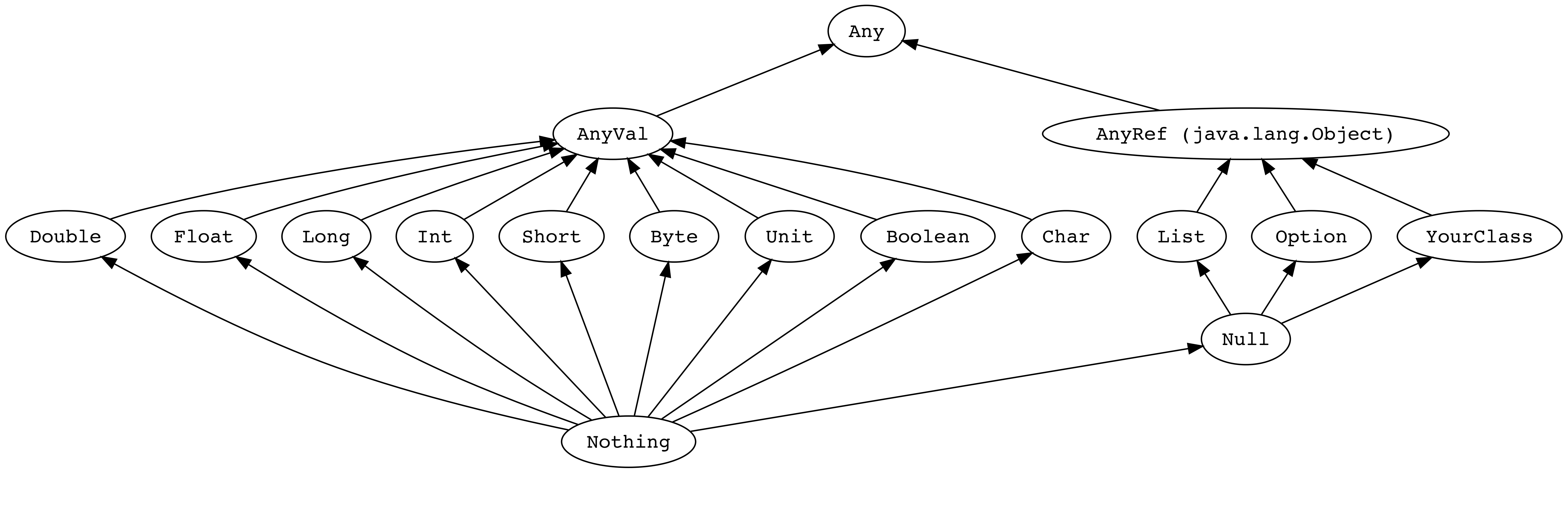
Inheritance

Scala Type Hierarchy



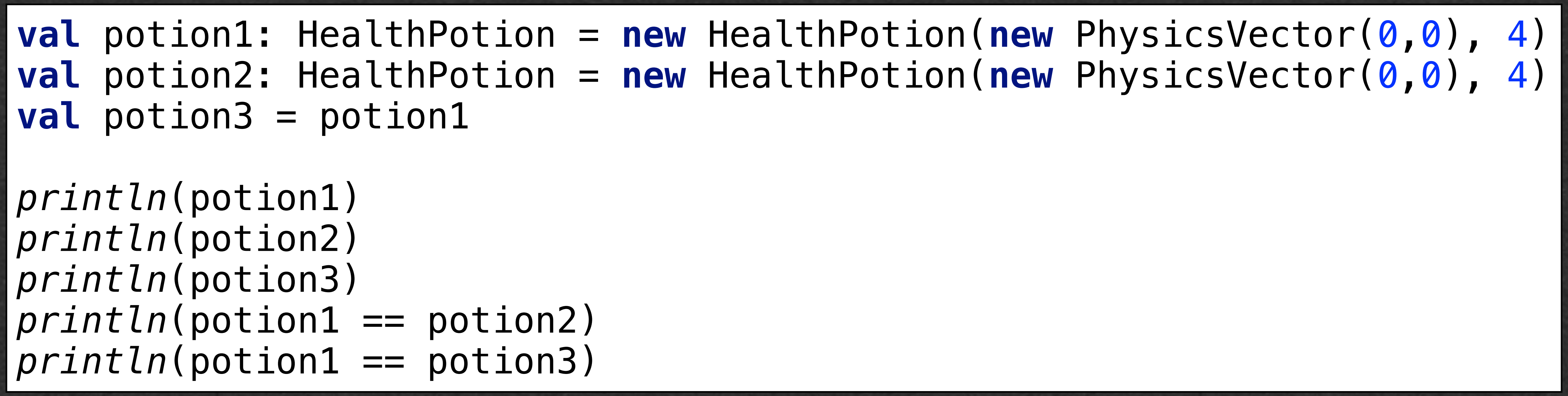
- All objects share Any as their base types
- Classes extending **AnyVal** will be stored on the **stack**
- Classes extending **AnyRef** will be stored on the **heap**

https://docs.scala-lang.org/tour/unified-types.html

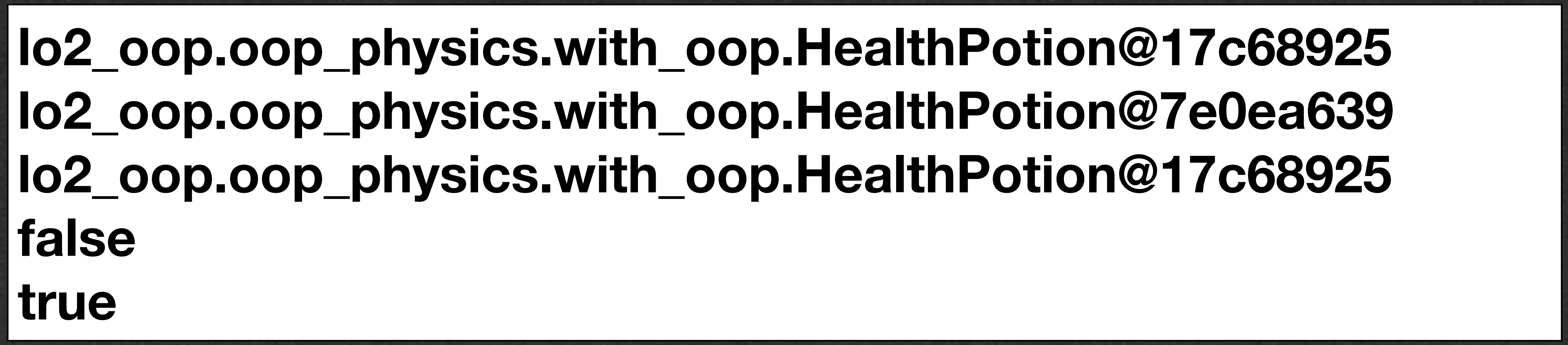
Override

Override

- Functionality is inherited from Any and AnyRef
- println calls an inherited .toString method
  - Converts object to a String with <object_type>@<reference>
- == calls the inherited .equals method
  - returns true only if the two variables **refer** to the same object in memory



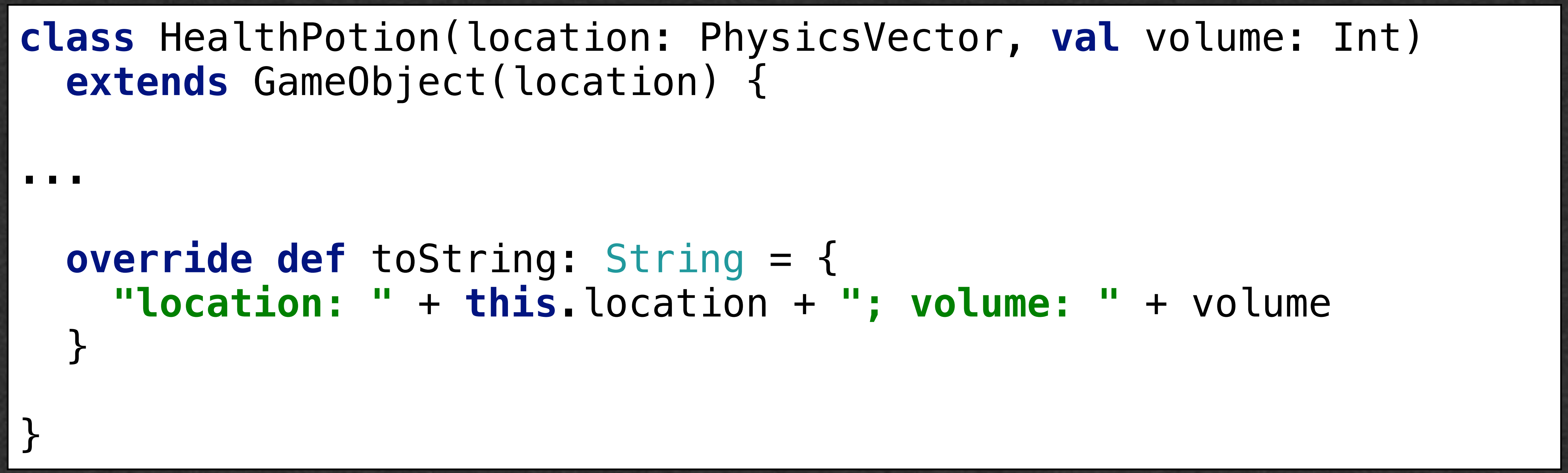
```
val potion1: HealthPotion = new HealthPotion(new PhysicsVector(0,0), 4)
val potion2: HealthPotion = new HealthPotion(new PhysicsVector(0,0), 4)
val potion3 = potion1

println(potion1)
println(potion2)
println(potion3)
println(potion1 == potion2)
println(potion1 == potion3)
```



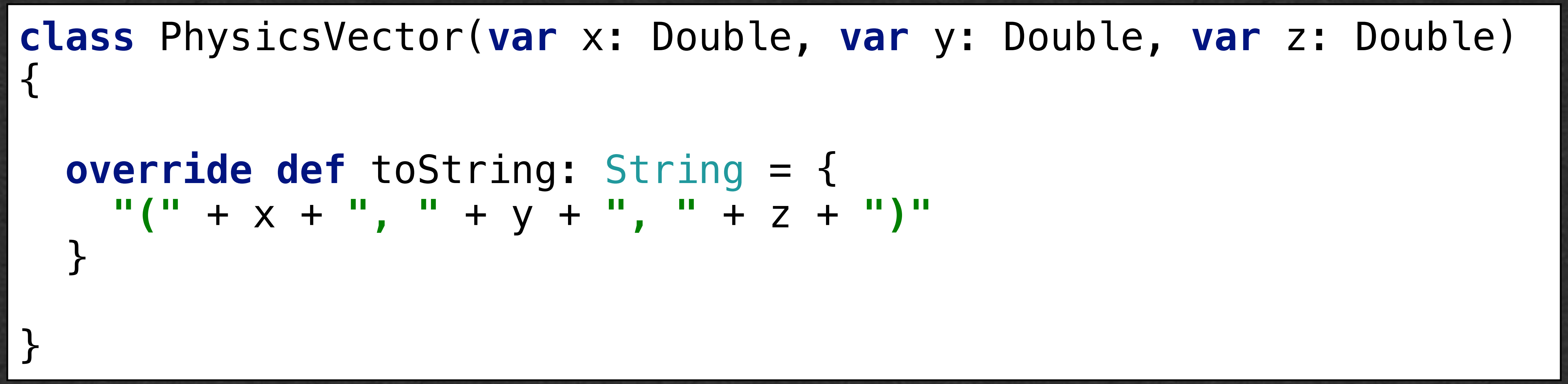
```
lo2_oop.oop_physics.with_oop.HealthPotion@17c68925
lo2_oop.oop_physics.with_oop.HealthPotion@7e0ea639
lo2_oop.oop_physics.with_oop.HealthPotion@17c68925
false
true
```

Override

- We can override this default functionality
- Override toString to return a different string



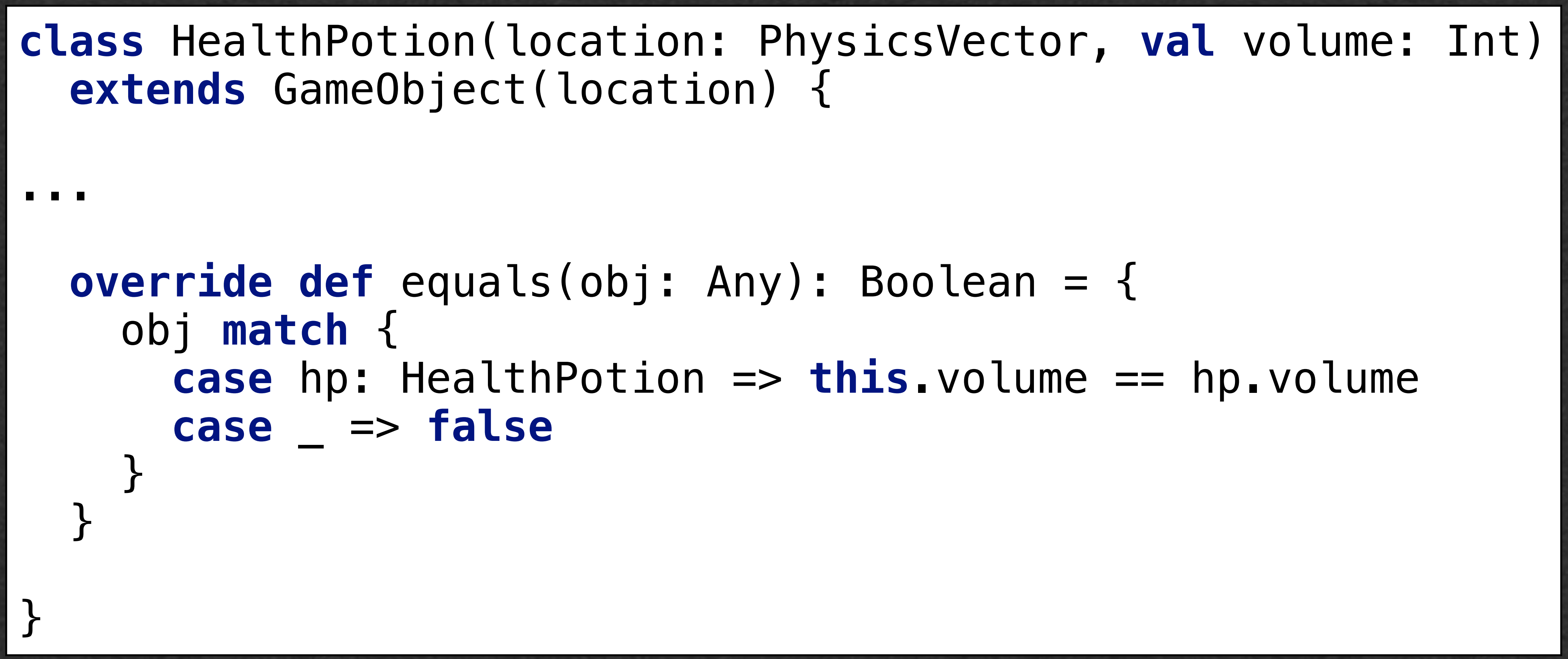
```
class HealthPotion(location: PhysicsVector, val volume: Int)
  extends GameObject(location) {

...

  override def toString: String = {
    "location: " + this.location + "; volume: " + volume
  }

}
```



```
class PhysicsVector(var x: Double, var y: Double, var z: Double)
{

  override def toString: String = {
    "(" + x + ", " + y + ", " + z + ")"
  }

}
```

Override

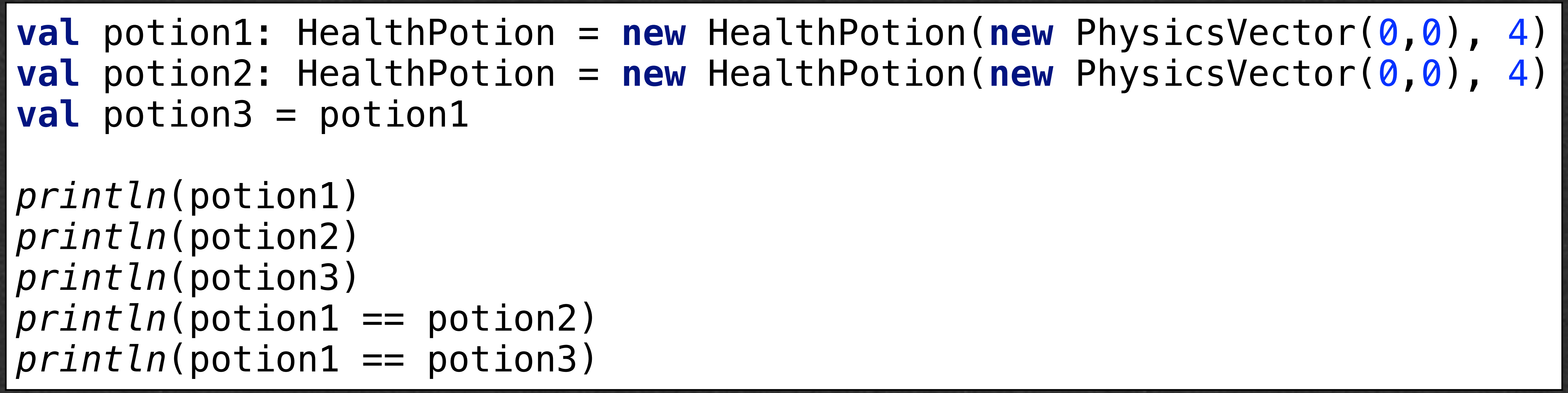
- Override equals to change the definition of equality
- Takes Any as a parameter
- Use match and case to behave differently on different types
- The _ wildcard covers all types not explicitly mentioned
- This method returns true when compared to another potion with the same volume, false otherwise



