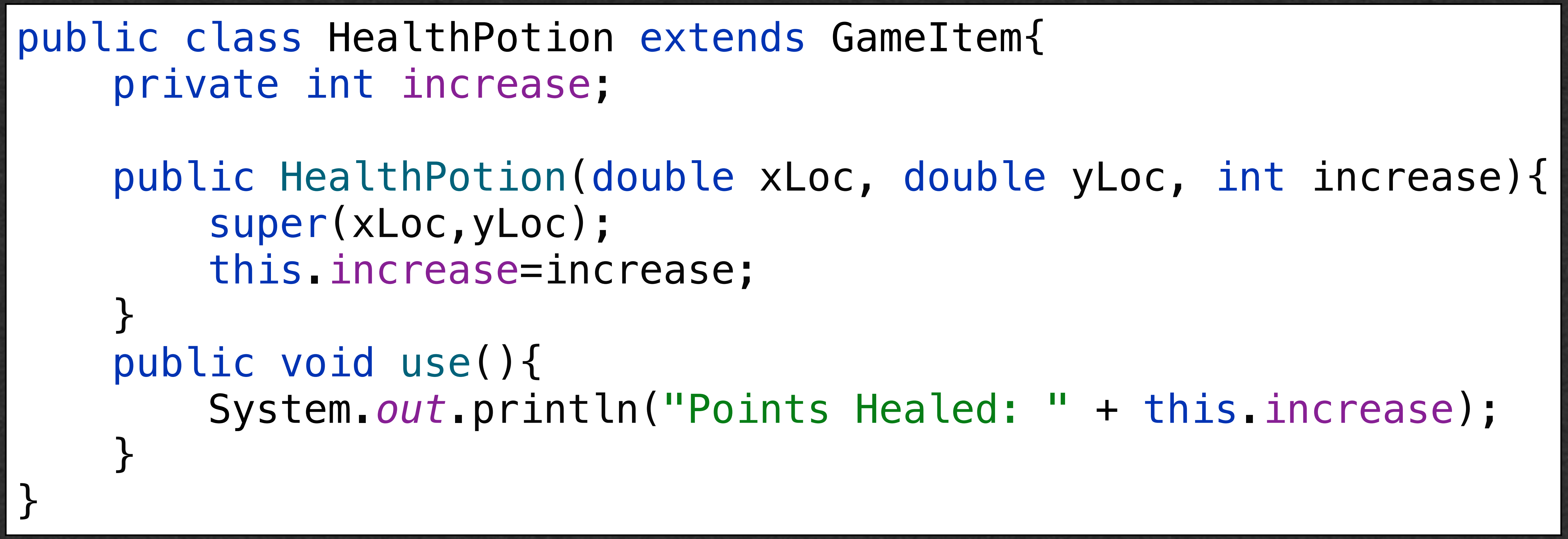

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    }
    public void use(){
        System.out.println("Points Healed: " + this.increase);
    }
}
```

- **BUT Y THO?**

- Since the child classes also inherit behavior
    - Write a method in GameItem and **ALL** child classes inherit that method
- Convenient with our 2 game items
    - Very powerful when there are 100's of game items!

Memory Diagram

```java
public class GameItem {
    private double xLoc;
    private double yLoc;

    public GameItem(double xLoc, double yLoc){
        this.xLoc = xLoc;
        this.yLoc = yLoc;
    }
    public void move(double dx, double dy){
        this.xLoc += dx;
        this.yLoc += dy;
    }
}
```

```java
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    private int damage;

    public Weapon(double xloc, double yLoc, int damage) {
        super(xloc, yLoc);
        this.damage = damage;
    }
    public void use() {
        System.out.println("Damage dealt: " + this.damage);
    }
}
```

```java
public static void main(String[] args) {
 ⇨  Weapon weapon = new Weapon(3.9, -0.5, 10);
    weapon.use();
    weapon.move(-0.5, 1.3);
}
```

Stack		Heap
Name	Value	

in/out

- As we go through the trace, note:
    - The super class constructor is called when creating an object
    - The method called can be a super class method

```
public class GameItem {
    private double xLoc;
    private double yLoc;

    public GameItem(double xLoc, double yLoc){
        this.xLoc = xLoc;
        this.yLoc = yLoc;
    }
    public void move(double dx, double dy){
        this.xLoc += dx;
        this.yLoc += dy;
    }
}
```

```
public class Weapon extends GameItem {
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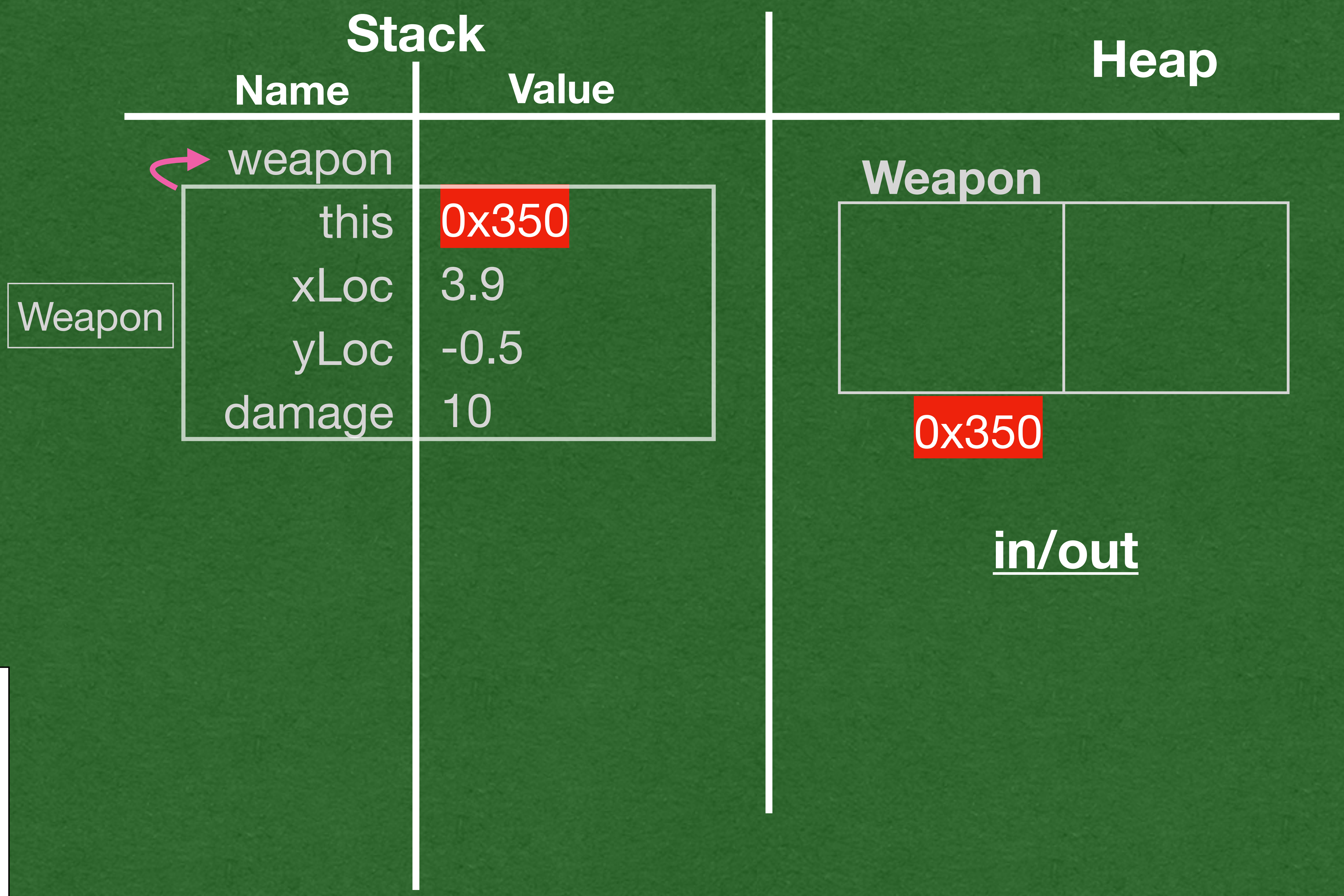

Stack

Name	Value
weapon	
this	0x350
xLoc	3.9
yLoc	-0.5
damage	10

Weapon

Heap

Weapon

0x350

in/out

- We start with the main method
- Create a stack frame for the Weapon constructor
- Create the Weapon object on the heap

```java
public class GameItem {
    private double xLoc;
    private double yLoc;

    public GameItem(double xLoc, double yLoc){
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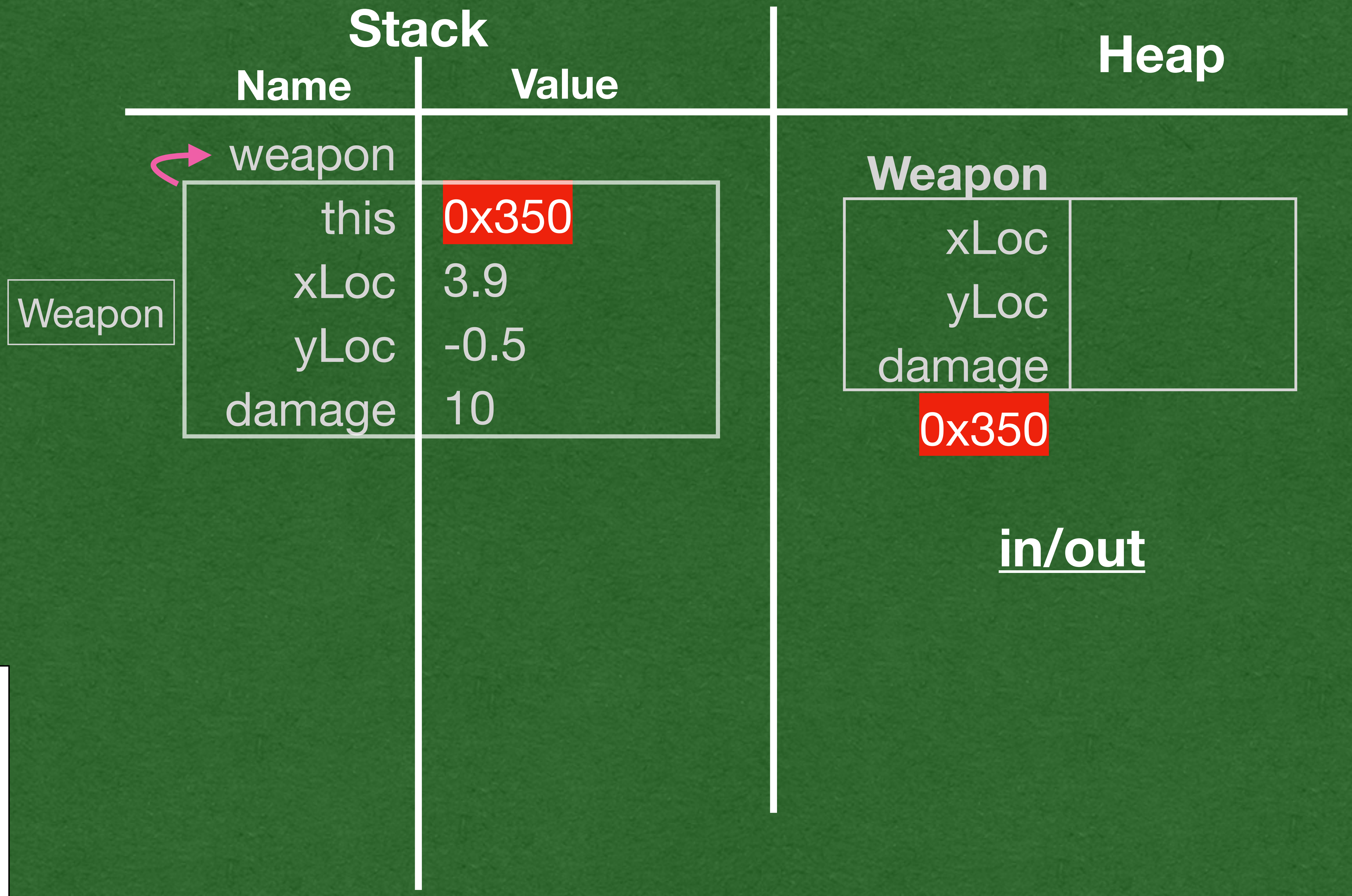

Stack

Name	Value
weapon	
this	0x350
xLoc	3.9
yLoc	-0.5
damage	10

Weapon

Heap

Weapon

xLoc	
yLoc	
damage	

0x350

in/out

- Since Weapon extends GameItem
- Weapon *inherits* all of GameItem's instance variables
- xLoc and yLoc are instance variables of every Weapon object