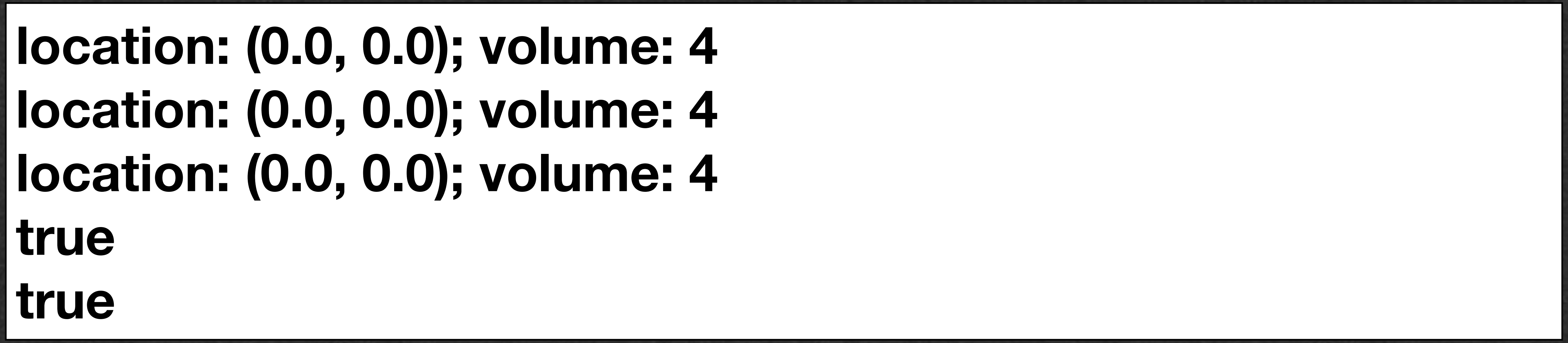
```
class HealthPotion(location: PhysicsVector, val volume: Int)
  extends GameObject(location) {

...

  override def equals(obj: Any): Boolean = {
    obj match {
      case hp: HealthPotion => this.volume == hp.volume
      case _ => false
    }
  }

}
```

Override

- With our overridden methods this code gives very different output

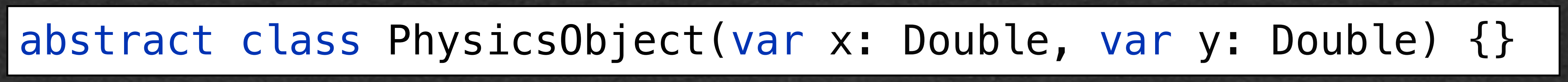


```
val potion1: HealthPotion = new HealthPotion(new PhysicsVector(0,0), 4)
val potion2: HealthPotion = new HealthPotion(new PhysicsVector(0,0), 4)
val potion3 = potion1

println(potion1)
println(potion2)
println(potion3)
println(potion1 == potion2)
println(potion1 == potion3)
```

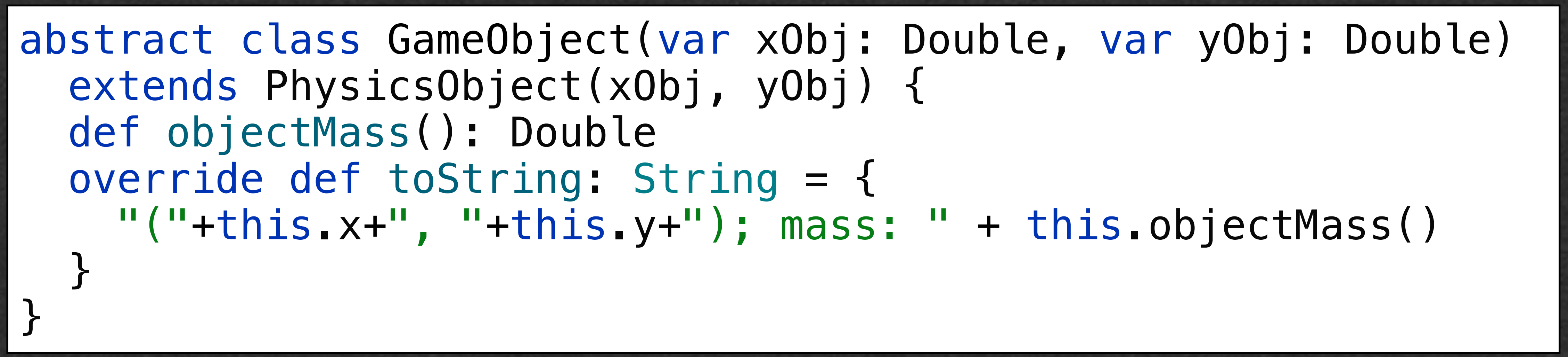


```
location: (0.0, 0.0); volume: 4
location: (0.0, 0.0); volume: 4
location: (0.0, 0.0); volume: 4
true
true
```

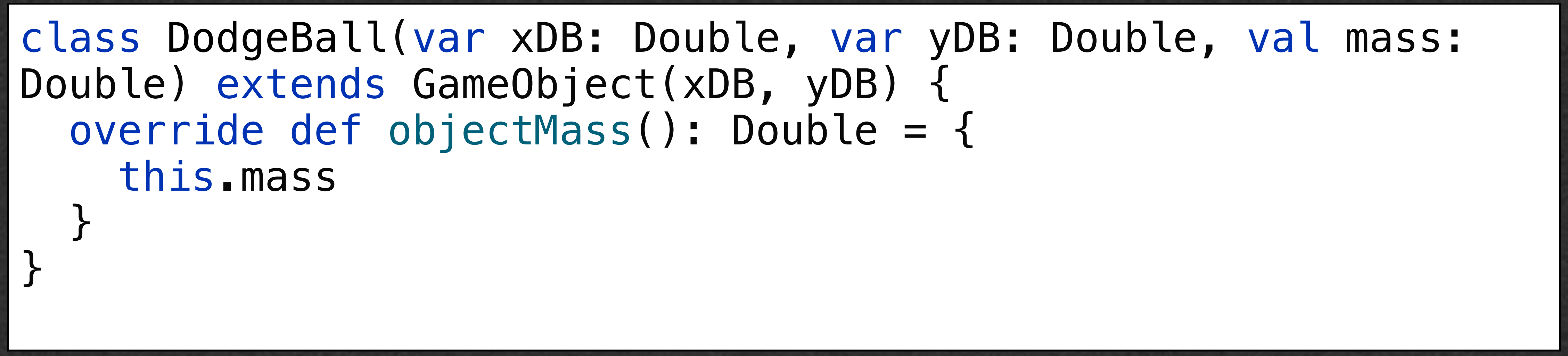
Incoming Memory Diagram!!



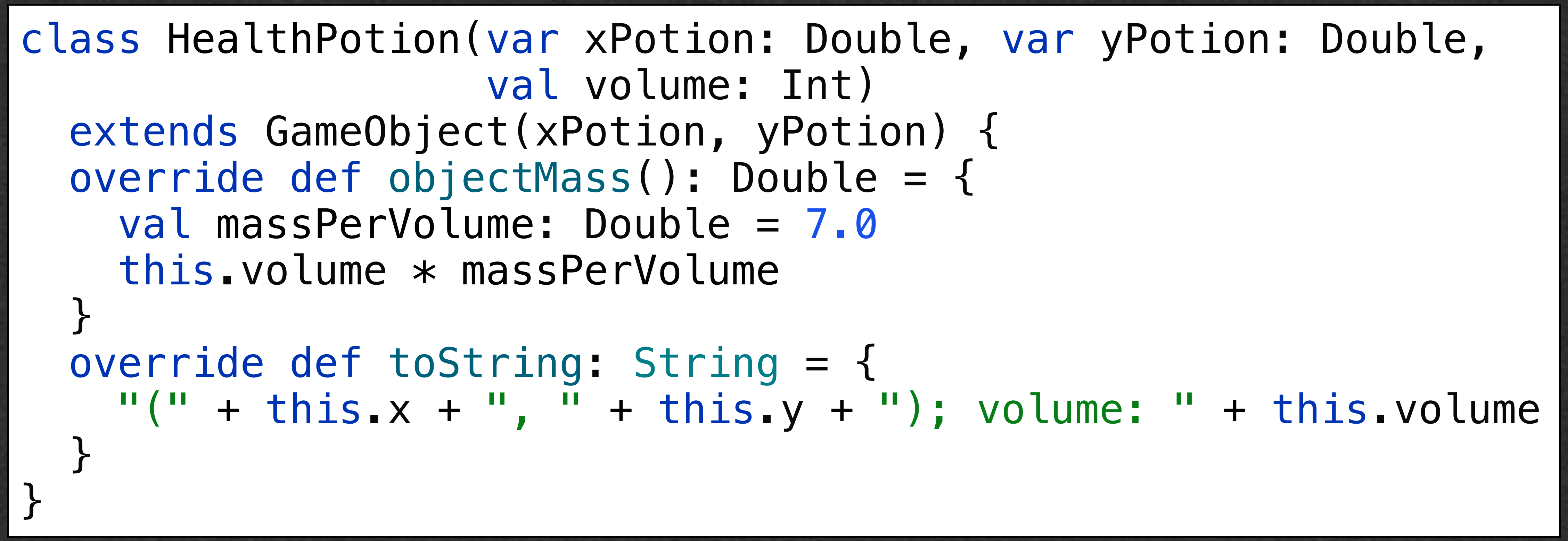
```
abstract class PhysicsObject(var x: Double, var y: Double) {}
```



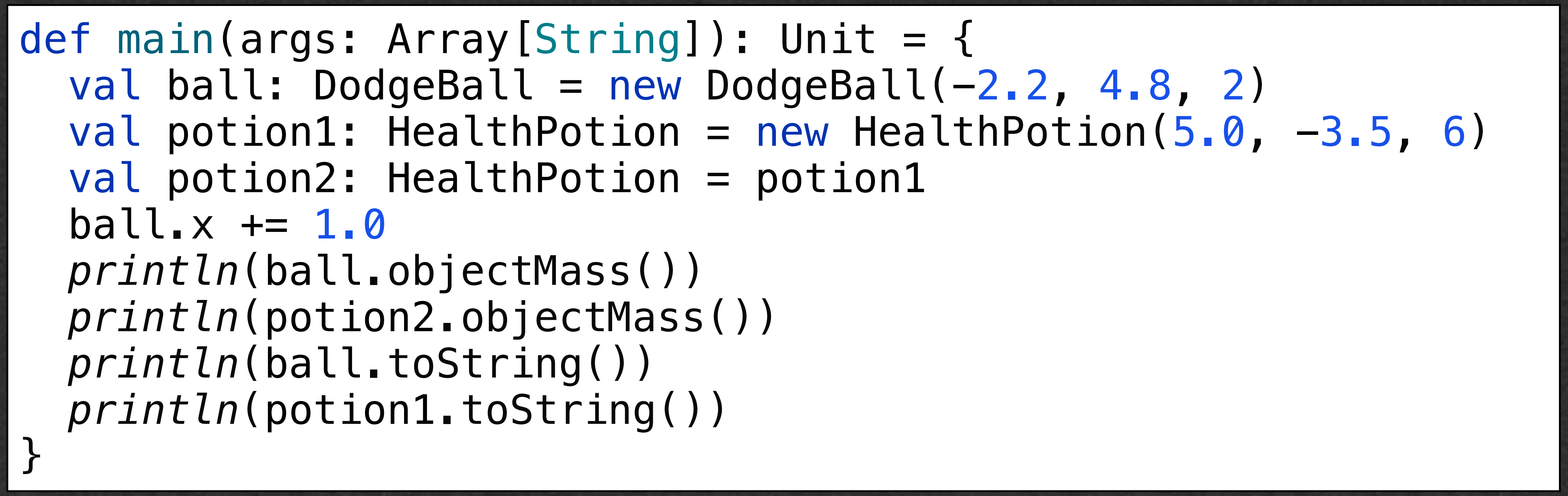
```
abstract class GameObject(var xObj: Double, var yObj: Double)
  extends PhysicsObject(xObj, yObj) {
  def objectMass(): Double
  override def toString: String = {
    "("+this.x+", "+this.y+"); mass: " + this.objectMass()
  }
}
```



```
class DodgeBall(var xDB: Double, var yDB: Double, val mass:
Double) extends GameObject(xDB, yDB) {
  override def objectMass(): Double = {
    this.mass
  }
}
```



```
class HealthPotion(var xPotion: Double, var yPotion: Double,
                   val volume: Int)
  extends GameObject(xPotion, yPotion) {
  override def objectMass(): Double = {
    val massPerVolume: Double = 7.0
    this.volume * massPerVolume
  }
  override def toString: String = {
    "(" + this.x + ", " + this.y + "); volume: " + this.volume
  }
}
```



```
def main(args: Array[String]): Unit = {
  val ball: DodgeBall = new DodgeBall(-2.2, 4.8, 2)
  val potion1: HealthPotion = new HealthPotion(5.0, -3.5, 6)
  val potion2: HealthPotion = potion1
  ball.x += 1.0
  println(ball.objectMass())
  println(potion2.objectMass())
  println(ball.toString())
  println(potion1.toString())
}
```

```
abstract class PhysicsObject(var x: Double, var y: Double) {}
```

```
abstract class GameObject(var xObj: Double, var yObj: Double)
  extends PhysicsObject(xObj, yObj) {
  def objectMass(): Double
  override def toString: String = {
    "("+this.x+", "+this.y+"); mass: " + this.objectMass()
  }
}
```

```
class DodgeBall(var xDB: Double, var yDB: Double, val mass:
Double) extends GameObject(xDB, yDB) {
  override def objectMass(): Double = {
    this.mass
  }
}
```

```
class HealthPotion(var xPotion: Double, var yPotion: Double,
                   val volume: Int)
  extends GameObject(xPotion, yPotion) {
  override def objectMass(): Double = {
    val massPerVolume: Double = 7.0
    this.volume * massPerVolume
  }
  override def toString: String = {
    "(" + this.x + ", " + this.y + "); volume: " + this.volume
  }
}
```

```
def main(args: Array[String]): Unit = {
  val ball: DodgeBall = new DodgeBall(-2.2, 4.8, 2)
  val potion1: HealthPotion = new HealthPotion(5.0, -3.5, 6)
  val potion2: HealthPotion = potion1
  ball.x += 1.0
  println(ball.objectMass())
  println(potion2.objectMass())
  println(ball.toString())
  println(potion1)
}
```

Stack		Heap
Name	Value	

in/out

- Let's start where it always begins
- The main method!

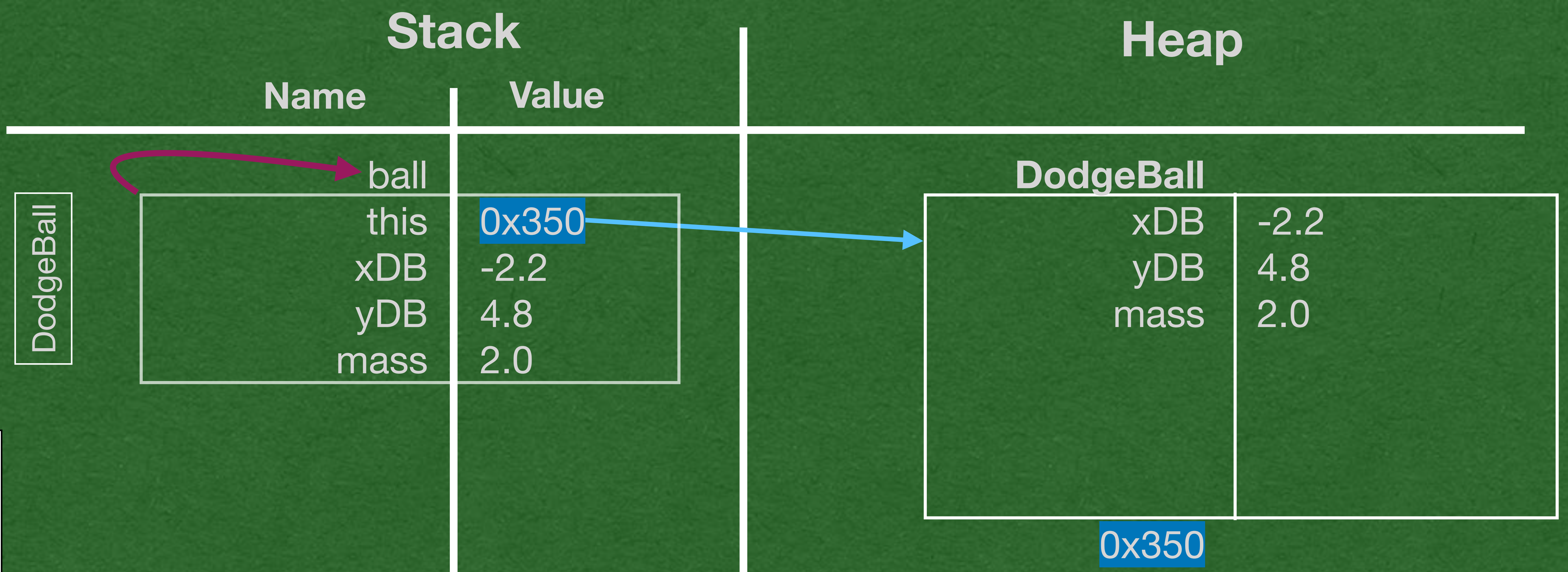
```scala
abstract class PhysicsObject(var x: Double, var y: Double) {}
```

```scala
abstract class GameObject(var xObj: Double, var yObj: Double)
  extends PhysicsObject(xObj, yObj) {
  def objectMass(): Double
  override def toString: String = {
    "("+this.x+", "+this.y+"); mass: " + this.objectMass()
  }
}
```

```scala
class DodgeBall(var xDB: Double, var yDB: Double, val mass:
Double) extends GameObject(xDB, yDB) {
  override def objectMass(): Double = {
    this.mass
  }
}
```

```scala
class HealthPotion(var xPotion: Double, var yPotion: Double,
                   val volume: Int)
  extends GameObject(xPotion, yPotion) {
  override def objectMass(): Double = {
    val massPerVolume: Double = 7.0
    this.volume * massPerVolume
  }
  override def toString: String = {
    "(" + this.x + ", " + this.y + "); volume: " + this.volume
  }
}
```

```scala
def main(args: Array[String]): Unit = {
  val ball: DodgeBall = new DodgeBall(-2.2, 4.8, 2)
  val potion1: HealthPotion = new HealthPotion(5.0, -3.5, 6)
  val potion2: HealthPotion = potion1
  ball.x += 1.0
  println(ball.objectMass())
  println(potion2.objectMass())
  println(ball.toString())
  println(potion1)
}
```