```java
public class GameItem {
    private double xLoc;
    private double yLoc;

    public GameItem(double xLoc, double yLoc){
        this.xLoc = xLoc;
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        this.xLoc += dx;
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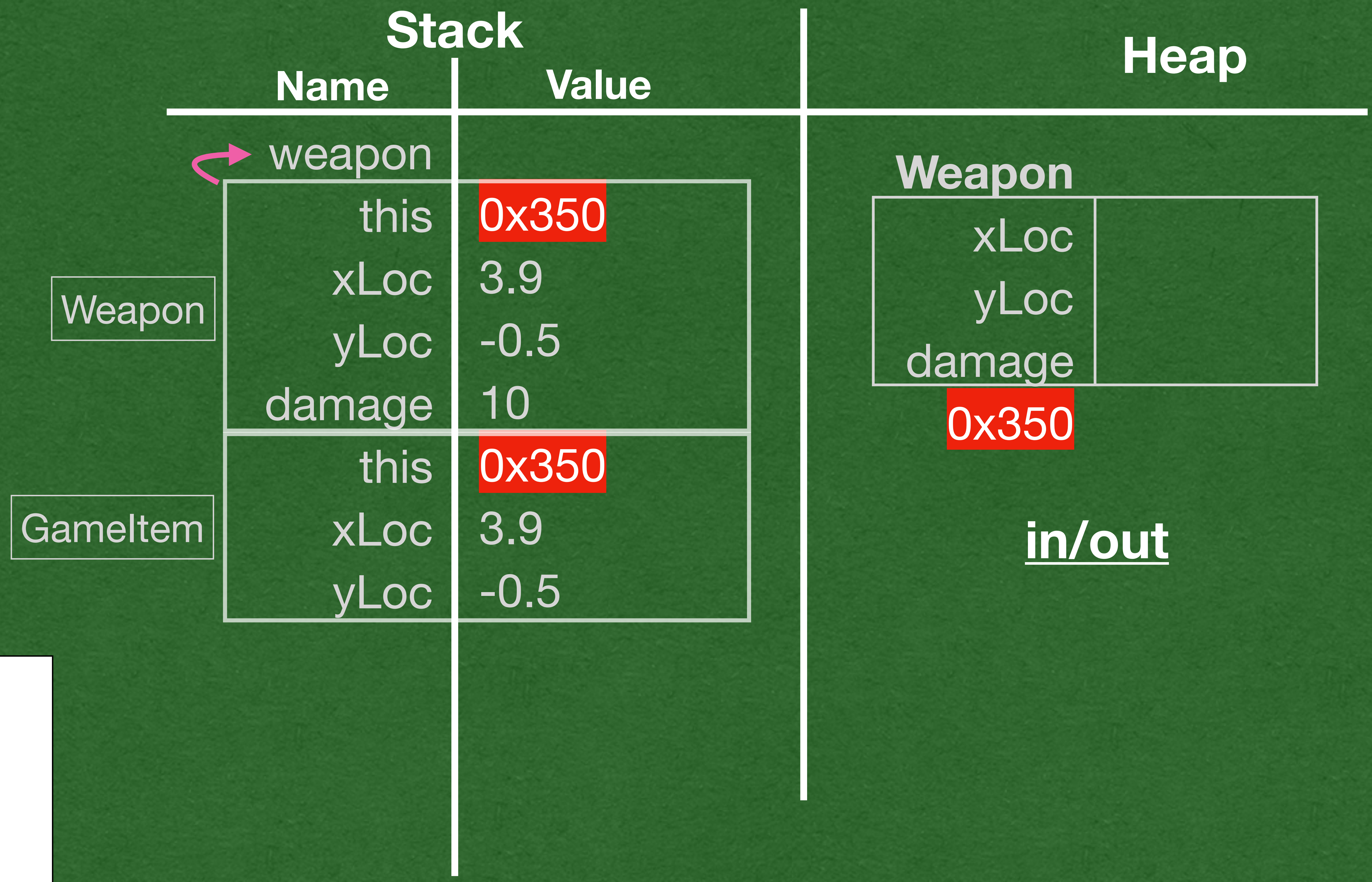

Stack

	Name	Value
	weapon	
Weapon	this	0x350
	xLoc	3.9
	yLoc	-0.5
	damage	10
GameItem	this	0x350
	xLoc	3.9
	yLoc	-0.5

Heap

Weapon

xLoc	
yLoc	
damage	

0x350

in/out

- The super class constructor is called
- This creates another stack frame
- *this* is still a reference to the object that's being created

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public class GameItem {
    private double xLoc;
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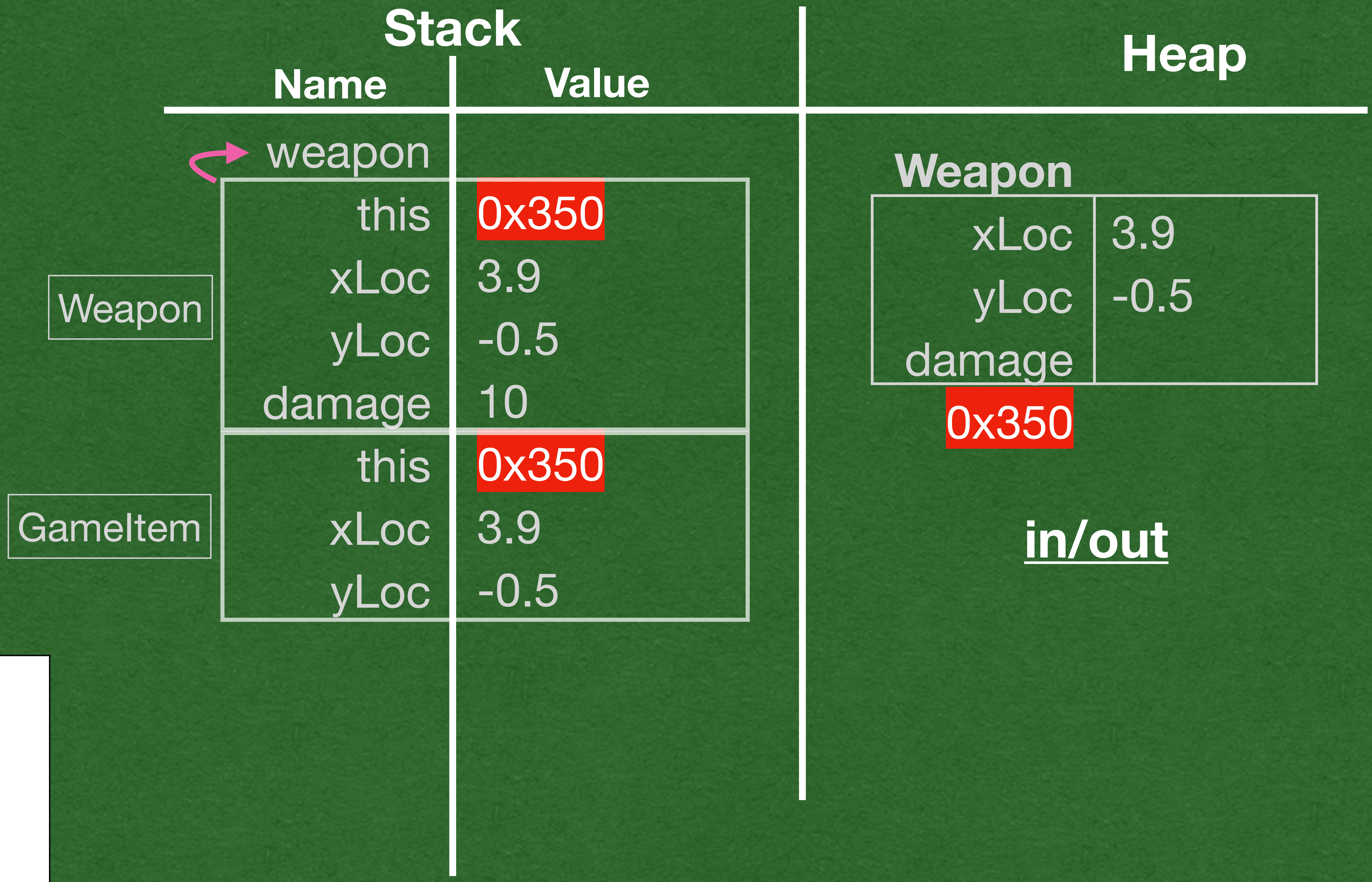
```java
public static void main(String[] args) {
    Weapon weapon = new Weapon(3.9, -0.5, 10);
    weapon.use();
    weapon.move(-0.5, 1.3);
}
```



Stack

	Name	Value
	weapon	
Weapon	this	0x350
	xLoc	3.9
	yLoc	-0.5
	damage	10
GameItem	this	0x350
	xLoc	3.9
	yLoc	-0.5

Heap

Weapon

xLoc	3.9
yLoc	-0.5
damage	

0x350

in/out

- Execute all the super class constructor code

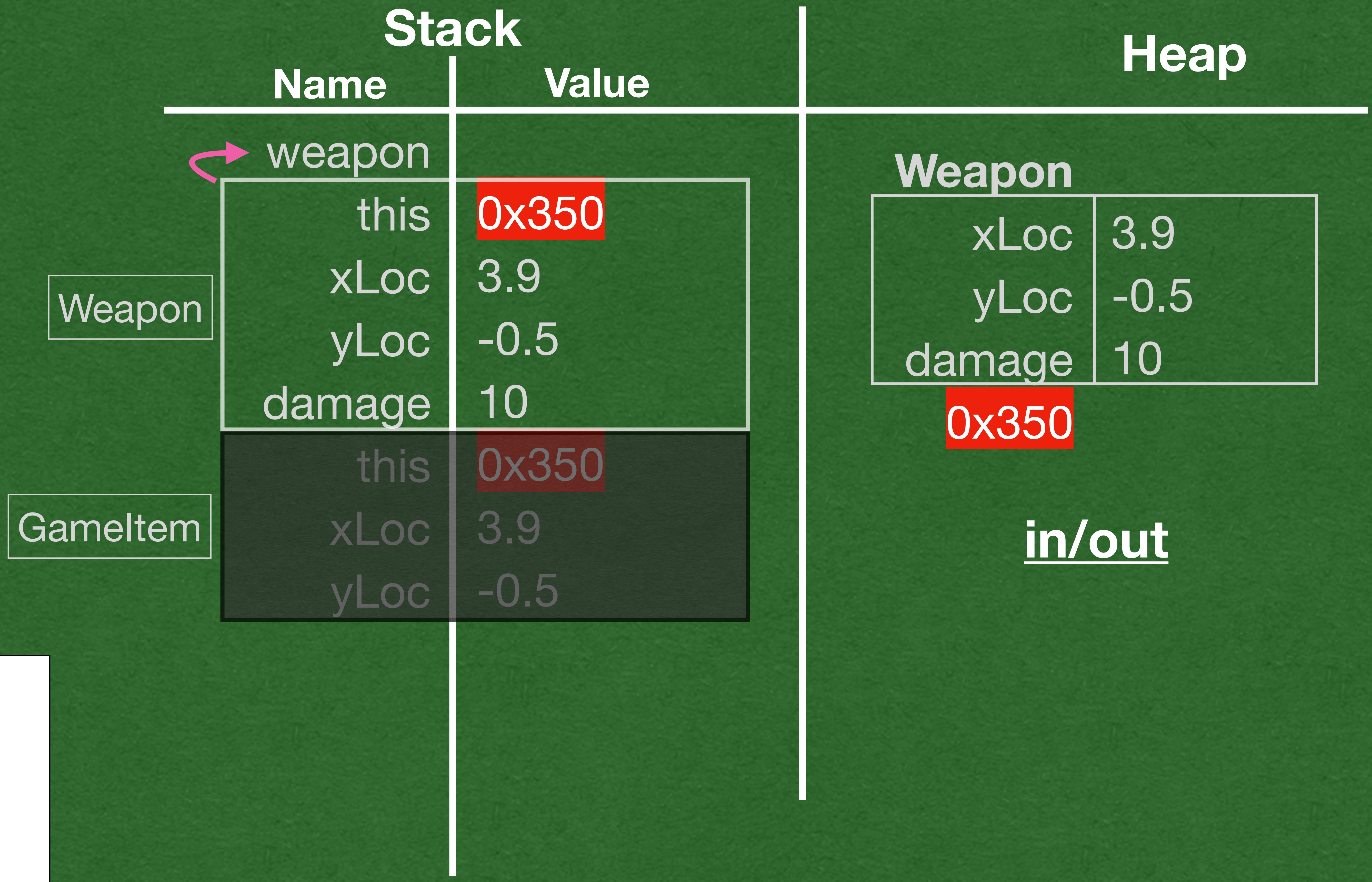
```java
public class GameItem {
    private double xLoc;
    private double yLoc;

    public GameItem(double xLoc, double yLoc){
        this.xLoc = xLoc;
        this.yLoc = yLoc;
    }
    public void move(double dx, double dy){
        this.xLoc += dx;
        this.yLoc += dy;
    }
}
```

```java
public class Weapon extends GameItem {
    private int damage;

    public Weapon(double xloc, double yLoc, int damage) {
        super(xloc, yLoc);
        this.damage = damage;
  ⇨}
    public void use() {
        System.out.println("Damage dealt: " + this.damage);
    }
}
```

```java
public static void main(String[] args) {
  ⇨ Weapon weapon = new Weapon(3.9, -0.5, 10);
    weapon.use();
    weapon.move(-0.5, 1.3);
}
```



Stack

	Name	Value
	weapon	
Weapon	this	0x350
	xLoc	3.9
	yLoc	-0.5
	damage	10
GameItem	this	0x350
	xLoc	3.9
	yLoc	-0.5

Heap

Weapon

xLoc	3.9
yLoc	-0.5
damage	10

0x350

in/out

- Super class constructor frame is removed from memory
- Run the code in the child class constructor

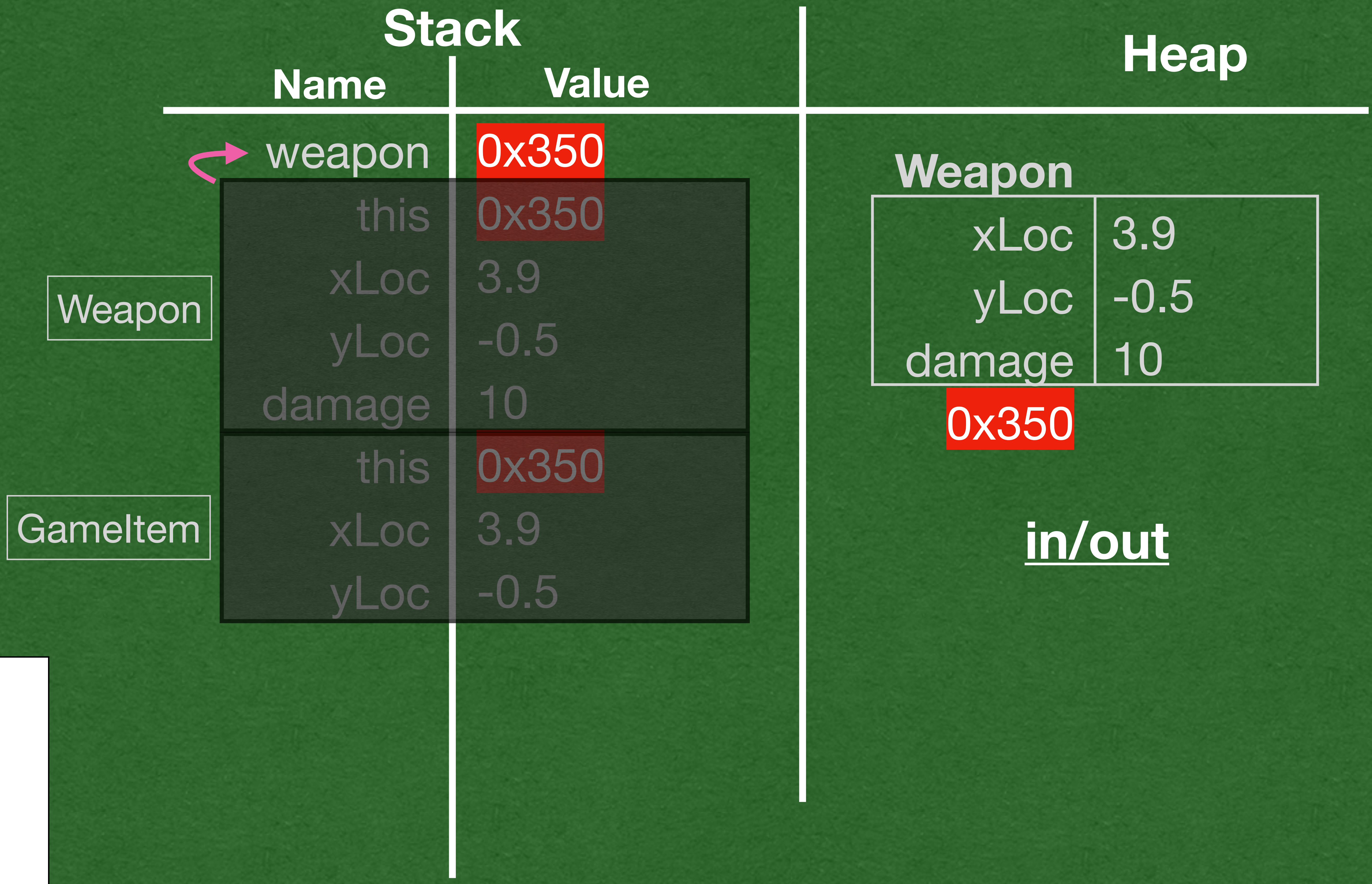
```java
public class GameItem {
    private double xLoc;
    private double yLoc;

    public GameItem(double xLoc, double yLoc){
        this.xLoc = xLoc;
        this.yLoc = yLoc;
    }
    public void move(double dx, double dy){
        this.xLoc += dx;
        this.yLoc += dy;
    }
}
```

```java
public class Weapon extends GameItem {
    private int damage;

    public Weapon(double xloc, double yLoc, int damage) {
        super(xloc, yLoc);
        this.damage = damage;
    }
    public void use() {
        System.out.println("Damage dealt: " + this.damage);
    }
}
```

```java
public static void main(String[] args) {
    Weapon weapon = new Weapon(3.9, -0.5, 10);
    weapon.use();
    weapon.move(-0.5, 1.3);
}
```



Stack

Name	Value
weapon	0x350
Weapon: this	0x350
xLoc	3.9
yLoc	-0.5
damage	10
GameItem: this	0x350
xLoc	3.9
yLoc	-0.5

Heap

Weapon

xLoc	3.9
yLoc	-0.5
damage	10

0x350

in/out

- Child class constructor returns a reference to the object that was created
- Do not forget to write the super class constructor stack frame on your memory diagrams! <-- Very common mistake