Stack

Name	Value
ball	
this	0x350
xDB	-2.2
yDB	4.8
mass	2.0

Heap

DodgeBall

xDB	-2.2
yDB	4.8
mass	2.0

0x350

in/out

- Create "ball" and and a **stack frame** for the call of the DodgeBall **constructor**
- Parameters become **state variables**

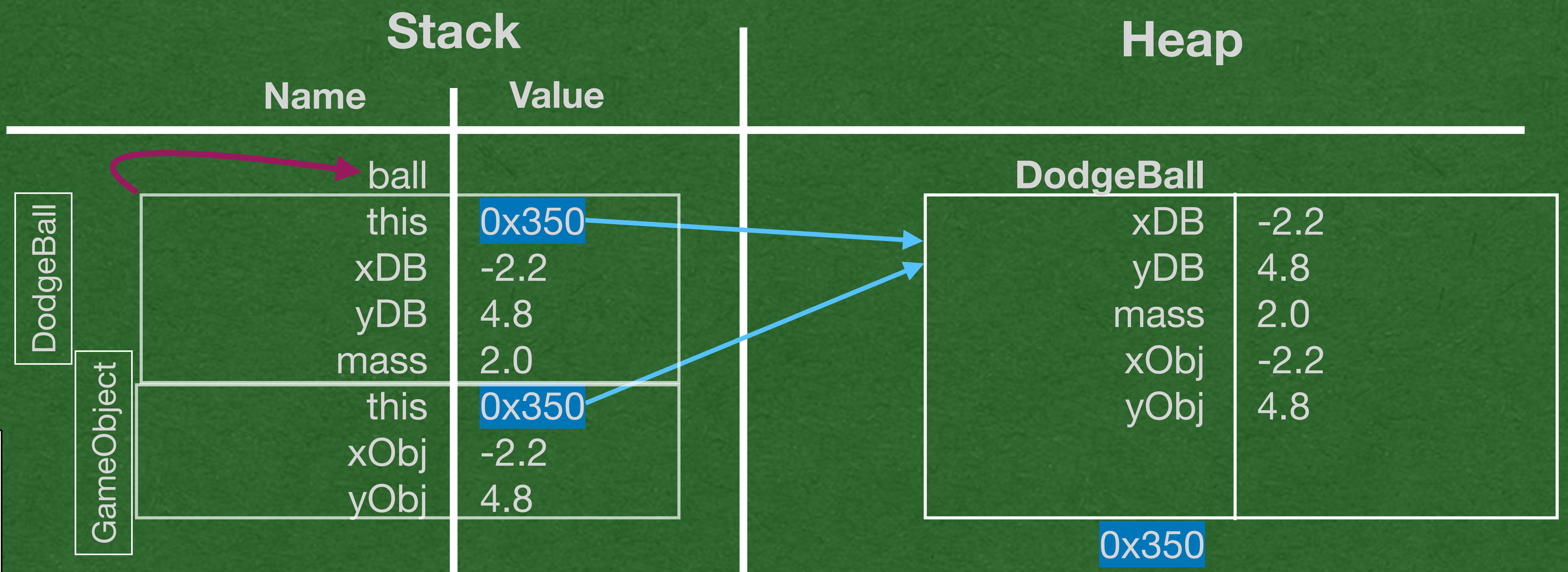
```
abstract class PhysicsObject(var x: Double, var y: Double) {}
```

```
abstract class GameObject(var xObj: Double, var yObj: Double)
  extends PhysicsObject(xObj, yObj) {
  def objectMass(): Double
  override def toString: String = {
    "("+this.x+", "+this.y+"); mass: " + this.objectMass()
  }
}
```

```
class DodgeBall(var xDB: Double, var yDB: Double, val mass:
Double) extends GameObject(xDB, yDB) {
  override def objectMass(): Double = {
    this.mass
  }
}
```

```
class HealthPotion(var xPotion: Double, var yPotion: Double,
                   val volume: Int)
  extends GameObject(xPotion, yPotion) {
  override def objectMass(): Double = {
    val massPerVolume: Double = 7.0
    this.volume * massPerVolume
  }
  override def toString: String = {
    "(" + this.x + ", " + this.y + "); volume: " + this.volume
  }
}
```

```
def main(args: Array[String]): Unit = {
  val ball: DodgeBall = new DodgeBall(-2.2, 4.8, 2)
  val potion1: HealthPotion = new HealthPotion(5.0, -3.5, 6)
  val potion2: HealthPotion = potion1
  ball.x += 1.0
  println(ball.objectMass())
  println(potion2.objectMass())
  println(ball.toString())
  println(potion1)
}
```



Stack

	Name	Value
	ball	
DodgeBall	this	0x350
	xDB	-2.2
	yDB	4.8
	mass	2.0
GameObject	this	0x350
	xObj	-2.2
	yObj	4.8

Heap

DodgeBall

xDB	-2.2
yDB	4.8
mass	2.0
xObj	-2.2
yObj	4.8

0x350

in/out

- From the DodgeBall constructor, the GameObject constructor is called
- New stack frame; parameters become state variables

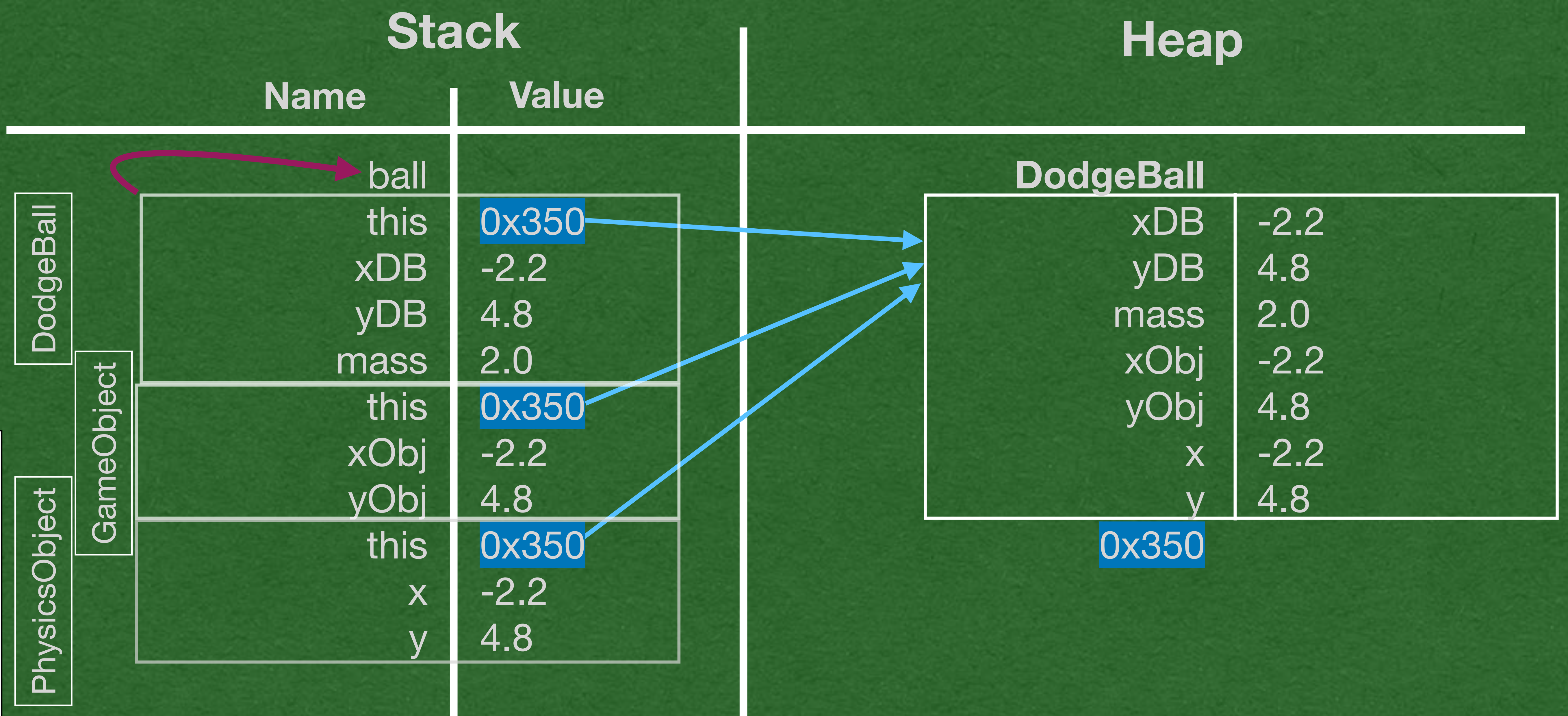
```scala
abstract class PhysicsObject(var x: Double, var y: Double) {}
```

```scala
abstract class GameObject(var xObj: Double, var yObj: Double)
  extends PhysicsObject(xObj, yObj) {
  def objectMass(): Double
  override def toString: String = {
    "("+this.x+", "+this.y+"); mass: " + this.objectMass()
  }
}
```

```scala
class DodgeBall(var xDB: Double, var yDB: Double, val mass:
Double) extends GameObject(xDB, yDB) {
  override def objectMass(): Double = {
    this.mass
  }
}
```

```scala
class HealthPotion(var xPotion: Double, var yPotion: Double,
                   val volume: Int)
  extends GameObject(xPotion, yPotion) {
  override def objectMass(): Double = {
    val massPerVolume: Double = 7.0
    this.volume * massPerVolume
  }
  override def toString: String = {
    "(" + this.x + ", " + this.y + "); volume: " + this.volume
  }
}
```

```scala
def main(args: Array[String]): Unit = {
  val ball: DodgeBall = new DodgeBall(-2.2, 4.8, 2)
  val potion1: HealthPotion = new HealthPotion(5.0, -3.5, 6)
  val potion2: HealthPotion = potion1
  ball.x += 1.0
  println(ball.objectMass())
  println(potion2.objectMass())
  println(ball.toString())
  println(potion1)
}
```



Stack

	Name	Value
	ball	
DodgeBall	this	0x350
	xDB	-2.2
	yDB	4.8
	mass	2.0
GameObject	this	0x350
	xObj	-2.2
	yObj	4.8
PhysicsObject	this	0x350
	x	-2.2
	y	4.8

Heap

DodgeBall

xDB	-2.2
yDB	4.8
mass	2.0
xObj	-2.2
yObj	4.8
x	-2.2
y	4.8

0x350

in/out

- GameObject constructor calls the PhysicsObject constructor
- Params from ALL 3 constructors become state variables

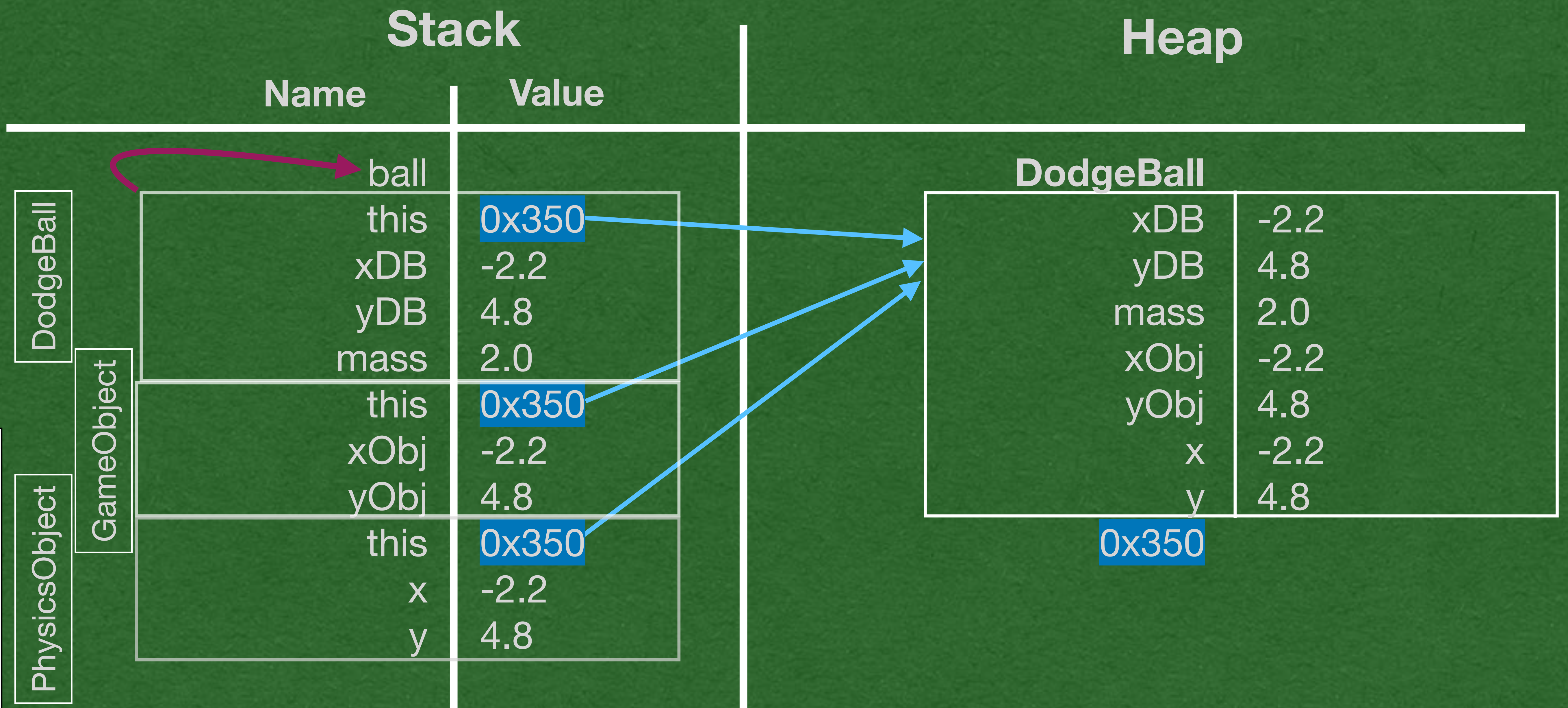
```
abstract class PhysicsObject(var x: Double, var y: Double) {}
```

```
abstract class GameObject(var xObj: Double, var yObj: Double)
  extends PhysicsObject(xObj, yObj) {
  def objectMass(): Double
  override def toString: String = {
    "("+this.x+", "+this.y+"); mass: " + this.objectMass()
  }
}
```

```
class DodgeBall(var xDB: Double, var yDB: Double, val mass:
Double) extends GameObject(xDB, yDB) {
  override def objectMass(): Double = {
    this.mass
  }
}
```

```
class HealthPotion(var xPotion: Double, var yPotion: Double,
                   val volume: Int)
  extends GameObject(xPotion, yPotion) {
  override def objectMass(): Double = {
    val massPerVolume: Double = 7.0
    this.volume * massPerVolume
  }
  override def toString: String = {
    "(" + this.x + ", " + this.y + "); volume: " + this.volume
  }
}
```

```
def main(args: Array[String]): Unit = {
  val ball: DodgeBall = new DodgeBall(-2.2, 4.8, 2)
  val potion1: HealthPotion = new HealthPotion(5.0, -3.5, 6)
  val potion2: HealthPotion = potion1
  ball.x += 1.0
  println(ball.objectMass())
  println(potion2.objectMass())
  println(ball.toString())
  println(potion1)
}
```



Stack

	Name	Value
	ball	
DodgeBall	this	0x350
	xDB	-2.2
	yDB	4.8
	mass	2.0
GameObject	this	0x350
	xObj	-2.2
	yObj	4.8
PhysicsObject	this	0x350
	x	-2.2
	y	4.8

Heap

DodgeBall

xDB	-2.2
yDB	4.8
mass	2.0
xObj	-2.2
yObj	4.8
x	-2.2
y	4.8

0x350

in/out

- Parameters from **ALL 3** constructors become state variables!
- DodgeBall **inherits** these state variables from its **super classes**

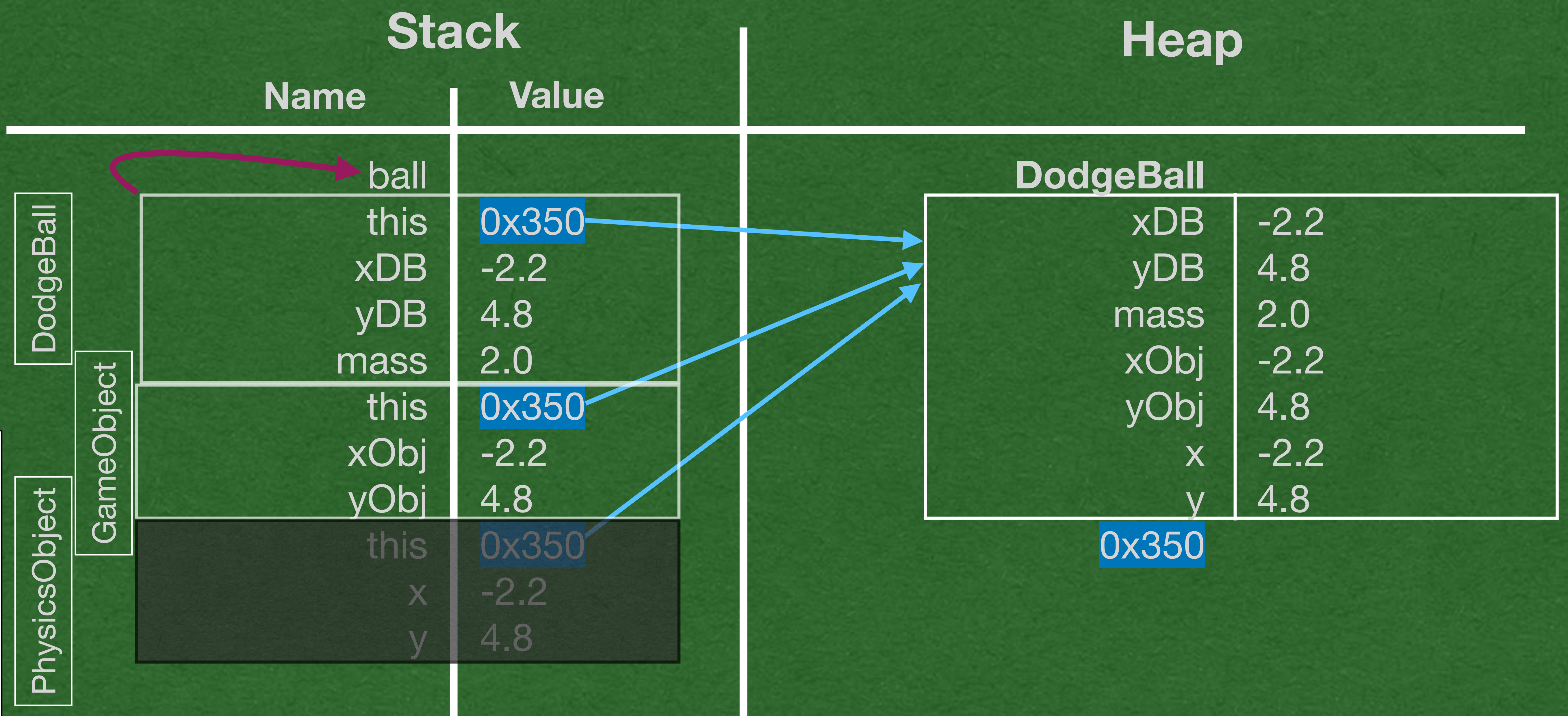
```
abstract class PhysicsObject(var x: Double, var y: Double) {}
```

```
abstract class GameObject(var xObj: Double, var yObj: Double)
  extends PhysicsObject(xObj, yObj) {
  def objectMass(): Double
  override def toString: String = {
    "("+this.x+", "+this.y+"); mass: " + this.objectMass()
  }
}
```

```
class DodgeBall(var xDB: Double, var yDB: Double, val mass:
Double) extends GameObject(xDB, yDB) {
  override def objectMass(): Double = {
    this.mass
  }
}
```

```
class HealthPotion(var xPotion: Double, var yPotion: Double,
                   val volume: Int)
  extends GameObject(xPotion, yPotion) {
  override def objectMass(): Double = {
    val massPerVolume: Double = 7.0
    this.volume * massPerVolume
  }
  override def toString: String = {
    "(" + this.x + ", " + this.y + "); volume: " + this.volume
  }
}
```

```
def main(args: Array[String]): Unit = {
  val ball: DodgeBall = new DodgeBall(-2.2, 4.8, 2)
  val potion1: HealthPotion = new HealthPotion(5.0, -3.5, 6)
  val potion2: HealthPotion = potion1
  ball.x += 1.0
  println(ball.objectMass())
  println(potion2.objectMass())
  println(ball.toString())
  println(potion1)
}
```



Stack

	Name	Value
	ball	
DodgeBall	this	0x350
	xDB	-2.2
	yDB	4.8
	mass	2.0
GameObject	this	0x350
	xObj	-2.2
	yObj	4.8
PhysicsObject	this	0x350
	x	-2.2
	y	4.8

Heap

DodgeBall	
xDB	-2.2
yDB	4.8
mass	2.0
xObj	-2.2
yObj	4.8
x	-2.2
y	4.8

0x350

in/out

- Run any code outside of the methods in PhysicsObject, then destroy the stack frame
  - [No code in this example]

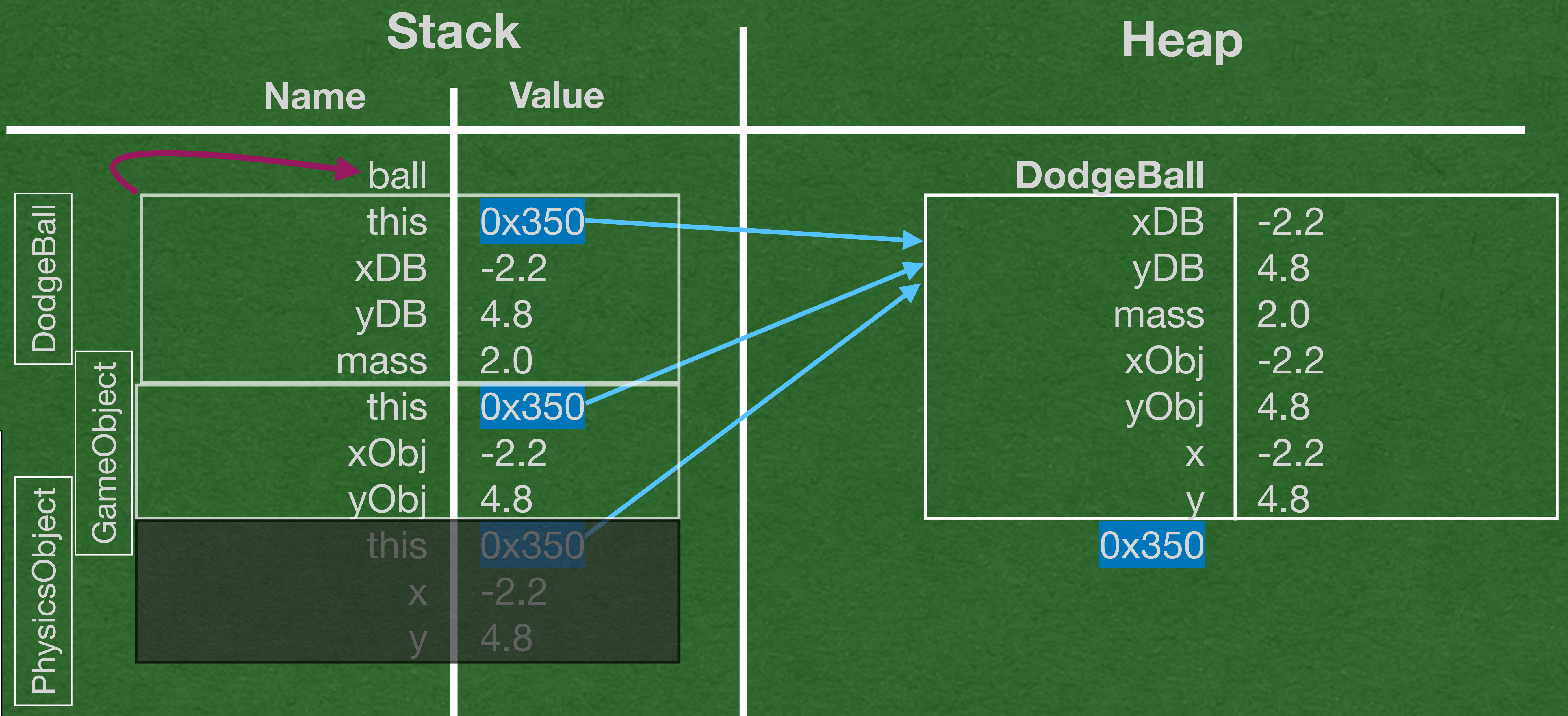
```
abstract class PhysicsObject(var x: Double, var y: Double) {}
```

```
abstract class GameObject(var xObj: Double, var yObj: Double)
  extends PhysicsObject(xObj, yObj) {
  def objectMass(): Double
  override def toString: String = {
    "("+this.x+", "+this.y+"); mass: " + this.objectMass()
  }
}
```

```
class DodgeBall(var xDB: Double, var yDB: Double, val mass:
Double) extends GameObject(xDB, yDB) {
  override def objectMass(): Double = {
    this.mass
  }
}
```

```
class HealthPotion(var xPotion: Double, var yPotion: Double,
                   val volume: Int)
  extends GameObject(xPotion, yPotion) {
  override def objectMass(): Double = {
    val massPerVolume: Double = 7.0
    this.volume * massPerVolume
  }
  override def toString: String = {
    "(" + this.x + ", " + this.y + "); volume: " + this.volume
  }
}
```

```
def main(args: Array[String]): Unit = {
  val ball: DodgeBall = new DodgeBall(-2.2, 4.8, 2)
  val potion1: HealthPotion = new HealthPotion(5.0, -3.5, 6)
  val potion2: HealthPotion = potion1
  ball.x += 1.0
  println(ball.objectMass())
  println(potion2.objectMass())
  println(ball.toString())
  println(potion1)
}
```



Stack

Name	Value
ball	
this	0x350
xDB	-2.2
yDB	4.8
mass	2.0
this	0x350
xObj	-2.2
yObj	4.8
this	0x350
x	-2.2
y	4.8

Heap

DodgeBall

xDB	-2.2
yDB	4.8
mass	2.0
xObj	-2.2
yObj	4.8
x	-2.2
y	4.8

0x350

in/out

- Run code outside methods in GameObject
  - [No code in this example]

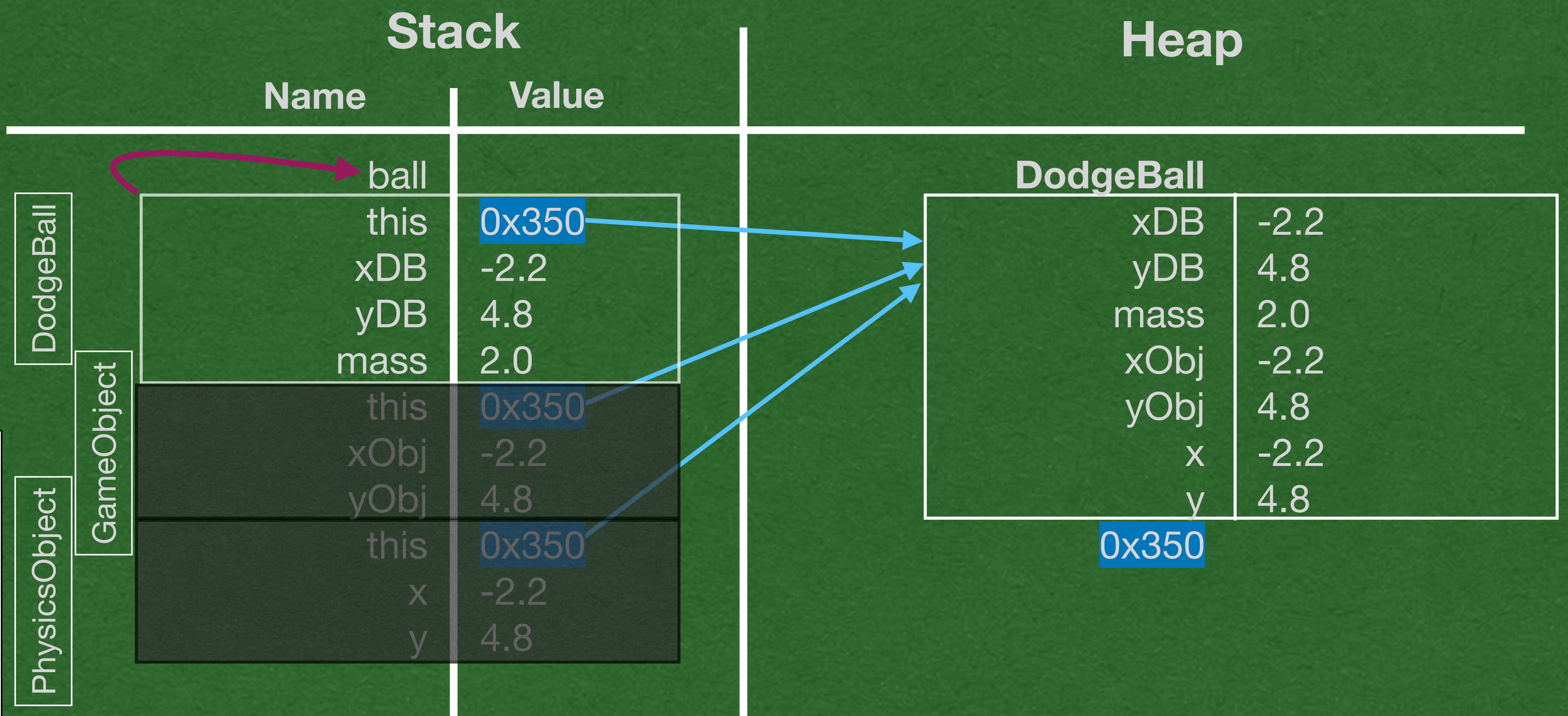
```
abstract class PhysicsObject(var x: Double, var y: Double) {}
```

```
abstract class GameObject(var xObj: Double, var yObj: Double)
  extends PhysicsObject(xObj, yObj) {
  def objectMass(): Double
  override def toString: String = {
    "("+this.x+", "+this.y+"); mass: " + this.objectMass()
  }
}
```

```
class DodgeBall(var xDB: Double, var yDB: Double, val mass:
Double) extends GameObject(xDB, yDB) {
  override def objectMass(): Double = {
    this.mass
  }
}
```

```
class HealthPotion(var xPotion: Double, var yPotion: Double,
                   val volume: Int)
  extends GameObject(xPotion, yPotion) {
  override def objectMass(): Double = {
    val massPerVolume: Double = 7.0
    this.volume * massPerVolume
  }
  override def toString: String = {
    "(" + this.x + ", " + this.y + "); volume: " + this.volume
  }
}
```

```
def main(args: Array[String]): Unit = {
  val ball: DodgeBall = new DodgeBall(-2.2, 4.8, 2)
  val potion1: HealthPotion = new HealthPotion(5.0, -3.5, 6)
  val potion2: HealthPotion = potion1
  ball.x += 1.0
  println(ball.objectMass())
  println(potion2.objectMass())
  println(ball.toString())
  println(potion1)
}
```



Name	Value
ball	
this	0x350
xDB	-2.2
yDB	4.8
mass	2.0
this	0x350
xObj	-2.2
yObj	4.8
this	0x350
x	-2.2
y	4.8

DodgeBall

xDB	-2.2
yDB	4.8
mass	2.0
xObj	-2.2
yObj	4.8
x	-2.2
y	4.8

0x350

in/out

- Repeat for DodgeBall

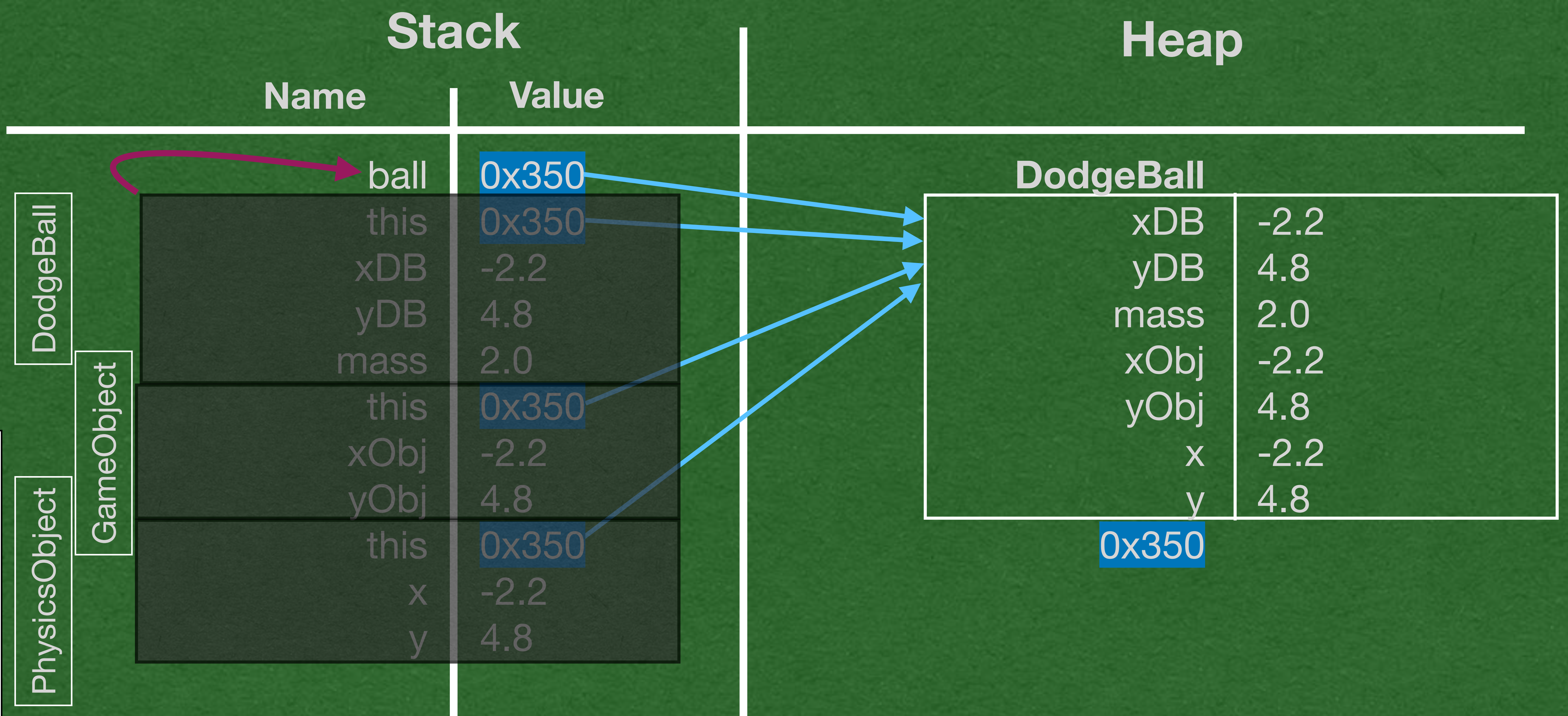
```
abstract class PhysicsObject(var x: Double, var y: Double) {}
```

```
abstract class GameObject(var xObj: Double, var yObj: Double)
  extends PhysicsObject(xObj, yObj) {
  def objectMass(): Double
  override def toString: String = {
    "("+this.x+", "+this.y+"); mass: " + this.objectMass()
  }
}
```

```
class DodgeBall(var xDB: Double, var yDB: Double, val mass:
Double) extends GameObject(xDB, yDB) {
  override def objectMass(): Double = {
    this.mass
  }
}
```

```
class HealthPotion(var xPotion: Double, var yPotion: Double,
                   val volume: Int)
  extends GameObject(xPotion, yPotion) {
  override def objectMass(): Double = {
    val massPerVolume: Double = 7.0
    this.volume * massPerVolume
  }
  override def toString: String = {
    "(" + this.x + ", " + this.y + "); volume: " + this.volume
  }
}
```

```
def main(args: Array[String]): Unit = {
  val ball: DodgeBall = new DodgeBall(-2.2, 4.8, 2)
  val potion1: HealthPotion = new HealthPotion(5.0, -3.5, 6)
  val potion2: HealthPotion = potion1
  ball.x += 1.0
  println(ball.objectMass())
  println(potion2.objectMass())
  println(ball.toString())
  println(potion1)
}
```