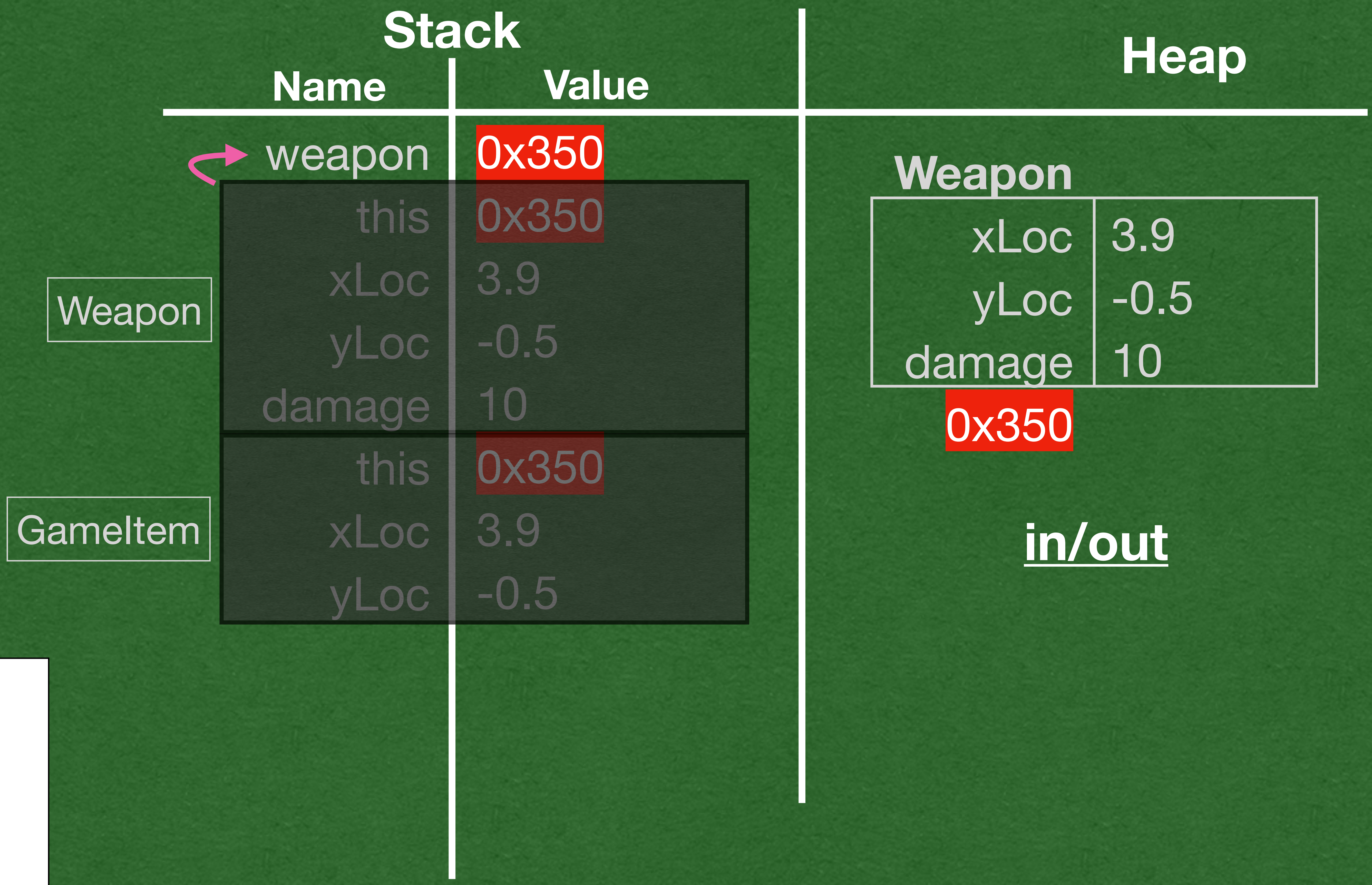
```java
public class GameItem {
    private double xLoc;
    private double yLoc;

    public GameItem(double xLoc, double yLoc){
        this.xLoc = xLoc;
        this.yLoc = yLoc;
    }
    public void move(double dx, double dy){
        this.xLoc += dx;
        this.yLoc += dy;
    }
}
```

```java
public class Weapon extends GameItem {
    private int damage;

    public Weapon(double xloc, double yLoc, int damage) {
        super(xloc, yLoc);
        this.damage = damage;
    }
    public void use() {
        System.out.println("Damage dealt: " + this.damage);
    }
}
```

```java
public static void main(String[] args) {
    Weapon weapon = new Weapon(3.9, -0.5, 10);
    weapon.use();
    weapon.move(-0.5, 1.3);
}
```



Stack

	Name	Value
	weapon	0x350
Weapon	this	0x350
	xLoc	3.9
	yLoc	-0.5
	damage	10
GameItem	this	0x350
	xLoc	3.9
	yLoc	-0.5

Heap

Weapon

xLoc	3.9
yLoc	-0.5
damage	10

0x350

in/out

- When a method is called:
  - Look in the class matching the type of the **object**
  - Find a method with the name of the method being called

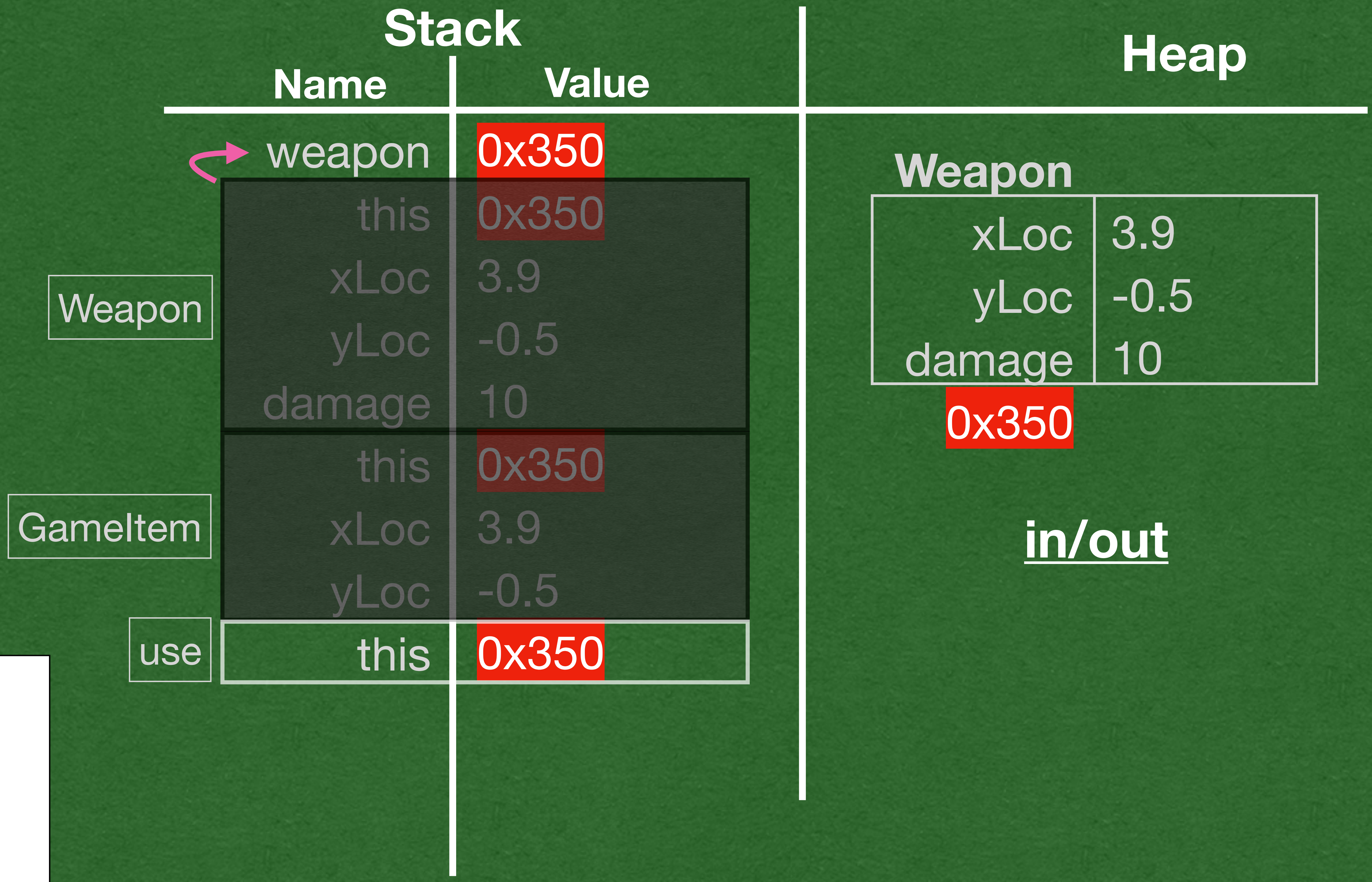
```java
public class GameItem {
    private double xLoc;
    private double yLoc;

    public GameItem(double xLoc, double yLoc){
        this.xLoc = xLoc;
        this.yLoc = yLoc;
    }
    public void move(double dx, double dy){
        this.xLoc += dx;
        this.yLoc += dy;
    }
}
```

```java
public class Weapon extends GameItem {
    private int damage;

    public Weapon(double xloc, double yLoc, int damage) {
        super(xloc, yLoc);
        this.damage = damage;
    }
⇨   public void use() {
        System.out.println("Damage dealt: " + this.damage);
    }
}
```

```java
public static void main(String[] args) {
    Weapon weapon = new Weapon(3.9, -0.5, 10);
⇨   weapon.use();
    weapon.move(-0.5, 1.3);
}
```



Stack

	Name	Value
	weapon	0x350
Weapon	this	0x350
	xLoc	3.9
	yLoc	-0.5
	damage	10
GameItem	this	0x350
	xLoc	3.9
	yLoc	-0.5
use	this	0x350

Heap

Weapon

xLoc	3.9
yLoc	-0.5
damage	10

0x350

in/out

- "use" is called through an object of type Weapon
- Look in the Weapon class
- Find a method named use and call it

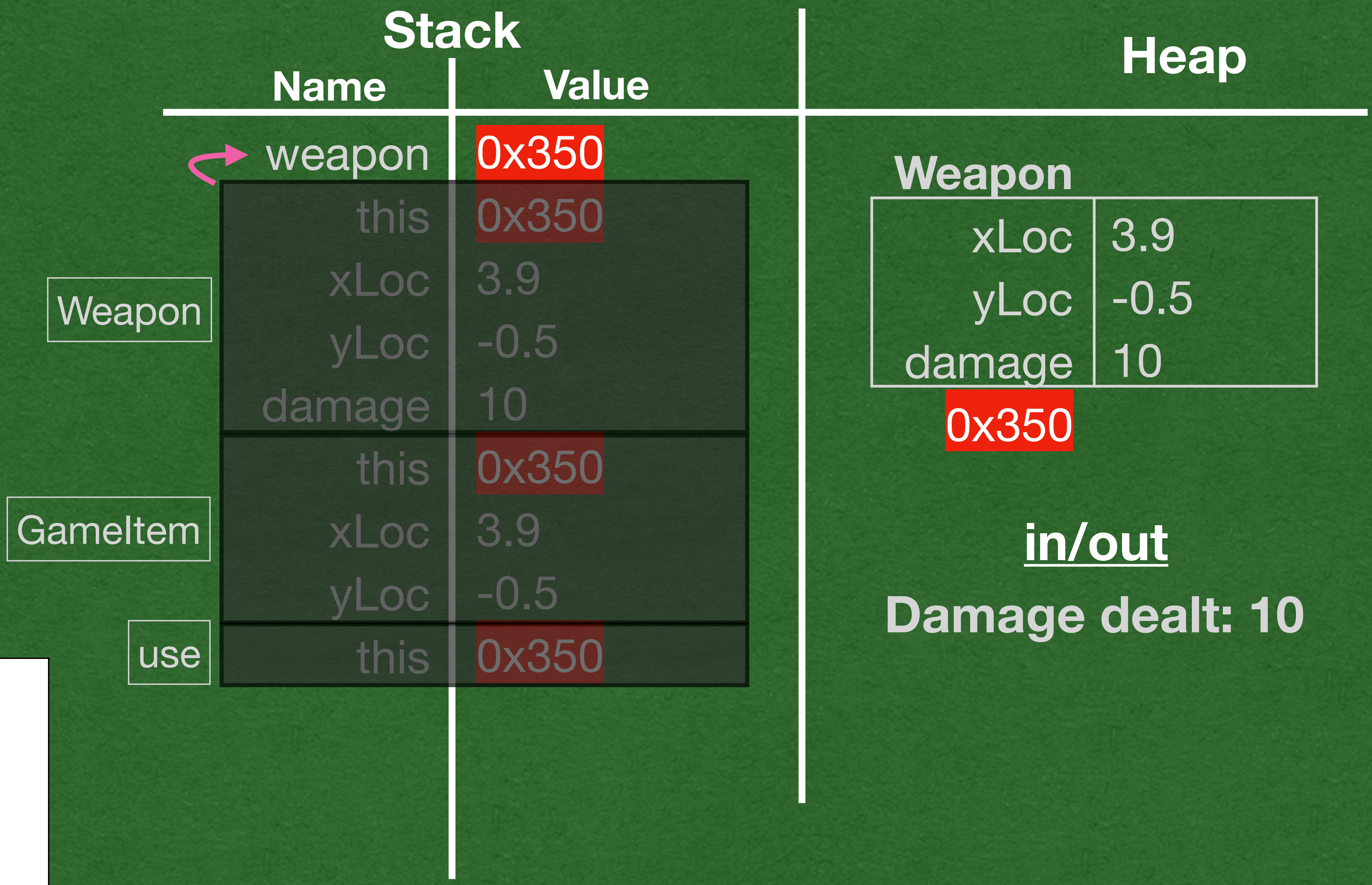
```java
public class GameItem {
    private double xLoc;
    private double yLoc;

    public GameItem(double xLoc, double yLoc){
        this.xLoc = xLoc;
        this.yLoc = yLoc;
    }
    public void move(double dx, double dy){
        this.xLoc += dx;
        this.yLoc += dy;
    }
}
```

```java
public class Weapon extends GameItem {
    private int damage;

    public Weapon(double xloc, double yLoc, int damage) {
        super(xloc, yLoc);
        this.damage = damage;
    }
    public void use() {
        System.out.println("Damage dealt: " + this.damage);
    }
}
```

```java
public static void main(String[] args) {
    Weapon weapon = new Weapon(3.9, -0.5, 10);
    weapon.use();
    weapon.move(-0.5, 1.3);
}
```



Stack

	Name	Value
	weapon	0x350
Weapon	this	0x350
	xLoc	3.9
	yLoc	-0.5
	damage	10
GameItem	this	0x350
	xLoc	3.9
	yLoc	-0.5
use	this	0x350

Heap

Weapon

xLoc	3.9
yLoc	-0.5
damage	10

0x350

in/out

Damage dealt: 10

- The method prints to the screen and returns

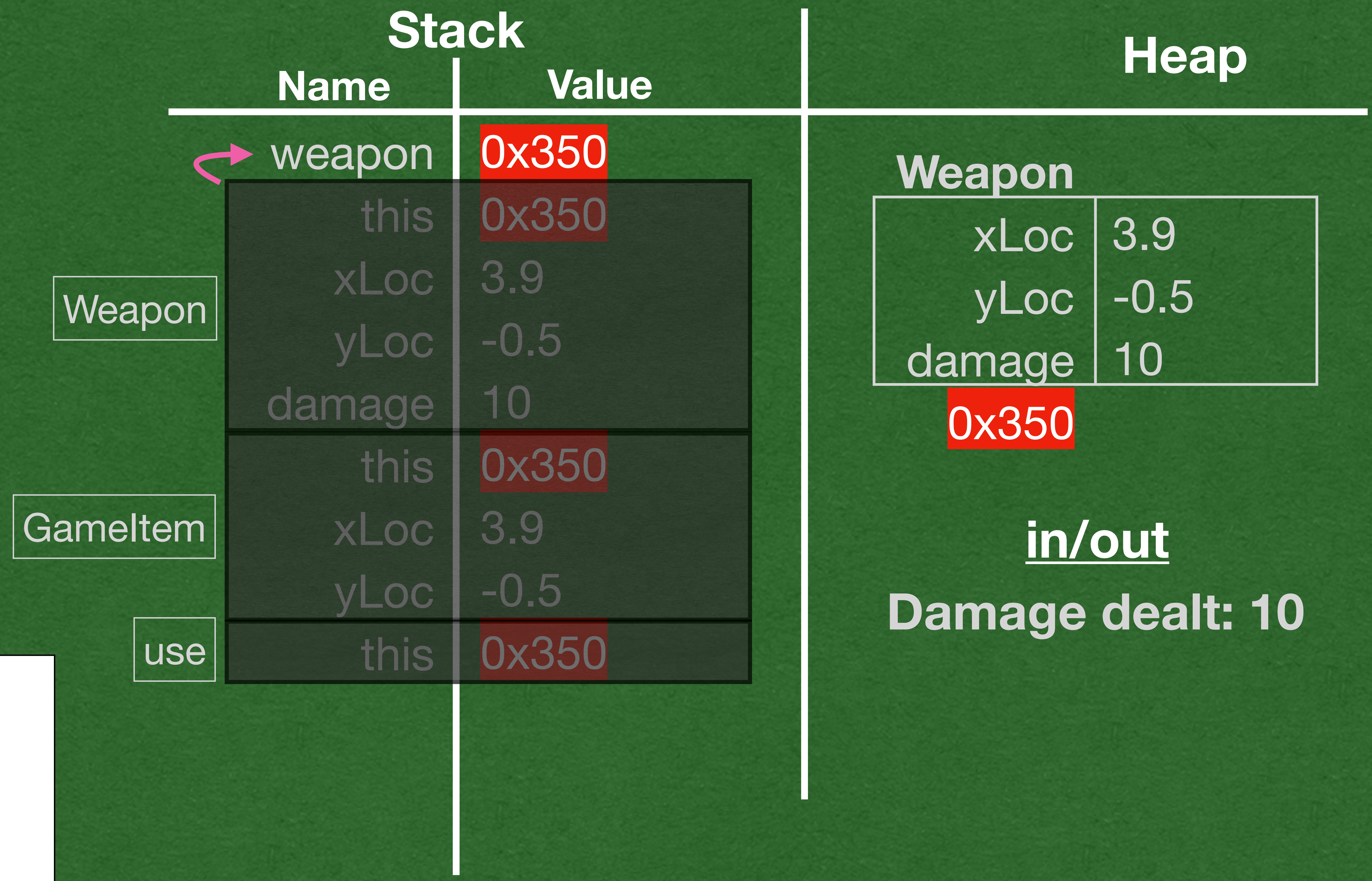
```java
public class GameItem {
    private double xLoc;
    private double yLoc;

    public GameItem(double xLoc, double yLoc){
        this.xLoc = xLoc;
        this.yLoc = yLoc;
    }
    public void move(double dx, double dy){
        this.xLoc += dx;
        this.yLoc += dy;
    }
}
```

```java
public class Weapon extends GameItem {
    private int damage;

    public Weapon(double xloc, double yLoc, int damage) {
        super(xloc, yLoc);
        this.damage = damage;
    }
    public void use() {
        System.out.println("Damage dealt: " + this.damage);
    }
}
```

```java
public static void main(String[] args) {
    Weapon weapon = new Weapon(3.9, -0.5, 10);
    weapon.use();
    weapon.move(-0.5, 1.3);
}
```



Stack

	Name	Value
	weapon	0x350
Weapon	this	0x350
	xLoc	3.9
	yLoc	-0.5
	damage	10
GameItem	this	0x350
	xLoc	3.9
	yLoc	-0.5
use	this	0x350

Heap

Weapon

xLoc	3.9
yLoc	-0.5
damage	10

0x350

in/out

Damage dealt: 10

- When move is called:
- Look for a method named move in the Weapon class
- .. but we don't find one