Name	Value
ball	0x350
this	0x350
xDB	-2.2
yDB	4.8
mass	2.0
this	0x350
xObj	-2.2
yObj	4.8
this	0x350
x	-2.2
y	4.8

DodgeBall

xDB	-2.2
yDB	4.8
mass	2.0
xObj	-2.2
yObj	4.8
x	-2.2
y	4.8

0x350

in/out

- Stack frame for the DodgeBall constructor returns a reference to the object that was created

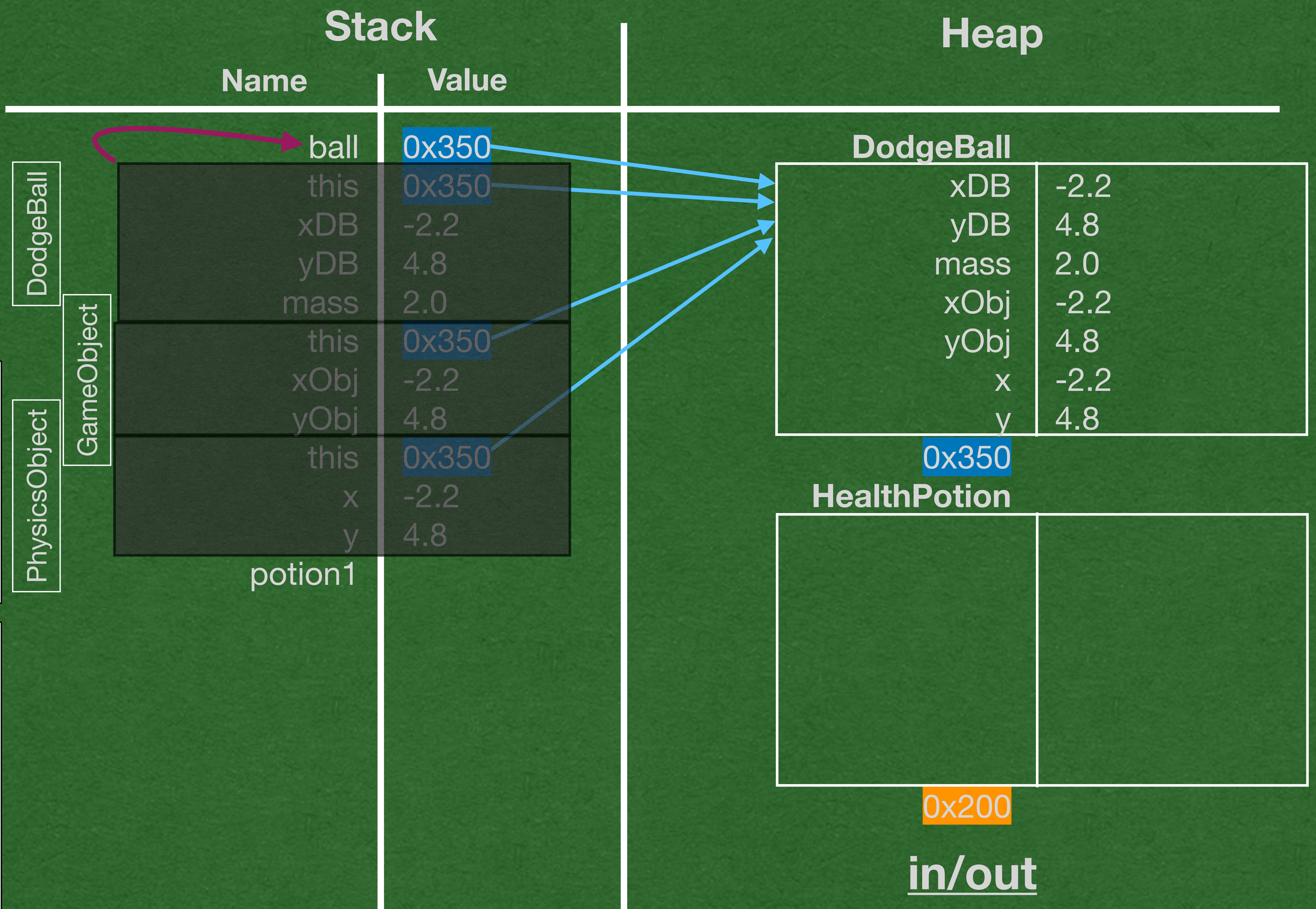
```
abstract class PhysicsObject(var x: Double, var y: Double) {}
```

```
abstract class GameObject(var xObj: Double, var yObj: Double)
  extends PhysicsObject(xObj, yObj) {
  def objectMass(): Double
  override def toString: String = {
    "("+this.x+", "+this.y+"); mass: " + this.objectMass()
  }
}
```

```
class DodgeBall(var xDB: Double, var yDB: Double, val mass:
Double) extends GameObject(xDB, yDB) {
  override def objectMass(): Double = {
    this.mass
  }
}
```

```
class HealthPotion(var xPotion: Double, var yPotion: Double,
                   val volume: Int)
  extends GameObject(xPotion, yPotion) {
  override def objectMass(): Double = {
    val massPerVolume: Double = 7.0
    this.volume * massPerVolume
  }
  override def toString: String = {
    "(" + this.x + ", " + this.y + "); volume: " + this.volume
  }
}
```

```
def main(args: Array[String]): Unit = {
  val ball: DodgeBall = new DodgeBall(-2.2, 4.8, 2)
  val potion1: HealthPotion = new HealthPotion(5.0, -3.5, 6)
  val potion2: HealthPotion = potion1
  ball.x += 1.0
  println(ball.objectMass())
  println(potion2.objectMass())
  println(ball.toString())
  println(potion1)
}
```



Stack

Name	Value
ball	0x350
this	0x350
xDB	-2.2
yDB	4.8
mass	2.0
this	0x350
xObj	-2.2
yObj	4.8
this	0x350
x	-2.2
y	4.8
potion1	

Heap

DodgeBall

xDB	-2.2
yDB	4.8
mass	2.0
xObj	-2.2
yObj	4.8
x	-2.2
y	4.8

0x350

HealthPotion

0x200

in/out

- Exercise: How is the HealthPotion constructed?

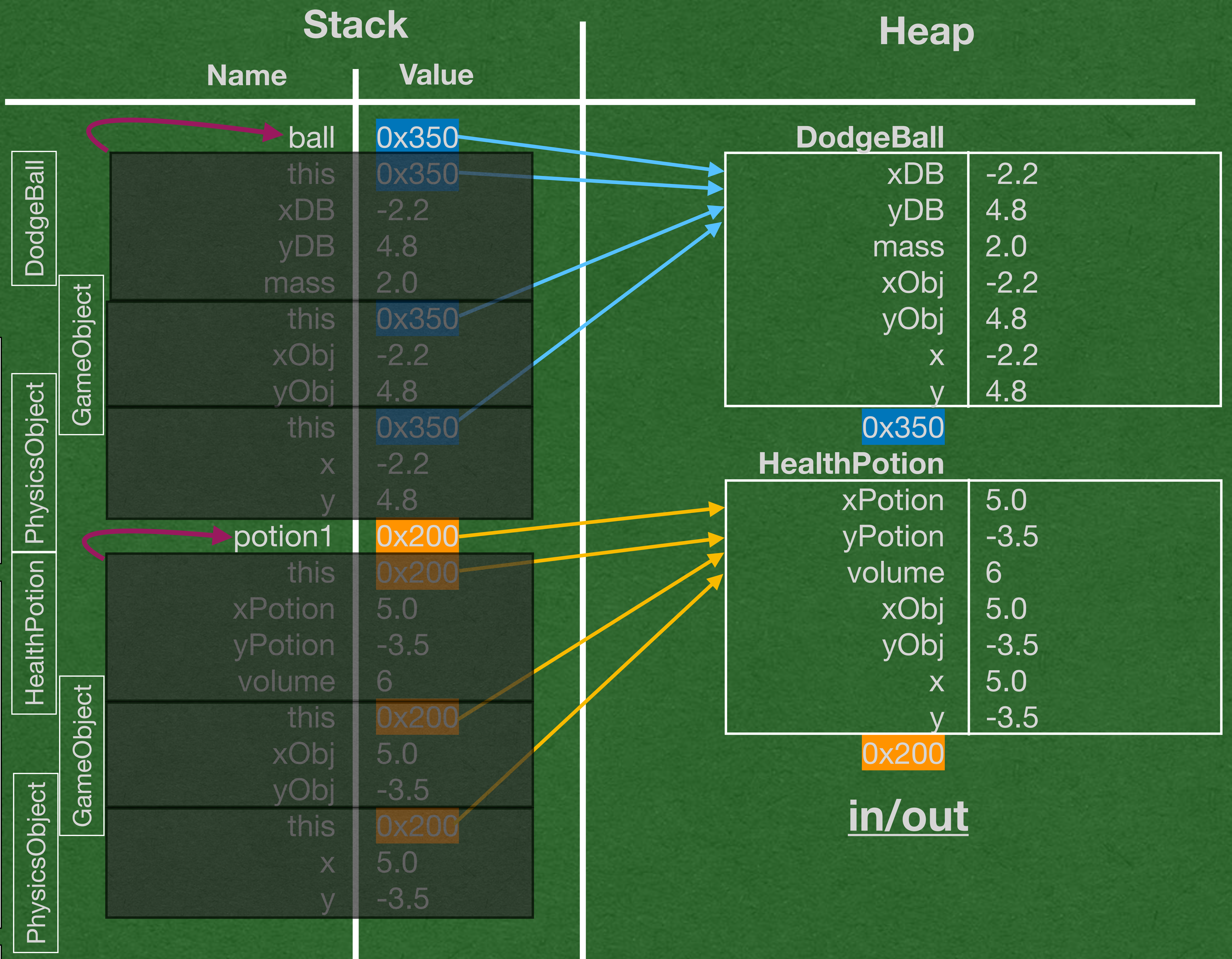
```
abstract class PhysicsObject(var x: Double, var y: Double) {}
```

```
abstract class GameObject(var xObj: Double, var yObj: Double)
  extends PhysicsObject(xObj, yObj) {
  def objectMass(): Double
  override def toString: String = {
    "("+this.x+", "+this.y+"); mass: " + this.objectMass()
  }
}
```

```
class DodgeBall(var xDB: Double, var yDB: Double, val mass:
Double) extends GameObject(xDB, yDB) {
  override def objectMass(): Double = {
    this.mass
  }
}
```

```
class HealthPotion(var xPotion: Double, var yPotion: Double,
                   val volume: Int)
  extends GameObject(xPotion, yPotion) {
  override def objectMass(): Double = {
    val massPerVolume: Double = 7.0
    this.volume * massPerVolume
  }
  override def toString: String = {
    "(" + this.x + ", " + this.y + "); volume: " + this.volume
  }
}
```

```
def main(args: Array[String]): Unit = {
  val ball: DodgeBall = new DodgeBall(-2.2, 4.8, 2)
  val potion1: HealthPotion = new HealthPotion(5.0, -3.5, 6)
  val potion2: HealthPotion = potion1
  ball.x += 1.0
  println(ball.objectMass())
  println(potion2.objectMass())
  println(ball.toString())
  println(potion1)
}
```



Name	Value
ball	0x350
this	0x350
xDB	-2.2
yDB	4.8
mass	2.0
this	0x350
xObj	-2.2
yObj	4.8
this	0x350
x	-2.2
y	4.8
potion1	0x200
this	0x200
xPotion	5.0
yPotion	-3.5
volume	6
this	0x200
xObj	5.0
yObj	-3.5
this	0x200
x	5.0
y	-3.5

DodgeBall

xDB	-2.2
yDB	4.8
mass	2.0
xObj	-2.2
yObj	4.8
x	-2.2
y	4.8

0x350

HealthPotion

xPotion	5.0
yPotion	-3.5
volume	6
xObj	5.0
yObj	-3.5
x	5.0
y	-3.5

0x200

- Exercise solution

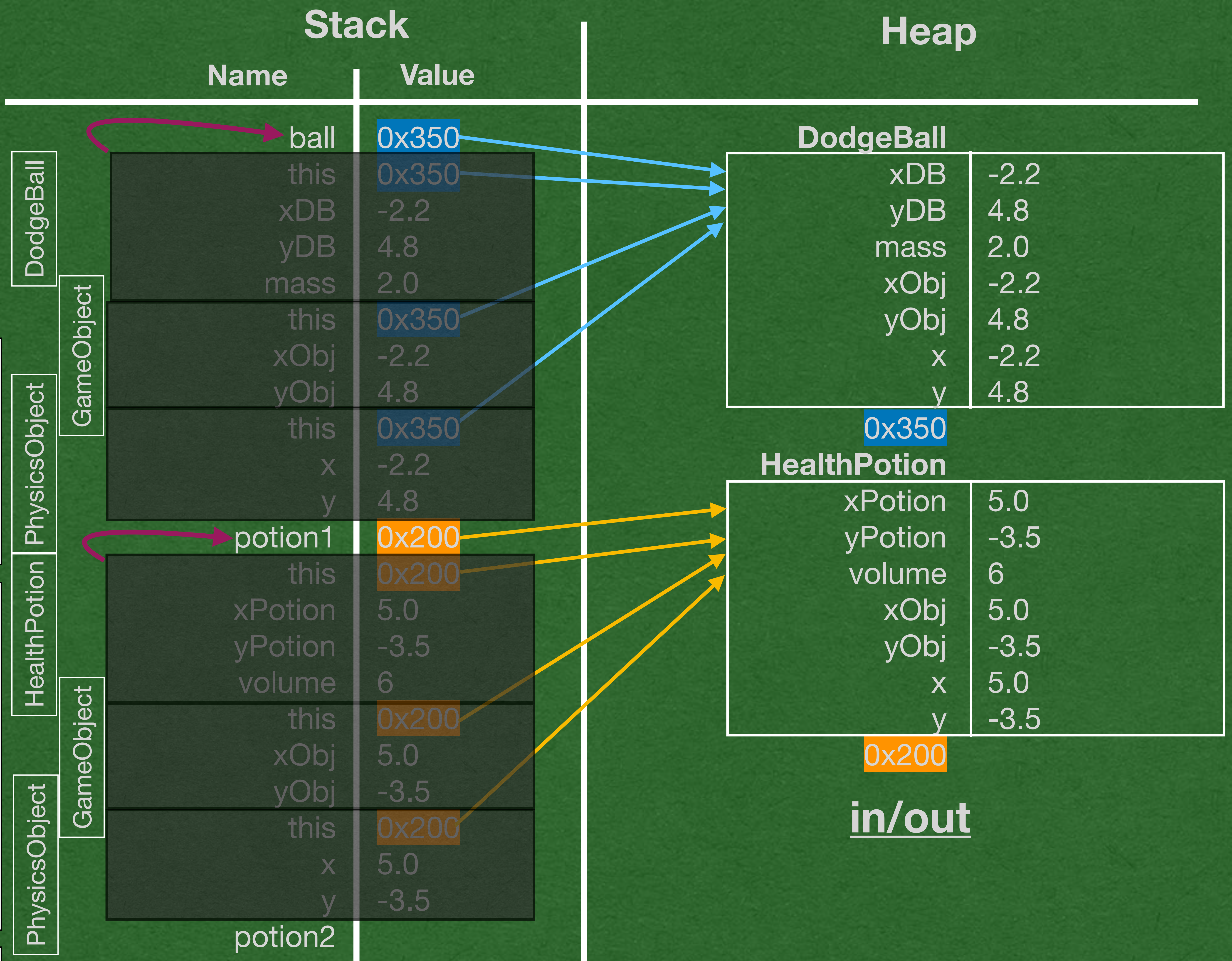
```
abstract class PhysicsObject(var x: Double, var y: Double) {}
```

```
abstract class GameObject(var xObj: Double, var yObj: Double)
  extends PhysicsObject(xObj, yObj) {
  def objectMass(): Double
  override def toString: String = {
    "("+this.x+", "+this.y+"); mass: " + this.objectMass()
  }
}
```

```
class DodgeBall(var xDB: Double, var yDB: Double, val mass:
Double) extends GameObject(xDB, yDB) {
  override def objectMass(): Double = {
    this.mass
  }
}
```

```
class HealthPotion(var xPotion: Double, var yPotion: Double,
                   val volume: Int)
  extends GameObject(xPotion, yPotion) {
  override def objectMass(): Double = {
    val massPerVolume: Double = 7.0
    this.volume * massPerVolume
  }
  override def toString: String = {
    "(" + this.x + ", " + this.y + "); volume: " + this.volume
  }
}
```

```
def main(args: Array[String]): Unit = {
  val ball: DodgeBall = new DodgeBall(-2.2, 4.8, 2)
  val potion1: HealthPotion = new HealthPotion(5.0, -3.5, 6)
  val potion2: HealthPotion = potion1
  ball.x += 1.0
  println(ball.objectMass())
  println(potion2.objectMass())
  println(ball.toString())
  println(potion1)
}
```



Stack

Name	Value
ball	0x350
this	0x350
xDB	-2.2
yDB	4.8
mass	2.0
this	0x350
xObj	-2.2
yObj	4.8
this	0x350
x	-2.2
y	4.8
potion1	0x200
this	0x200
xPotion	5.0
yPotion	-3.5
volume	6
this	0x200
xObj	5.0
yObj	-3.5
this	0x200
x	5.0
y	-3.5
potion2	

Heap

DodgeBall

xDB	-2.2
yDB	4.8
mass	2.0
xObj	-2.2
yObj	4.8
x	-2.2
y	4.8

0x350

HealthPotion

xPotion	5.0
yPotion	-3.5
volume	6
xObj	5.0
yObj	-3.5
x	5.0
y	-3.5

0x200

in/out

- Exercise: How about potion2?