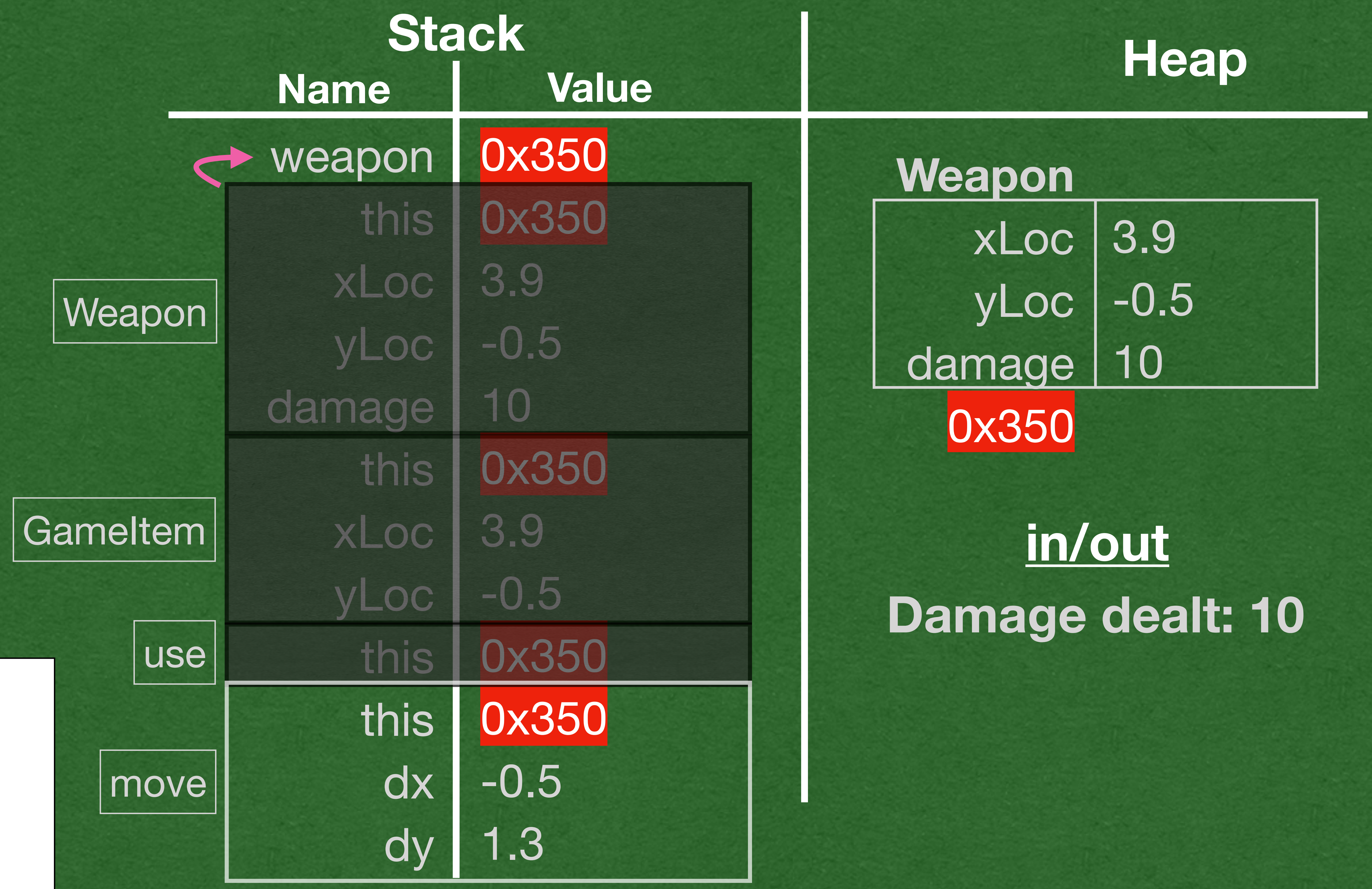
```
public class GameItem {
    private double xLoc;
    private double yLoc;

    public GameItem(double xLoc, double yLoc){
        this.xLoc = xLoc;
        this.yLoc = yLoc;
    }
  ⇨ public void move(double dx, double dy){
        this.xLoc += dx;
        this.yLoc += dy;
    }
}
```

```
public class Weapon extends GameItem {
    private int damage;

    public Weapon(double xloc, double yLoc, int damage) {
        super(xloc, yLoc);
        this.damage = damage;
    }
    public void use() {
        System.out.println("Damage dealt: " + this.damage);
    }
}
```

```
public static void main(String[] args) {
    Weapon weapon = new Weapon(3.9, -0.5, 10);
    weapon.use();
  ⇨ weapon.move(-0.5, 1.3);
}
```



Stack

	Name	Value
	weapon	0x350
Weapon	this	0x350
	xLoc	3.9
	yLoc	-0.5
	damage	10
GameItem	this	0x350
	xLoc	3.9
	yLoc	-0.5
use	this	0x350
move	this	0x350
	dx	-0.5
	dy	1.3

Heap

Weapon

xLoc	3.9
yLoc	-0.5
damage	10

0x350

in/out

Damage dealt: 10

- If a method is not found, check in the super class
- Weapon inherited the methods defined in GameItem
  - "move" is part of the Weapon class and can be called from objects of type Weapon

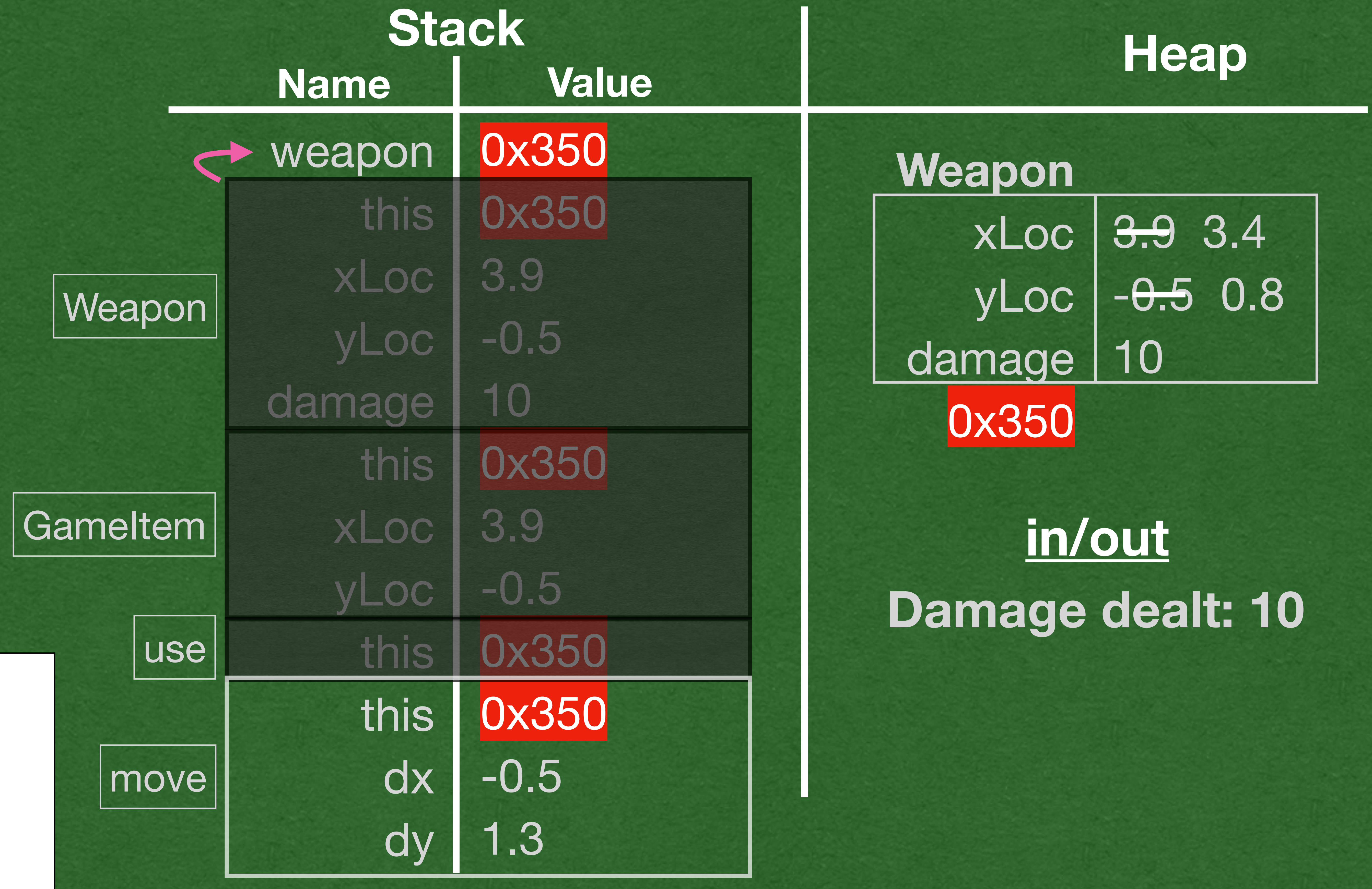
```java
public class GameItem {
    private double xLoc;
    private double yLoc;

    public GameItem(double xLoc, double yLoc){
        this.xLoc = xLoc;
        this.yLoc = yLoc;
    }
    public void move(double dx, double dy){
        this.xLoc += dx;
        this.yLoc += dy;
    }
}
```

```java
public class Weapon extends GameItem {
    private int damage;

    public Weapon(double xloc, double yLoc, int damage) {
        super(xloc, yLoc);
        this.damage = damage;
    }
    public void use() {
        System.out.println("Damage dealt: " + this.damage);
    }
}
```

```java
public static void main(String[] args) {
    Weapon weapon = new Weapon(3.9, -0.5, 10);
    weapon.use();
    weapon.move(-0.5, 1.3);
}
```



Stack

	Name	Value
	weapon	0x350
Weapon	this	0x350
	xLoc	3.9
	yLoc	-0.5
	damage	10
GameItem	this	0x350
	xLoc	3.9
	yLoc	-0.5
use	this	0x350
move	this	0x350
	dx	-0.5
	dy	1.3

Heap

Weapon

xLoc	~~3.9~~ 3.4
yLoc	~~-0.5~~ 0.8
damage	10

0x350

in/out

Damage dealt: 10

- *this* is still a reference to the Weapon object
- We call a GameItem method where this refers to a Weapon!