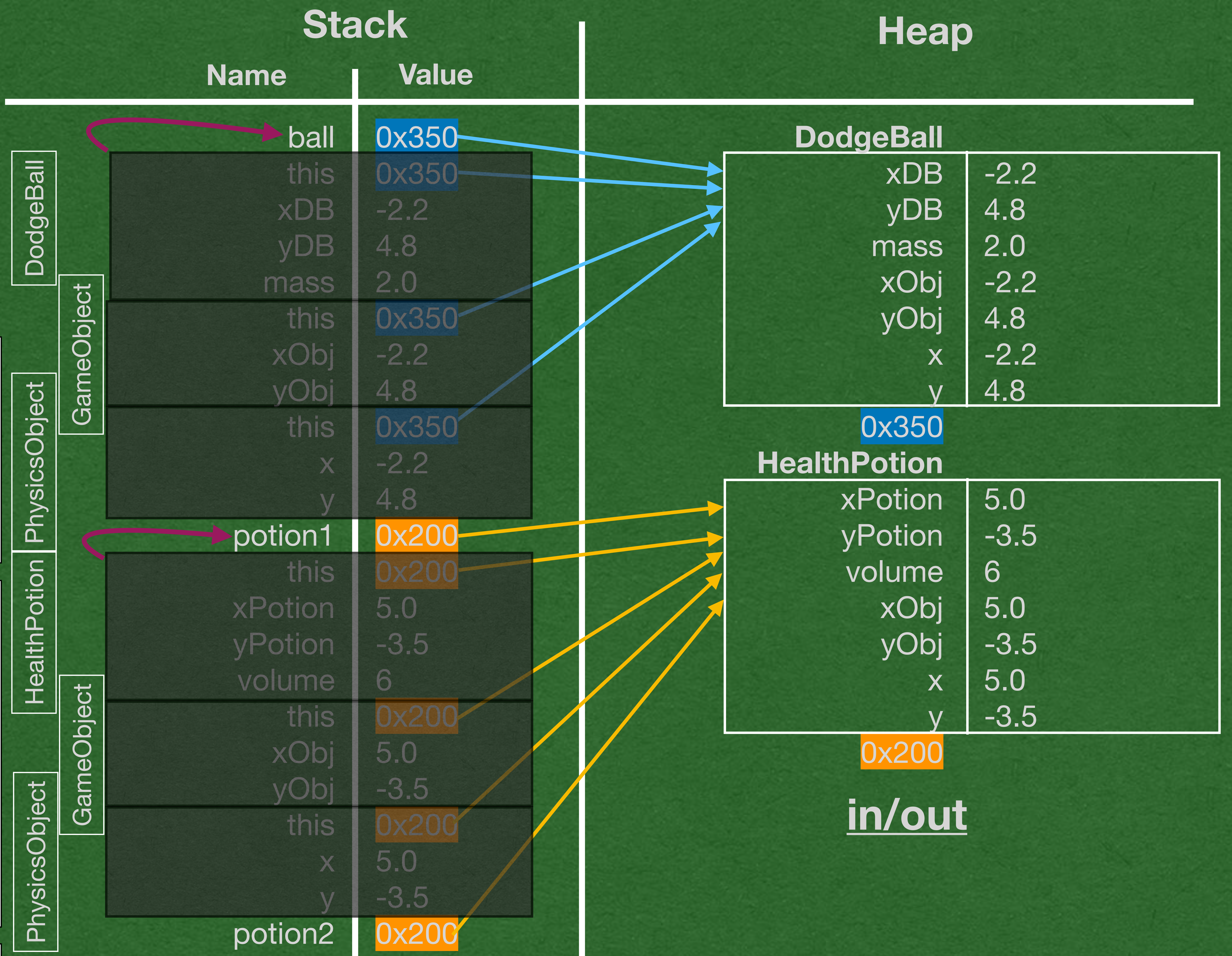
```
abstract class PhysicsObject(var x: Double, var y: Double) {}
```

```
abstract class GameObject(var xObj: Double, var yObj: Double)
  extends PhysicsObject(xObj, yObj) {
  def objectMass(): Double
  override def toString: String = {
    "("+this.x+", "+this.y+"); mass: " + this.objectMass()
  }
}
```

```
class DodgeBall(var xDB: Double, var yDB: Double, val mass:
Double) extends GameObject(xDB, yDB) {
  override def objectMass(): Double = {
    this.mass
  }
}
```

```
class HealthPotion(var xPotion: Double, var yPotion: Double,
                   val volume: Int)
  extends GameObject(xPotion, yPotion) {
  override def objectMass(): Double = {
    val massPerVolume: Double = 7.0
    this.volume * massPerVolume
  }
  override def toString: String = {
    "(" + this.x + ", " + this.y + "); volume: " + this.volume
  }
}
```

```
def main(args: Array[String]): Unit = {
  val ball: DodgeBall = new DodgeBall(-2.2, 4.8, 2)
  val potion1: HealthPotion = new HealthPotion(5.0, -3.5, 6)
  val potion2: HealthPotion = potion1
  ball.x += 1.0
  println(ball.objectMass())
  println(potion2.objectMass())
  println(ball.toString())
  println(potion1)
}
```



Stack

Name	Value
ball	0x350
this	0x350
xDB	-2.2
yDB	4.8
mass	2.0
this	0x350
xObj	-2.2
yObj	4.8
this	0x350
x	-2.2
y	4.8
potion1	0x200
this	0x200
xPotion	5.0
yPotion	-3.5
volume	6
this	0x200
xObj	5.0
yObj	-3.5
this	0x200
x	5.0
y	-3.5
potion2	0x200

Heap

DodgeBall

xDB	-2.2
yDB	4.8
mass	2.0
xObj	-2.2
yObj	4.8
x	-2.2
y	4.8

0x350

HealthPotion

xPotion	5.0
yPotion	-3.5
volume	6
xObj	5.0
yObj	-3.5
x	5.0
y	-3.5

0x200

in/out

- Exercise solution

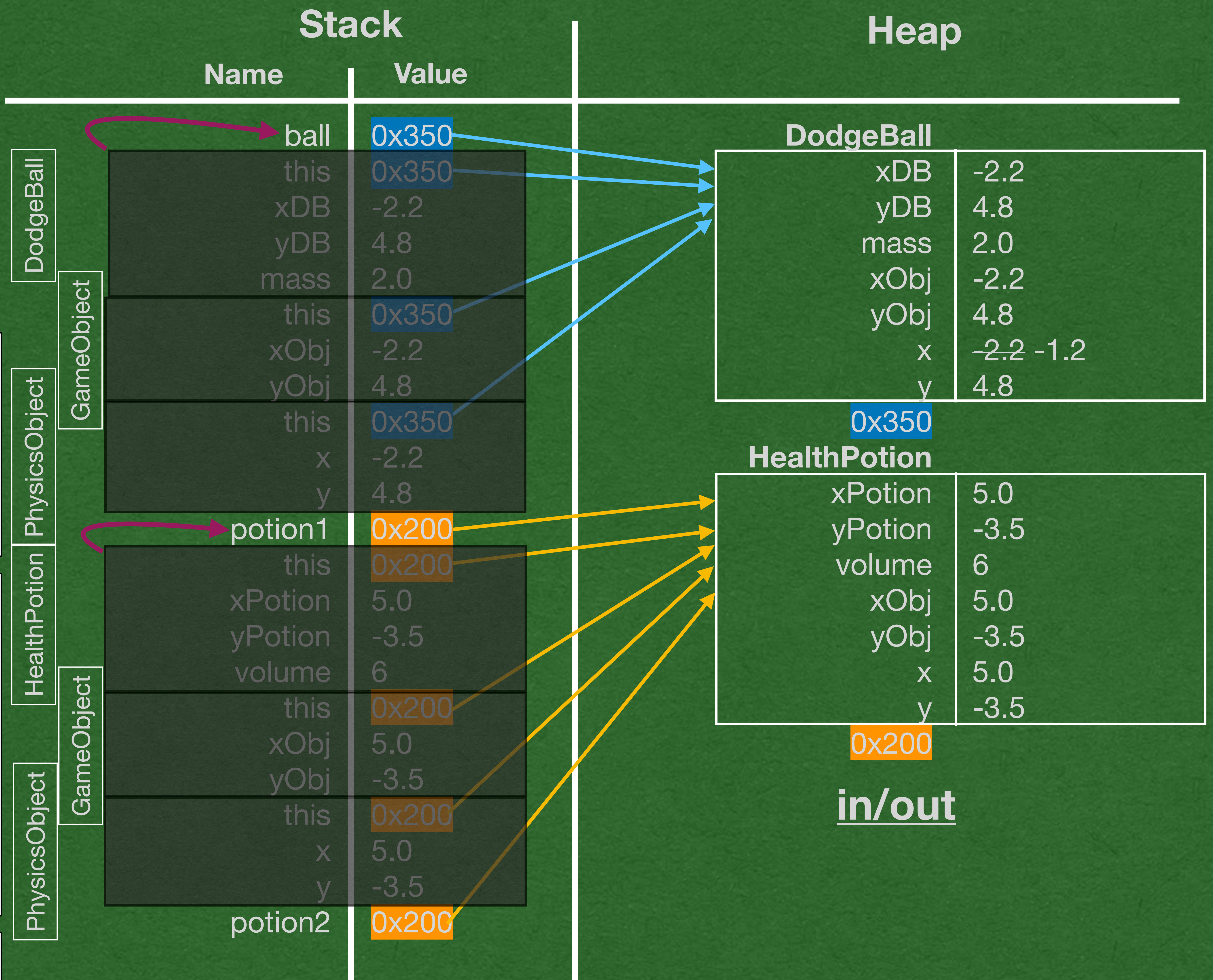
```
abstract class PhysicsObject(var x: Double, var y: Double) {}
```

```
abstract class GameObject(var xObj: Double, var yObj: Double)
  extends PhysicsObject(xObj, yObj) {
  def objectMass(): Double
  override def toString: String = {
    "("+this.x+", "+this.y+"); mass: " + this.objectMass()
  }
}
```

```
class DodgeBall(var xDB: Double, var yDB: Double, val mass:
Double) extends GameObject(xDB, yDB) {
  override def objectMass(): Double = {
    this.mass
  }
}
```

```
class HealthPotion(var xPotion: Double, var yPotion: Double,
                   val volume: Int)
  extends GameObject(xPotion, yPotion) {
  override def objectMass(): Double = {
    val massPerVolume: Double = 7.0
    this.volume * massPerVolume
  }
  override def toString: String = {
    "(" + this.x + ", " + this.y + "); volume: " + this.volume
  }
}
```

```
def main(args: Array[String]): Unit = {
  val ball: DodgeBall = new DodgeBall(-2.2, 4.8, 2)
  val potion1: HealthPotion = new HealthPotion(5.0, -3.5, 6)
  val potion2: HealthPotion = potion1
  ball.x += 1.0
  println(ball.objectMass())
  println(potion2.objectMass())
  println(ball.toString())
  println(potion1)
}
```



Stack

Name	Value
ball	0x350
this	0x350
xDB	-2.2
yDB	4.8
mass	2.0
this	0x350
xObj	-2.2
yObj	4.8
this	0x350
x	-2.2
y	4.8
potion1	0x200
this	0x200
xPotion	5.0
yPotion	-3.5
volume	6
this	0x200
xObj	5.0
yObj	-3.5
this	0x200
x	5.0
y	-3.5
potion2	0x200

Heap

DodgeBall

xDB	-2.2
yDB	4.8
mass	2.0
xObj	-2.2
yObj	4.8
x	~~-2.2~~ -1.2
y	4.8

0x350

HealthPotion

xPotion	5.0
yPotion	-3.5
volume	6
xObj	5.0
yObj	-3.5
x	5.0
y	-3.5

0x200

in/out

- Update the x state variable of the DodgeBall

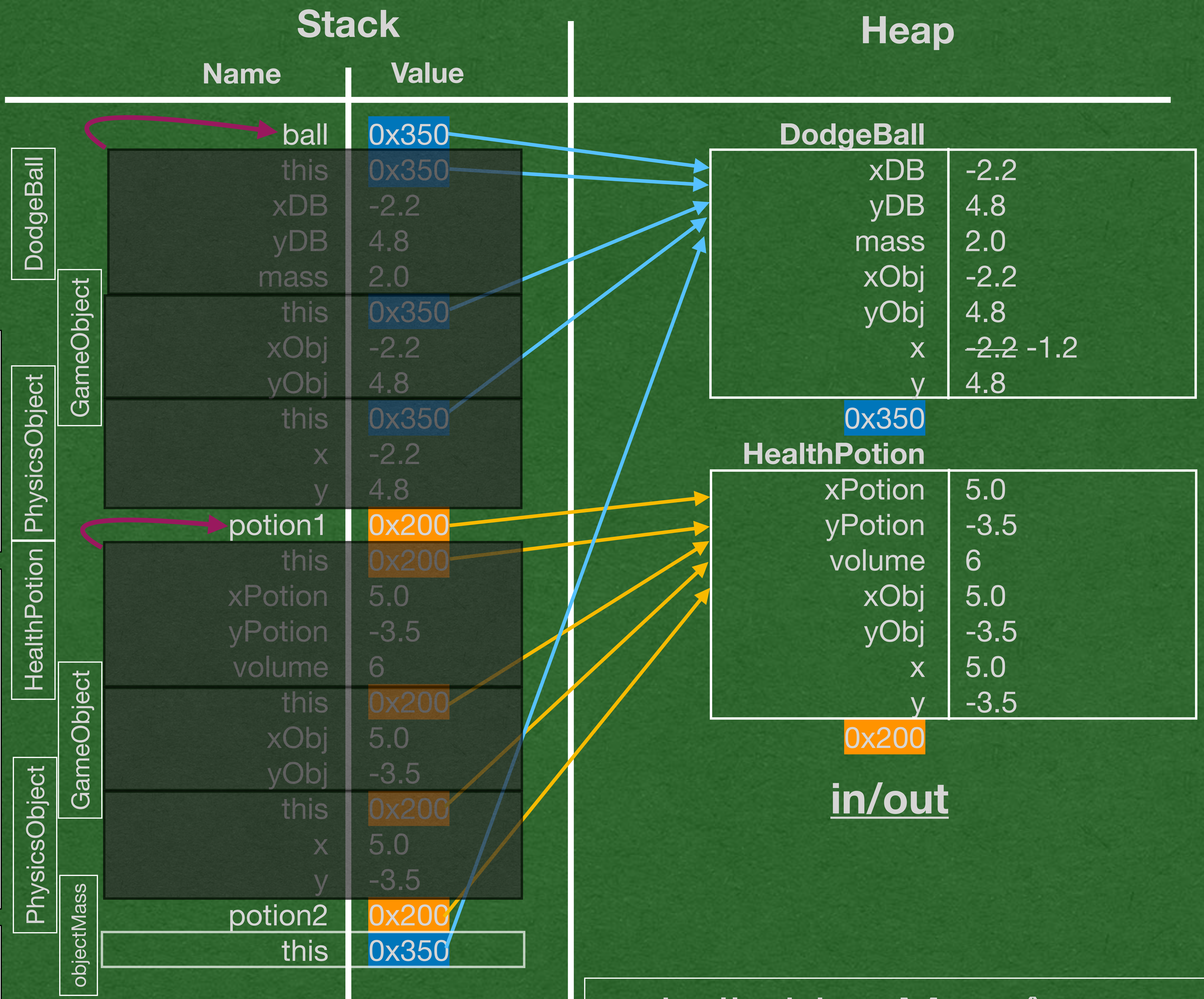
```
abstract class PhysicsObject(var x: Double, var y: Double) {}
```

```
abstract class GameObject(var xObj: Double, var yObj: Double)
  extends PhysicsObject(xObj, yObj) {
  def objectMass(): Double
  override def toString: String = {
    "("+this.x+", "+this.y+"); mass: " + this.objectMass()
  }
}
```

```
class DodgeBall(var xDB: Double, var yDB: Double, val mass:
Double) extends GameObject(xDB, yDB) {
  override def objectMass(): Double = {
    this.mass
  }
}
```

```
class HealthPotion(var xPotion: Double, var yPotion: Double,
                   val volume: Int)
  extends GameObject(xPotion, yPotion) {
  override def objectMass(): Double = {
    val massPerVolume: Double = 7.0
    this.volume * massPerVolume
  }
  override def toString: String = {
    "(" + this.x + ", " + this.y + "); volume: " + this.volume
  }
}
```

```
def main(args: Array[String]): Unit = {
  val ball: DodgeBall = new DodgeBall(-2.2, 4.8, 2)
  val potion1: HealthPotion = new HealthPotion(5.0, -3.5, 6)
  val potion2: HealthPotion = potion1
  ball.x += 1.0
  println(ball.objectMass())
  println(potion2.objectMass())
  println(ball.toString())
  println(potion1)
}
```



Stack

	Name	Value
	ball	0x350
DodgeBall	this	0x350
	xDB	-2.2
	yDB	4.8
	mass	2.0
GameObject	this	0x350
	xObj	-2.2
	yObj	4.8
PhysicsObject	this	0x350
	x	-2.2
	y	4.8
	potion1	0x200
HealthPotion	this	0x200
	xPotion	5.0
	yPotion	-3.5
	volume	6
GameObject	this	0x200
	xObj	5.0
	yObj	-3.5
PhysicsObject	this	0x200
	x	5.0
	y	-3.5
	potion2	0x200
objectMass	this	0x350

Heap

DodgeBall

xDB	-2.2
yDB	4.8
mass	2.0
xObj	-2.2
yObj	4.8
x	~~-2.2~~ -1.2
y	4.8

0x350

HealthPotion

xPotion	5.0
yPotion	-3.5
volume	6
xObj	5.0
yObj	-3.5
x	5.0
y	-3.5

0x200

in/out

- ball.objectMass()
- What objectMass method is called? Why?

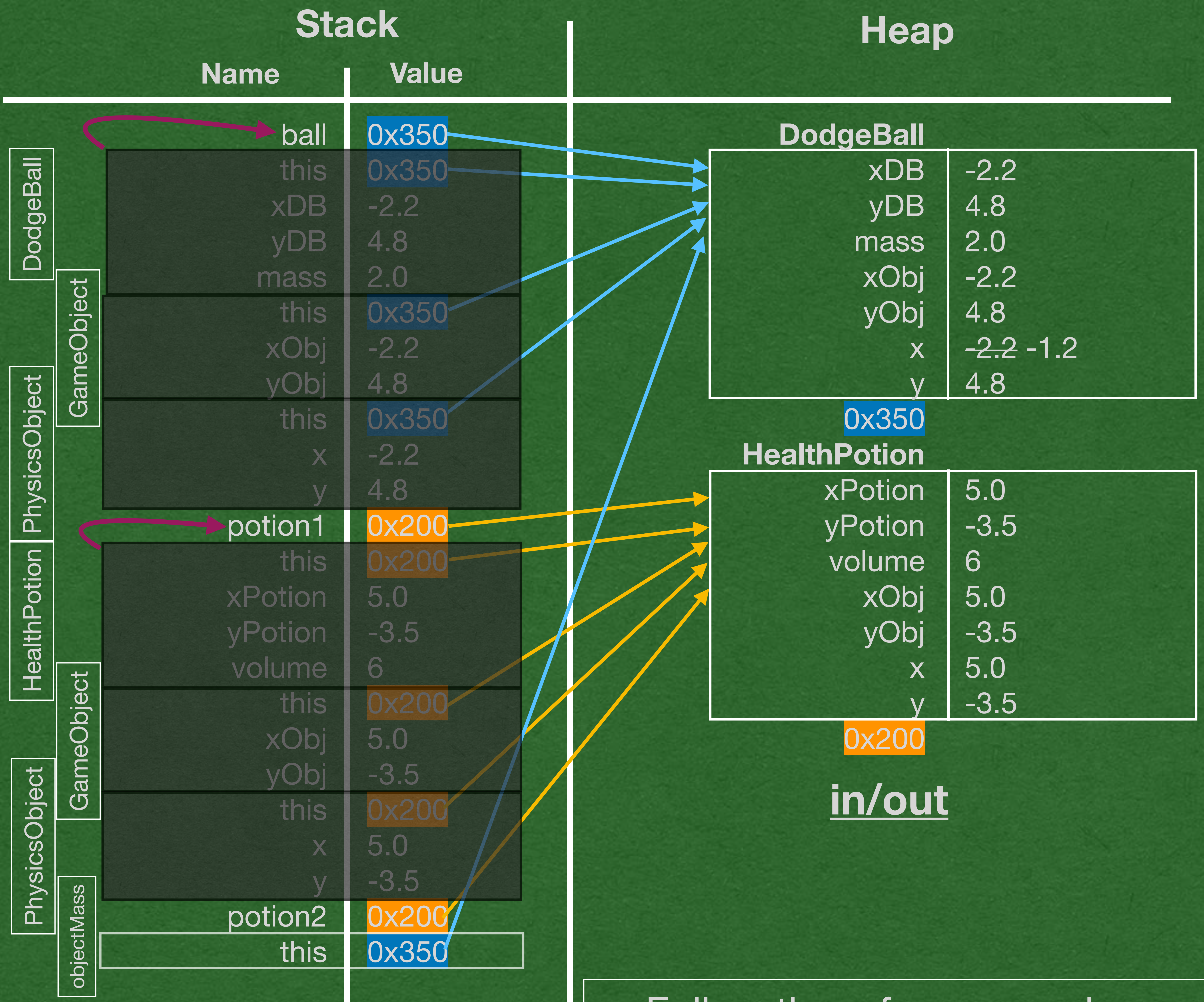
```
abstract class PhysicsObject(var x: Double, var y: Double) {}
```

```
abstract class GameObject(var xObj: Double, var yObj: Double)
  extends PhysicsObject(xObj, yObj) {
  def objectMass(): Double
  override def toString: String = {
    "("+this.x+", "+this.y+"); mass: " + this.objectMass()
  }
}
```

```
class DodgeBall(var xDB: Double, var yDB: Double, val mass:
Double) extends GameObject(xDB, yDB) {
  override def objectMass(): Double = {
    this.mass
  }
}
```

```
class HealthPotion(var xPotion: Double, var yPotion: Double,
                   val volume: Int)
  extends GameObject(xPotion, yPotion) {
  override def objectMass(): Double = {
    val massPerVolume: Double = 7.0
    this.volume * massPerVolume
  }
  override def toString: String = {
    "(" + this.x + ", " + this.y + "); volume: " + this.volume
  }
}
```

```
def main(args: Array[String]): Unit = {
  val ball: DodgeBall = new DodgeBall(-2.2, 4.8, 2)
  val potion1: HealthPotion = new HealthPotion(5.0, -3.5, 6)
  val potion2: HealthPotion = potion1
  ball.x += 1.0
  println(ball.objectMass())
  println(potion2.objectMass())
  println(ball.toString())
  println(potion1)
}
```



Stack

Name	Value
ball	0x350
this	0x350
xDB	-2.2
yDB	4.8
mass	2.0
this	0x350
xObj	-2.2
yObj	4.8
this	0x350
x	-2.2
y	4.8
potion1	0x200
this	0x200
xPotion	5.0
yPotion	-3.5
volume	6
this	0x200
xObj	5.0
yObj	-3.5
this	0x200
x	5.0
y	-3.5
potion2	0x200
this	0x350

Heap

DodgeBall

xDB	-2.2
yDB	4.8
mass	2.0
xObj	-2.2
yObj	4.8
x	~~-2.2~~ -1.2
y	4.8

0x350

HealthPotion

xPotion	5.0
yPotion	-3.5
volume	6
xObj	5.0
yObj	-3.5
x	5.0
y	-3.5

0x200

- Follow the reference and check the **type** of the object on the heap
- ball stores 0x350 which refers to a **DodgeBall**

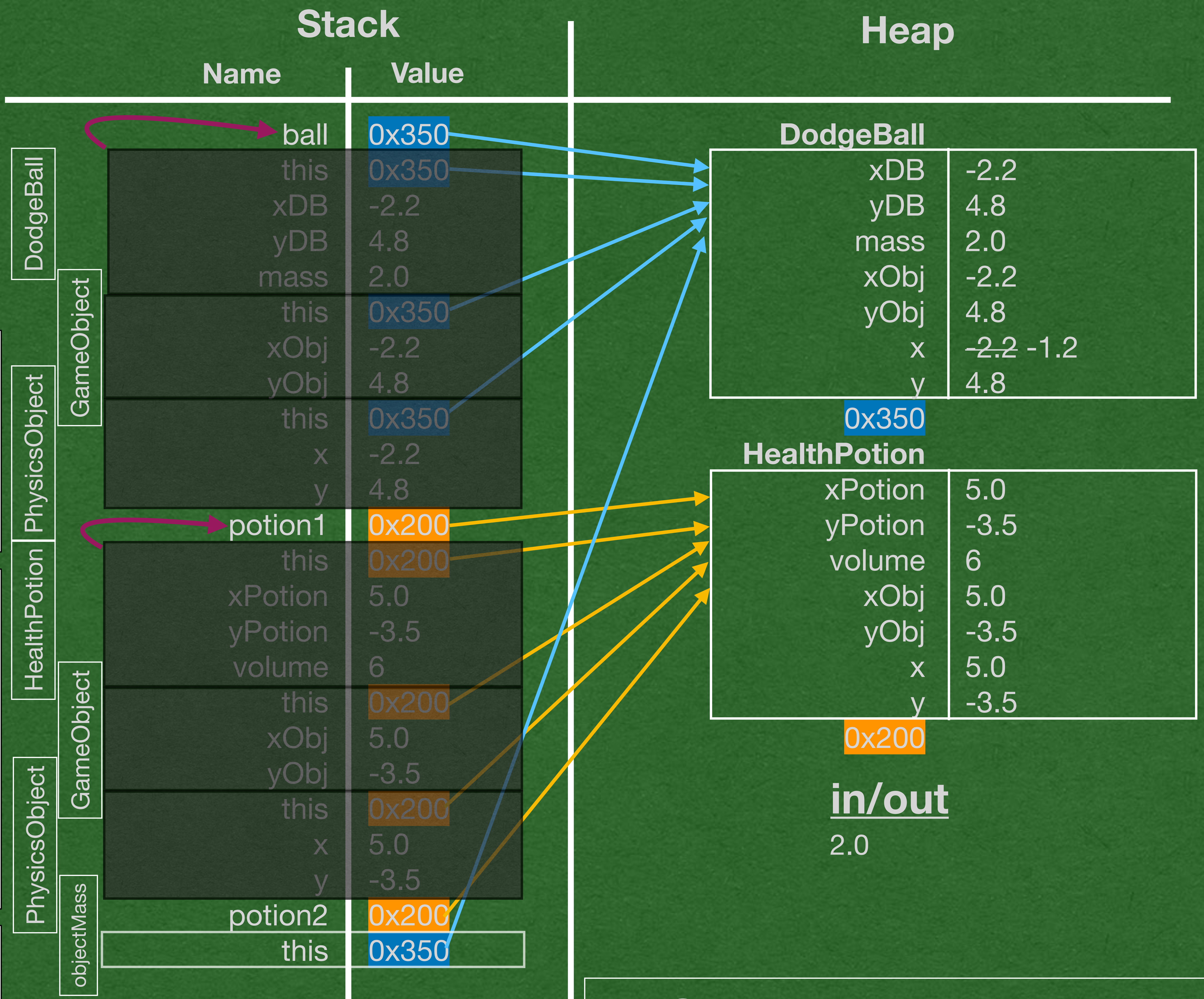
```
abstract class PhysicsObject(var x: Double, var y: Double) {}
```

```
abstract class GameObject(var xObj: Double, var yObj: Double)
  extends PhysicsObject(xObj, yObj) {
  def objectMass(): Double
  override def toString: String = {
    "("+this.x+", "+this.y+"); mass: " + this.objectMass()
  }
}
```

```
class DodgeBall(var xDB: Double, var yDB: Double, val mass:
Double) extends GameObject(xDB, yDB) {
  override def objectMass(): Double = {
    this.mass
  }
}
```

```
class HealthPotion(var xPotion: Double, var yPotion: Double,
                   val volume: Int)
  extends GameObject(xPotion, yPotion) {
  override def objectMass(): Double = {
    val massPerVolume: Double = 7.0
    this.volume * massPerVolume
  }
  override def toString: String = {
    "(" + this.x + ", " + this.y + "); volume: " + this.volume
  }
}
```

```
def main(args: Array[String]): Unit = {
  val ball: DodgeBall = new DodgeBall(-2.2, 4.8, 2)
  val potion1: HealthPotion = new HealthPotion(5.0, -3.5, 6)
  val potion2: HealthPotion = potion1
  ball.x += 1.0
  println(ball.objectMass())
  println(potion2.objectMass())
  println(ball.toString())
  println(potion1)
}
```



Stack

Name	Value
ball	0x350
this	0x350
xDB	-2.2
yDB	4.8
mass	2.0
this	0x350
xObj	-2.2
yObj	4.8
this	0x350
x	-2.2
y	4.8
potion1	0x200
this	0x200
xPotion	5.0
yPotion	-3.5
volume	6
this	0x200
xObj	5.0
yObj	-3.5
this	0x200
x	5.0
y	-3.5
potion2	0x200
this	0x350

Heap

DodgeBall

xDB	-2.2
yDB	4.8
mass	2.0
xObj	-2.2
yObj	4.8
x	~~-2.2~~ -1.2
y	4.8

0x350

HealthPotion

xPotion	5.0
yPotion	-3.5
volume	6
xObj	5.0
yObj	-3.5
x	5.0
y	-3.5

0x200

in/out

2.0

- Call objectMass defined in DodgeBall
- Prints 2.0 to the screen

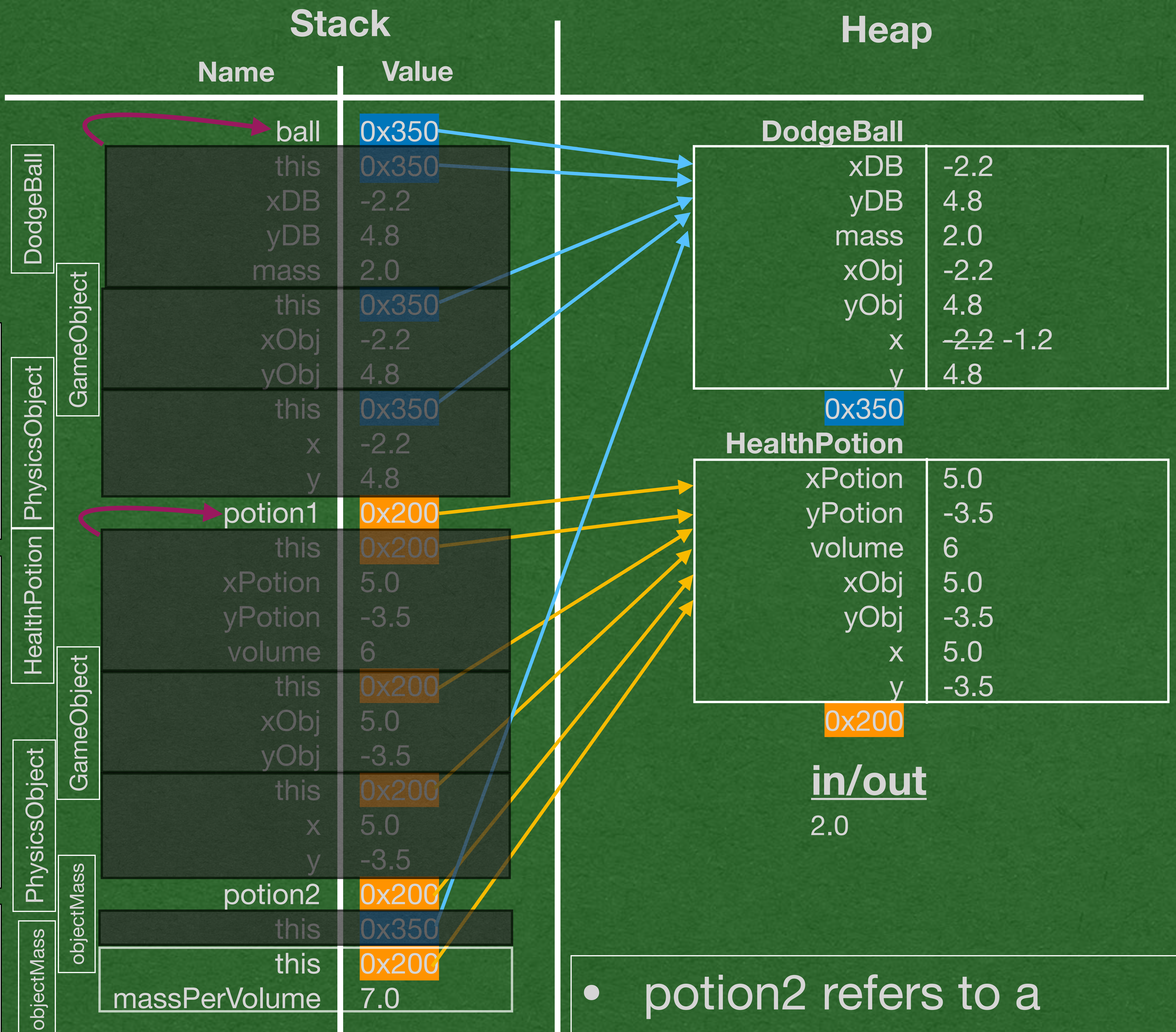
```
abstract class PhysicsObject(var x: Double, var y: Double) {}
```

```
abstract class GameObject(var xObj: Double, var yObj: Double)
  extends PhysicsObject(xObj, yObj) {
  def objectMass(): Double
  override def toString: String = {
    "("+this.x+", "+this.y+"); mass: " + this.objectMass()
  }
}
```

```
class DodgeBall(var xDB: Double, var yDB: Double, val mass:
Double) extends GameObject(xDB, yDB) {
  override def objectMass(): Double = {
    this.mass
  }
}
```

```
class HealthPotion(var xPotion: Double, var yPotion: Double,
                   val volume: Int)
  extends GameObject(xPotion, yPotion) {
  override def objectMass(): Double = {
    val massPerVolume: Double = 7.0
    this.volume * massPerVolume
  }
  override def toString: String = {
    "(" + this.x + ", " + this.y + "); volume: " + this.volume
  }
}
```

```
def main(args: Array[String]): Unit = {
  val ball: DodgeBall = new DodgeBall(-2.2, 4.8, 2)
  val potion1: HealthPotion = new HealthPotion(5.0, -3.5, 6)
  val potion2: HealthPotion = potion1
  ball.x += 1.0
  println(ball.objectMass())
  println(potion2.objectMass())
  println(ball.toString())
  println(potion1)
}
```



Stack

Name	Value
ball	0x350
this	0x350
xDB	-2.2
yDB	4.8
mass	2.0
this	0x350
xObj	-2.2
yObj	4.8
this	0x350
x	-2.2
y	4.8
potion1	0x200
this	0x200
xPotion	5.0
yPotion	-3.5
volume	6
this	0x200
xObj	5.0
yObj	-3.5
this	0x200
x	5.0
y	-3.5
potion2	0x200
this	0x350
this	0x200
massPerVolume	7.0