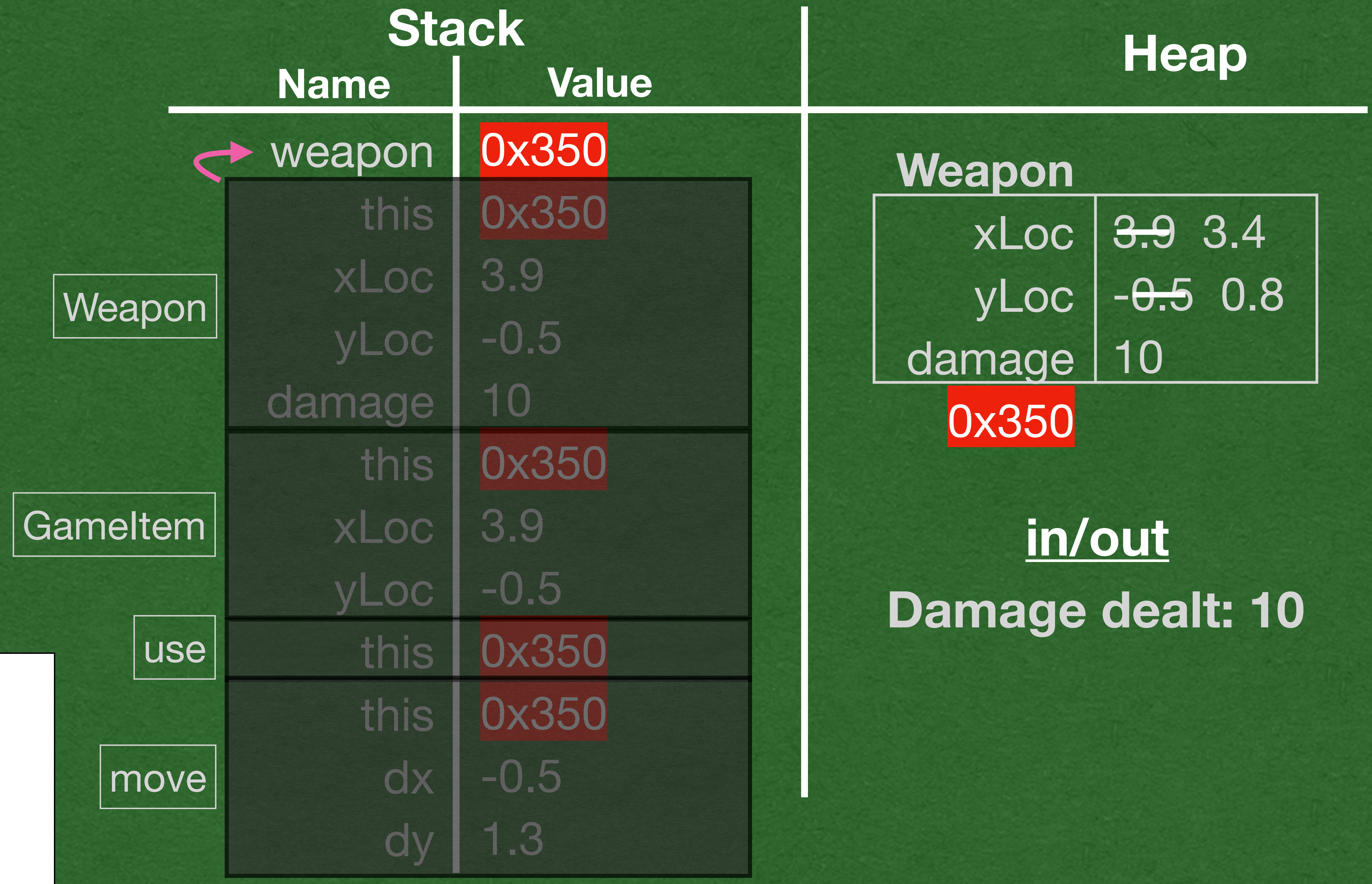
```
public class GameItem {
    private double xLoc;
    private double yLoc;

    public GameItem(double xLoc, double yLoc){
        this.xLoc = xLoc;
        this.yLoc = yLoc;
    }
    public void move(double dx, double dy){
        this.xLoc += dx;
        this.yLoc += dy;
    }
}
```

```
public class Weapon extends GameItem {
    private int damage;

    public Weapon(double xloc, double yLoc, int damage) {
        super(xloc, yLoc);
        this.damage = damage;
    }
    public void use() {
        System.out.println("Damage dealt: " + this.damage);
    }
}
```

```
public static void main(String[] args) {
    Weapon weapon = new Weapon(3.9, -0.5, 10);
    weapon.use();
    weapon.move(-0.5, 1.3);
}
```



Stack

	Name	Value
	weapon	0x350
Weapon	this	0x350
	xLoc	3.9
	yLoc	-0.5
	damage	10
GameItem	this	0x350
	xLoc	3.9
	yLoc	-0.5
use	this	0x350
move	this	0x350
	dx	-0.5
	dy	1.3

Heap

Weapon

xLoc	~~3.9~~ 3.4
yLoc	-~~0.5~~ 0.8
damage	10

0x350

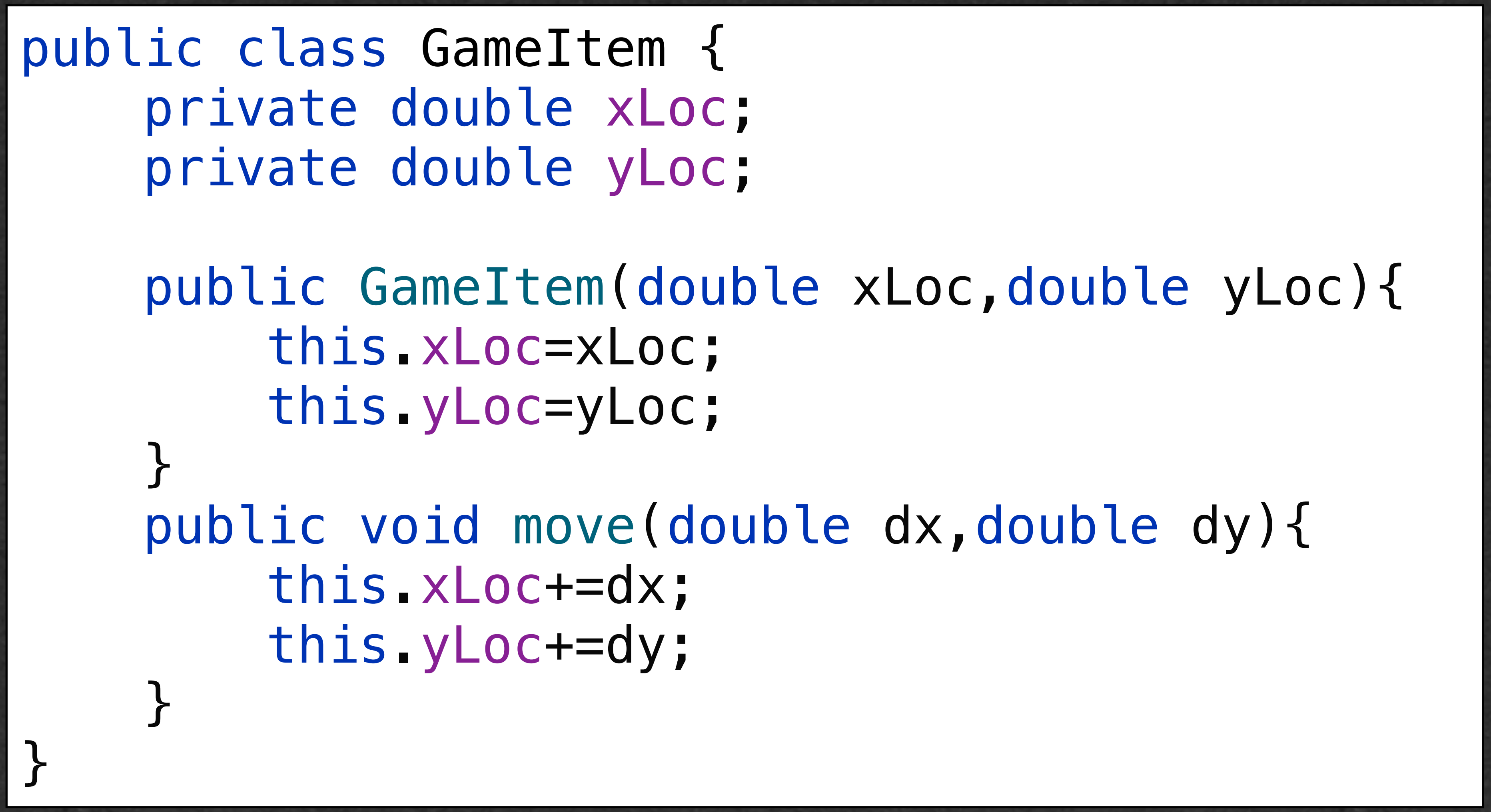
in/out

Damage dealt: 10

- End program

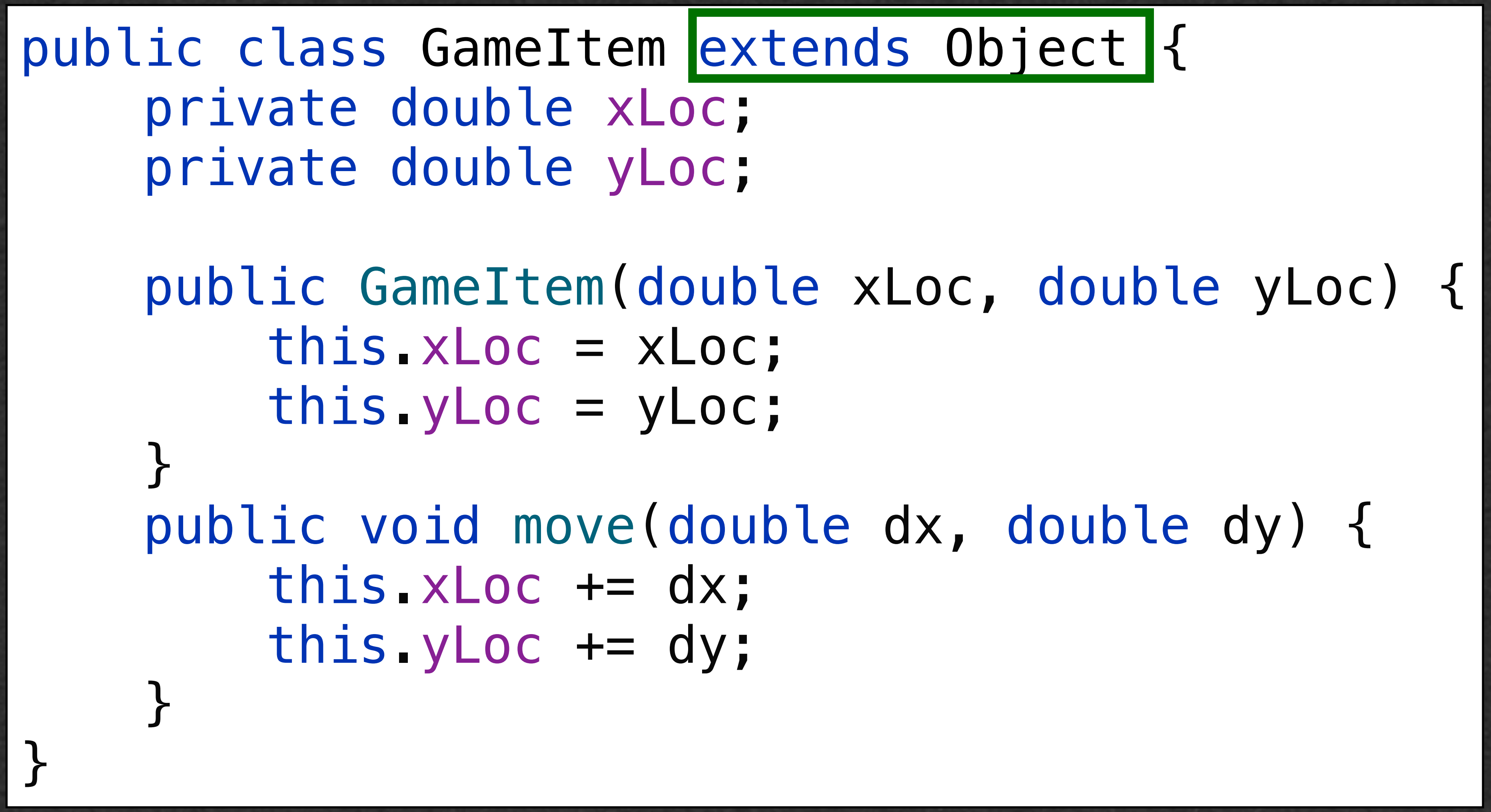
Object

The Object Class



```
public class GameItem {
    private double xLoc;
    private double yLoc;

    public GameItem(double xLoc,double yLoc){
        this.xLoc=xLoc;
        this.yLoc=yLoc;
    }
    public void move(double dx,double dy){
        this.xLoc+=dx;
        this.yLoc+=dy;
    }
}
```



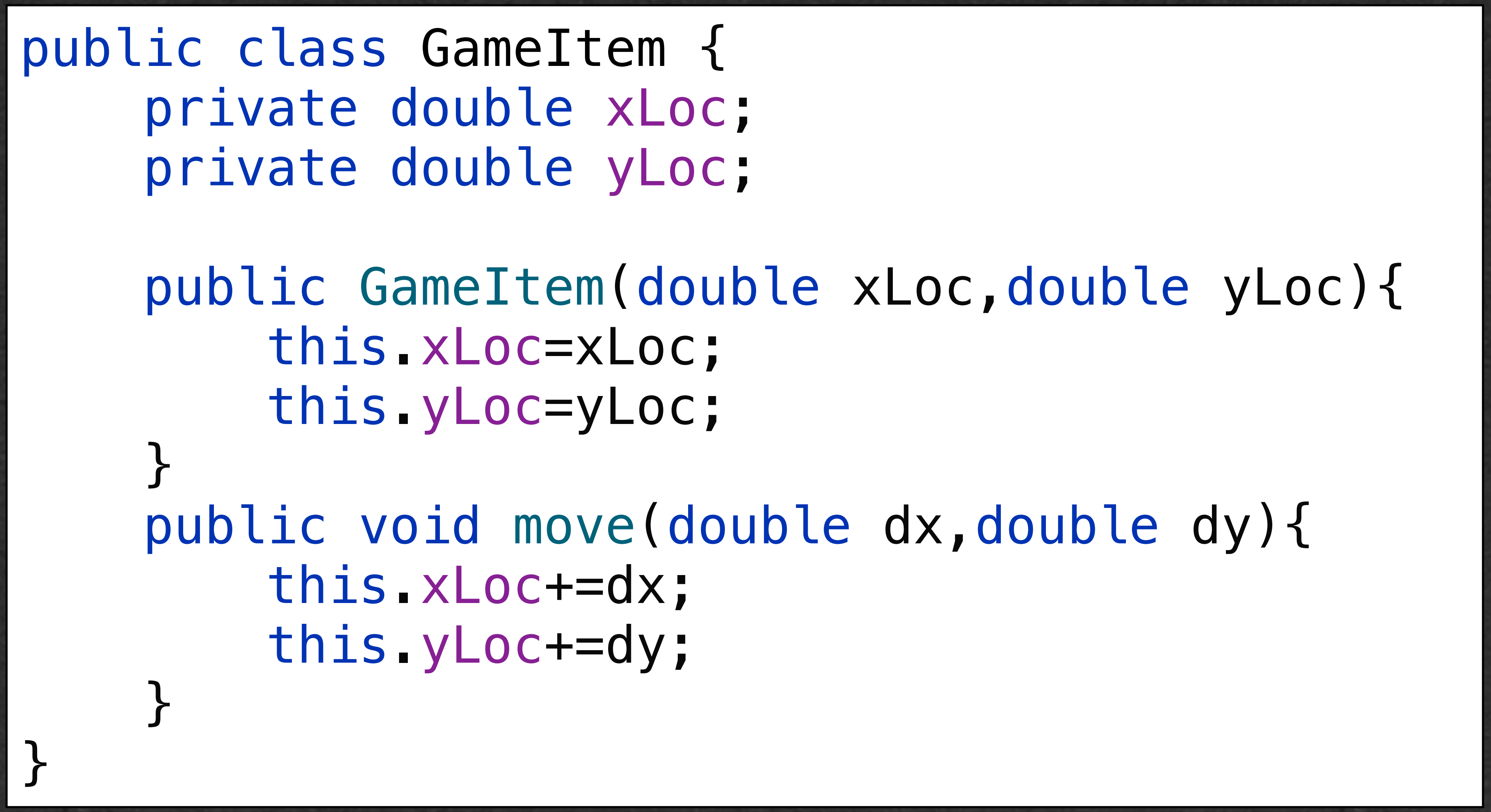
```
public class GameItem extends Object {
    private double xLoc;
    private double yLoc;

    public GameItem(double xLoc, double yLoc) {
        this.xLoc = xLoc;
        this.yLoc = yLoc;
    }
    public void move(double dx, double dy) {
        this.xLoc += dx;
        this.yLoc += dy;
    }
}
```

- If your class does not explicitly extend any super class
    - It will implicitly extend the Object class

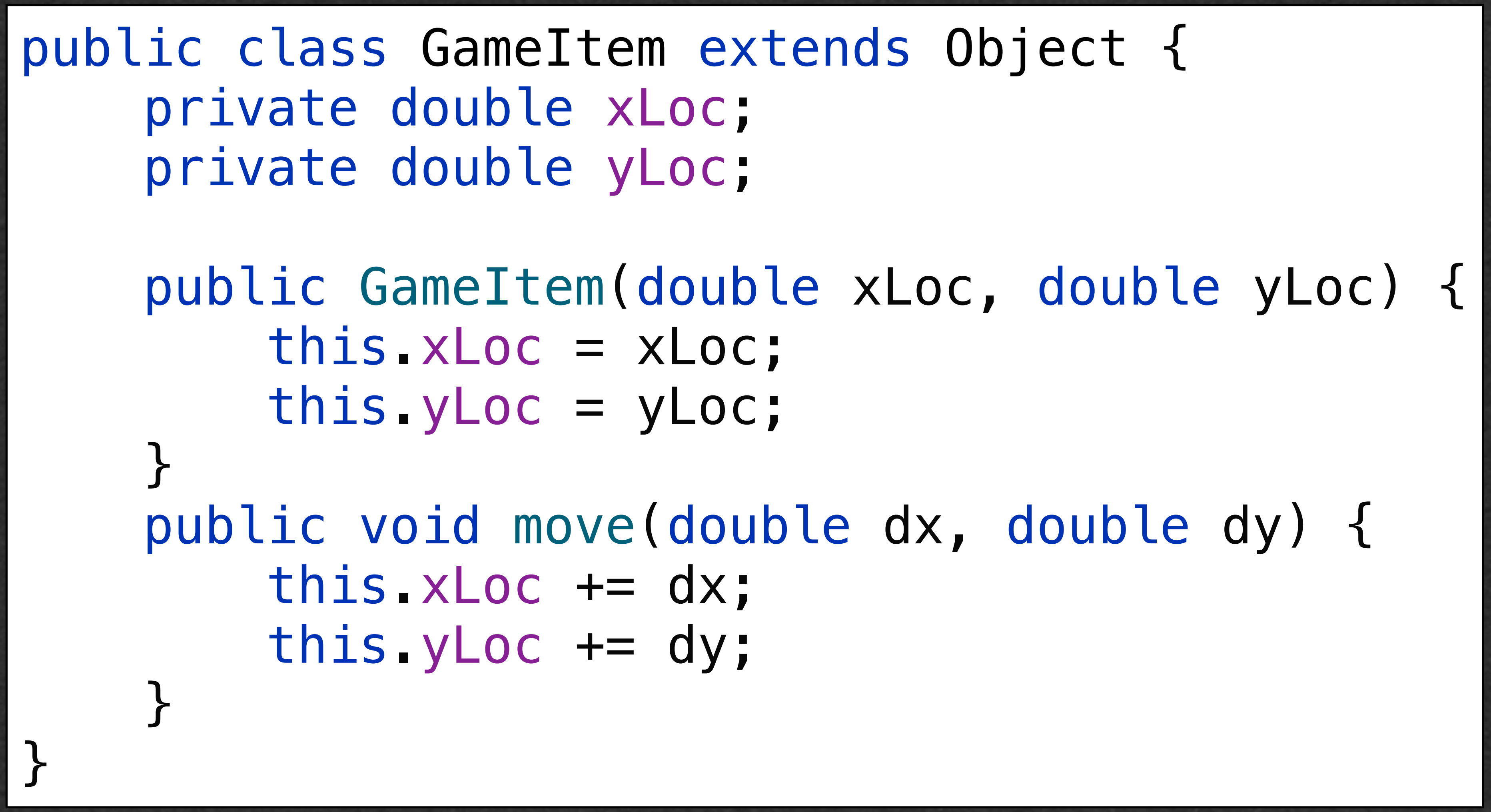
- These two classes are identical

The Object Class



```java
public class GameItem {
    private double xLoc;
    private double yLoc;

    public GameItem(double xLoc,double yLoc){
        this.xLoc=xLoc;
        this.yLoc=yLoc;
    }
    public void move(double dx,double dy){
        this.xLoc+=dx;
        this.yLoc+=dy;
    }
}
```



```java
public class GameItem extends Object {
    private double xLoc;
    private double yLoc;

    public GameItem(double xLoc, double yLoc) {
        this.xLoc = xLoc;
        this.yLoc = yLoc;
    }
    public void move(double dx, double dy) {
        this.xLoc += dx;
        this.yLoc += dy;
    }
}
```

- The Object class contains several useful methods
  - toString
  - equals
- Every class in Java extends Objects either directly or indirectly
  - Weapon extends GameItem which extends Object
- Every object in Java has a toString and equals method that it inherited from Object