Heap

DodgeBall

xDB	-2.2
yDB	4.8
mass	2.0
xObj	-2.2
yObj	4.8
x	~~-2.2~~ -1.2
y	4.8

0x350

HealthPotion

xPotion	5.0
yPotion	-3.5
volume	6
xObj	5.0
yObj	-3.5
x	5.0
y	-3.5

0x200

in/out

2.0

- potion2 refers to a HealthPotion
- Use the HealthPotion objectMass method

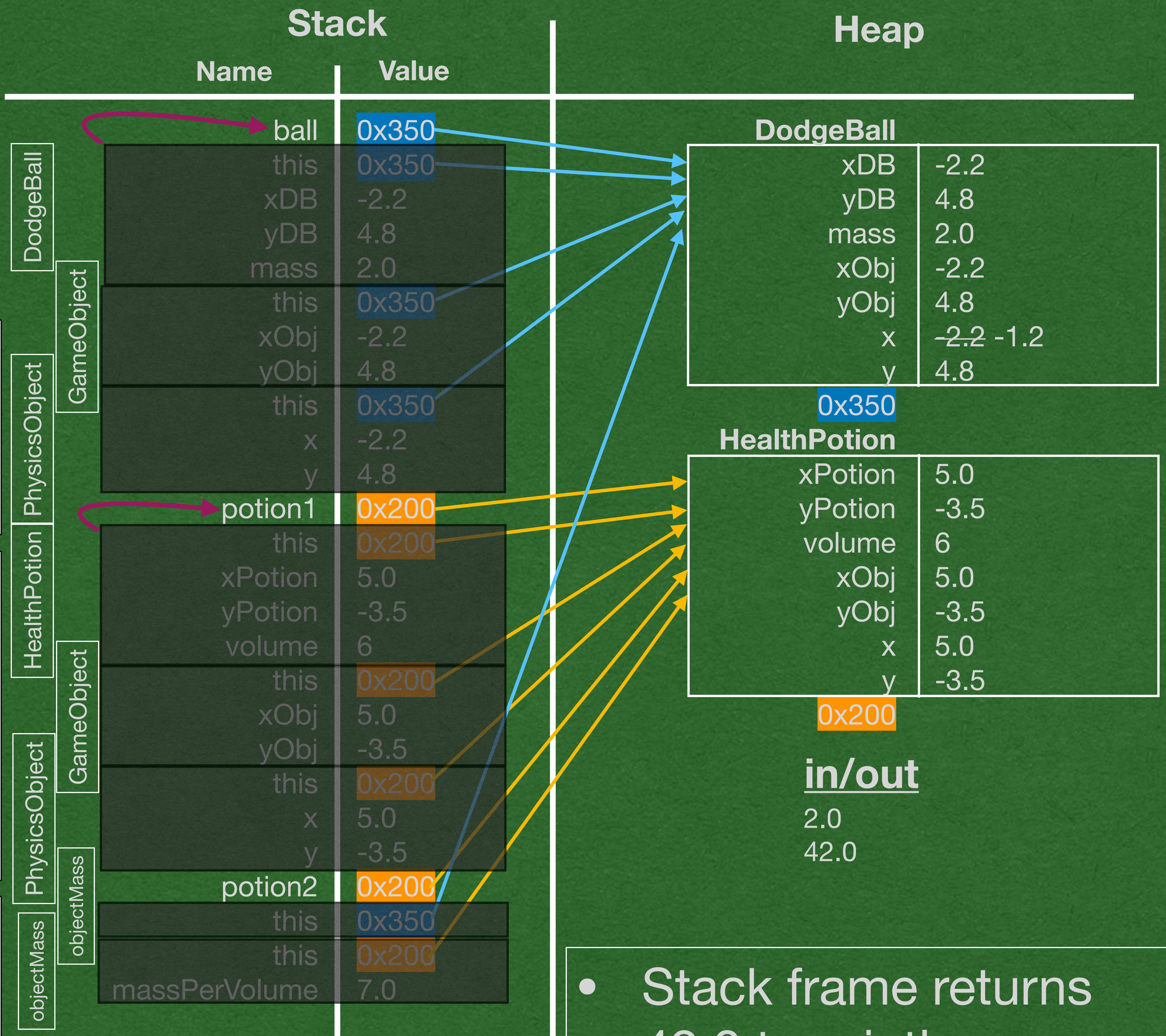
```
abstract class PhysicsObject(var x: Double, var y: Double) {}
```

```
abstract class GameObject(var xObj: Double, var yObj: Double)
  extends PhysicsObject(xObj, yObj) {
  def objectMass(): Double
  override def toString: String = {
    "("+this.x+", "+this.y+"); mass: " + this.objectMass()
  }
}
```

```
class DodgeBall(var xDB: Double, var yDB: Double, val mass:
Double) extends GameObject(xDB, yDB) {
  override def objectMass(): Double = {
    this.mass
  }
}
```

```
class HealthPotion(var xPotion: Double, var yPotion: Double,
                   val volume: Int)
  extends GameObject(xPotion, yPotion) {
  override def objectMass(): Double = {
    val massPerVolume: Double = 7.0
    this.volume * massPerVolume
  }
  override def toString: String = {
    "(" + this.x + ", " + this.y + "); volume: " + this.volume
  }
}
```

```
def main(args: Array[String]): Unit = {
  val ball: DodgeBall = new DodgeBall(-2.2, 4.8, 2)
  val potion1: HealthPotion = new HealthPotion(5.0, -3.5, 6)
  val potion2: HealthPotion = potion1
  ball.x += 1.0
  println(ball.objectMass())
  println(potion2.objectMass())
  println(ball.toString())
  println(potion1)
}
```



Stack

	Name	Value
	ball	0x350
DodgeBall	this	0x350
	xDB	-2.2
	yDB	4.8
	mass	2.0
GameObject	this	0x350
	xObj	-2.2
	yObj	4.8
PhysicsObject	this	0x350
	x	-2.2
	y	4.8
	potion1	0x200
HealthPotion	this	0x200
	xPotion	5.0
	yPotion	-3.5
	volume	6
GameObject	this	0x200
	xObj	5.0
	yObj	-3.5
PhysicsObject	this	0x200
	x	5.0
	y	-3.5
	potion2	0x200
objectMass	this	0x350
objectMass	this	0x200
	massPerVolume	7.0

Heap

DodgeBall

xDB	-2.2
yDB	4.8
mass	2.0
xObj	-2.2
yObj	4.8
x	~~-2.2~~ -1.2
y	4.8

0x350

HealthPotion

xPotion	5.0
yPotion	-3.5
volume	6
xObj	5.0
yObj	-3.5
x	5.0
y	-3.5

0x200

in/out

2.0
42.0

- Stack frame returns 42.0 to println
- Print 42.0 to the screen

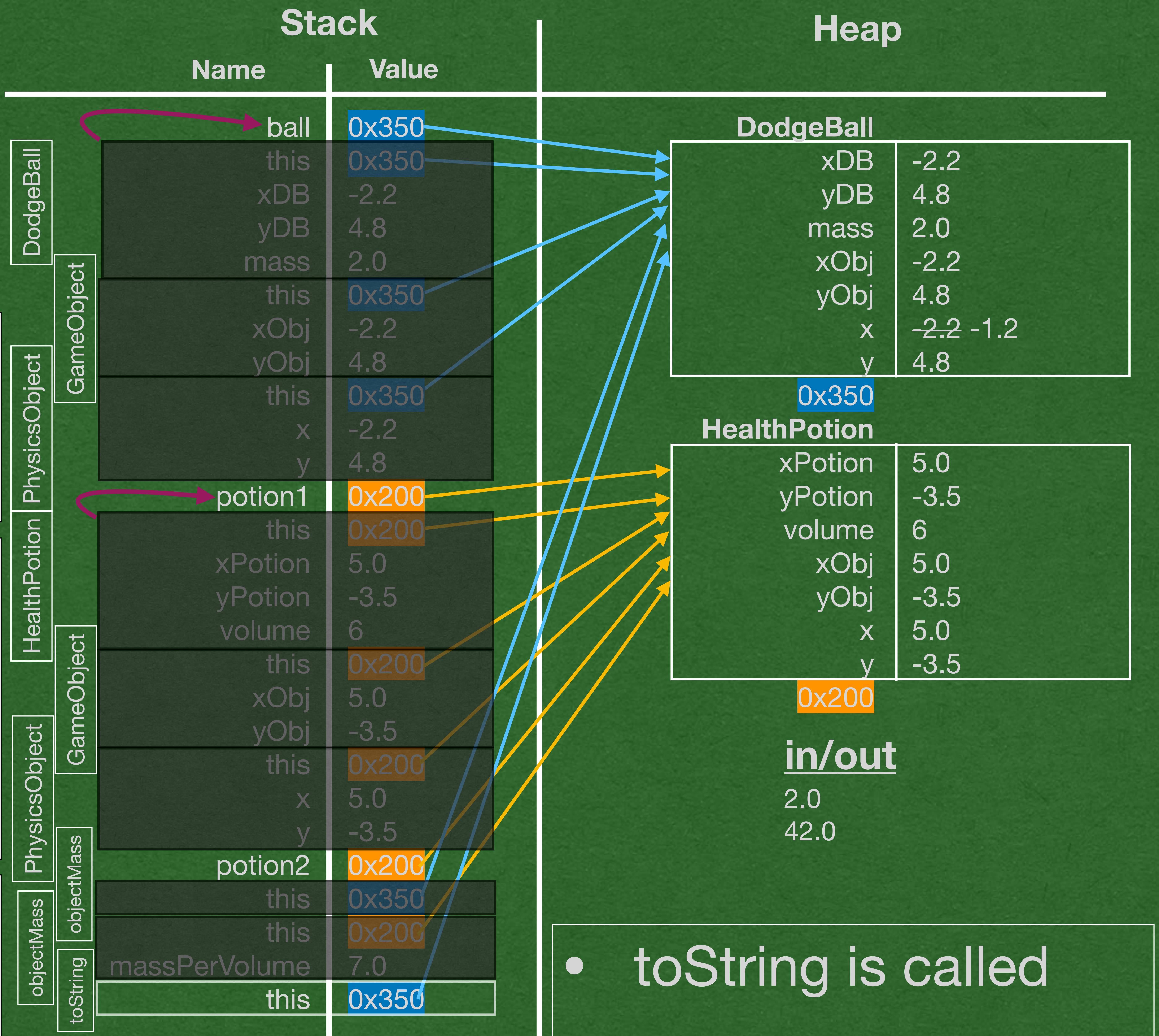
```
abstract class PhysicsObject(var x: Double, var y: Double) {}
```

```
abstract class GameObject(var xObj: Double, var yObj: Double)
  extends PhysicsObject(xObj, yObj) {
  def objectMass(): Double
  override def toString: String = {
    "("+this.x+", "+this.y+"); mass: " + this.objectMass()
  }
}
```

```
class DodgeBall(var xDB: Double, var yDB: Double, val mass:
Double) extends GameObject(xDB, yDB) {
  override def objectMass(): Double = {
    this.mass
  }
}
```

```
class HealthPotion(var xPotion: Double, var yPotion: Double,
                   val volume: Int)
  extends GameObject(xPotion, yPotion) {
  override def objectMass(): Double = {
    val massPerVolume: Double = 7.0
    this.volume * massPerVolume
  }
  override def toString: String = {
    "(" + this.x + ", " + this.y + "); volume: " + this.volume
  }
}
```

```
def main(args: Array[String]): Unit = {
  val ball: DodgeBall = new DodgeBall(-2.2, 4.8, 2)
  val potion1: HealthPotion = new HealthPotion(5.0, -3.5, 6)
  val potion2: HealthPotion = potion1
  ball.x += 1.0
  println(ball.objectMass())
  println(potion2.objectMass())
  println(ball.toString())
  println(potion1)
}
```



Stack

Frame	Name	Value
	ball	0x350
DodgeBall	this	0x350
	xDB	-2.2
	yDB	4.8
	mass	2.0
GameObject	this	0x350
	xObj	-2.2
	yObj	4.8
PhysicsObject	this	0x350
	x	-2.2
	y	4.8
	potion1	0x200
HealthPotion	this	0x200
	xPotion	5.0
	yPotion	-3.5
	volume	6
GameObject	this	0x200
	xObj	5.0
	yObj	-3.5
PhysicsObject	this	0x200
	x	5.0
	y	-3.5
	potion2	0x200
objectMass	this	0x350
objectMass	this	0x200
	massPerVolume	7.0
toString	this	0x350

Heap

DodgeBall

xDB	-2.2
yDB	4.8
mass	2.0
xObj	-2.2
yObj	4.8
x	~~-2.2~~ -1.2
y	4.8

0x350

HealthPotion

xPotion	5.0
yPotion	-3.5
volume	6
xObj	5.0
yObj	-3.5
x	5.0
y	-3.5

0x200

in/out

2.0
42.0

- toString is called
- Which definition of the method is used?

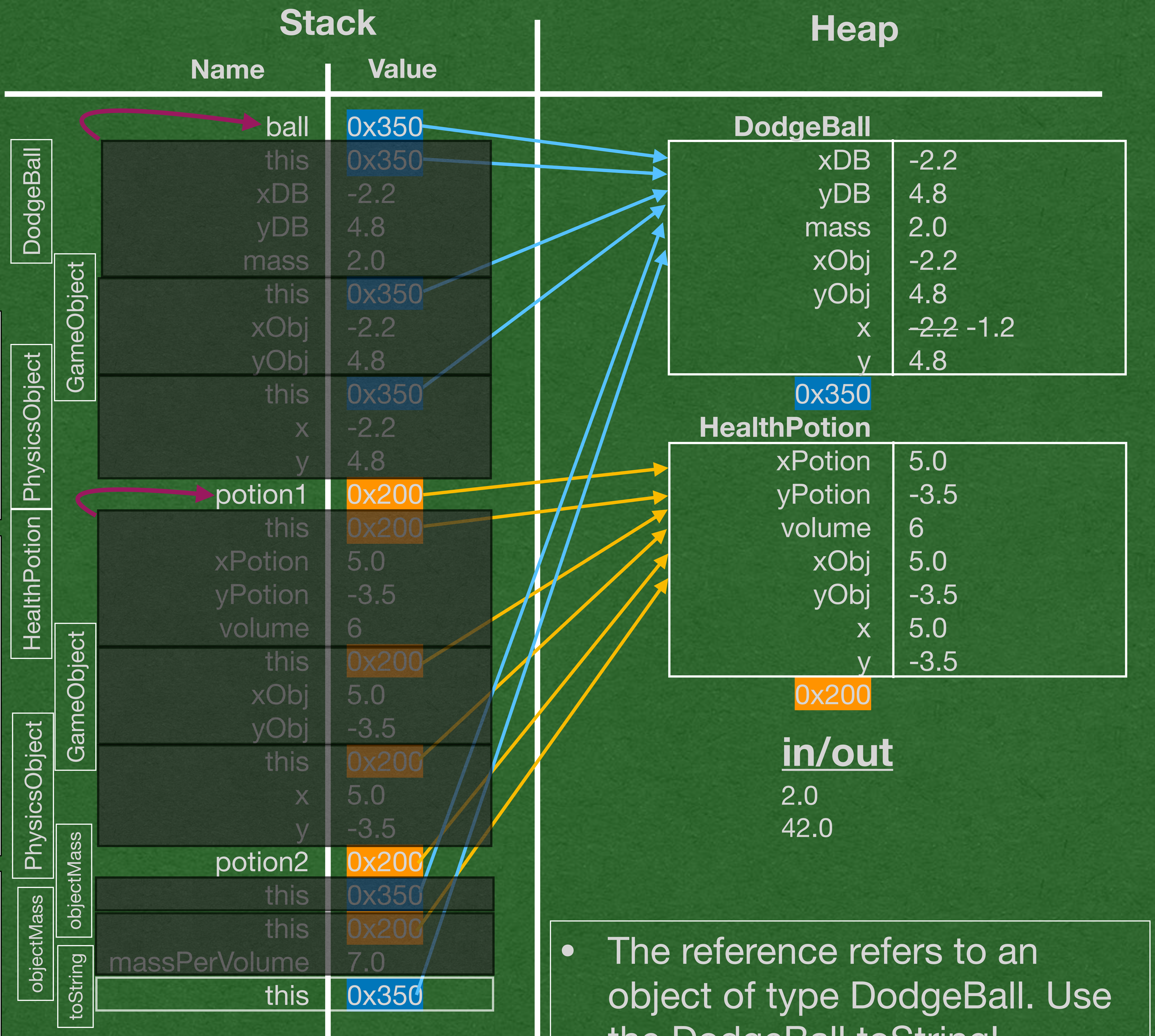
```
abstract class PhysicsObject(var x: Double, var y: Double) {}
```

```
abstract class GameObject(var xObj: Double, var yObj: Double)
  extends PhysicsObject(xObj, yObj) {
  def objectMass(): Double
  override def toString: String = {
    "("+this.x+", "+this.y+"); mass: " + this.objectMass()
  }
}
```

```
class DodgeBall(var xDB: Double, var yDB: Double, val mass:
Double) extends GameObject(xDB, yDB) {
  override def objectMass(): Double = {
    this.mass
  }
}
```

```
class HealthPotion(var xPotion: Double, var yPotion: Double,
                   val volume: Int)
  extends GameObject(xPotion, yPotion) {
  override def objectMass(): Double = {
    val massPerVolume: Double = 7.0
    this.volume * massPerVolume
  }
  override def toString: String = {
    "(" + this.x + ", " + this.y + "); volume: " + this.volume
  }
}
```

```
def main(args: Array[String]): Unit = {
  val ball: DodgeBall = new DodgeBall(-2.2, 4.8, 2)
  val potion1: HealthPotion = new HealthPotion(5.0, -3.5, 6)
  val potion2: HealthPotion = potion1
  ball.x += 1.0
  println(ball.objectMass())
  println(potion2.objectMass())
  println(ball.toString())
  println(potion1)
}
```



Stack

Name	Value
ball	0x350
this	0x350
xDB	-2.2
yDB	4.8
mass	2.0
this	0x350
xObj	-2.2
yObj	4.8
this	0x350
x	-2.2
y	4.8
potion1	0x200
this	0x200
xPotion	5.0
yPotion	-3.5
volume	6
this	0x200
xObj	5.0
yObj	-3.5
this	0x200
x	5.0
y	-3.5
potion2	0x200
this	0x350
this	0x200
massPerVolume	7.0
this	0x350

Heap

DodgeBall

xDB	-2.2
yDB	4.8
mass	2.0
xObj	-2.2
yObj	4.8
x	~~-2.2~~ -1.2
y	4.8

0x350

HealthPotion

xPotion	5.0
yPotion	-3.5
volume	6
xObj	5.0
yObj	-3.5
x	5.0
y	-3.5

0x200

in/out

```
2.0
42.0
```

- The reference refers to an object of type DodgeBall. Use the DodgeBall toString!
- Uh Oh. No method definition... 🤔

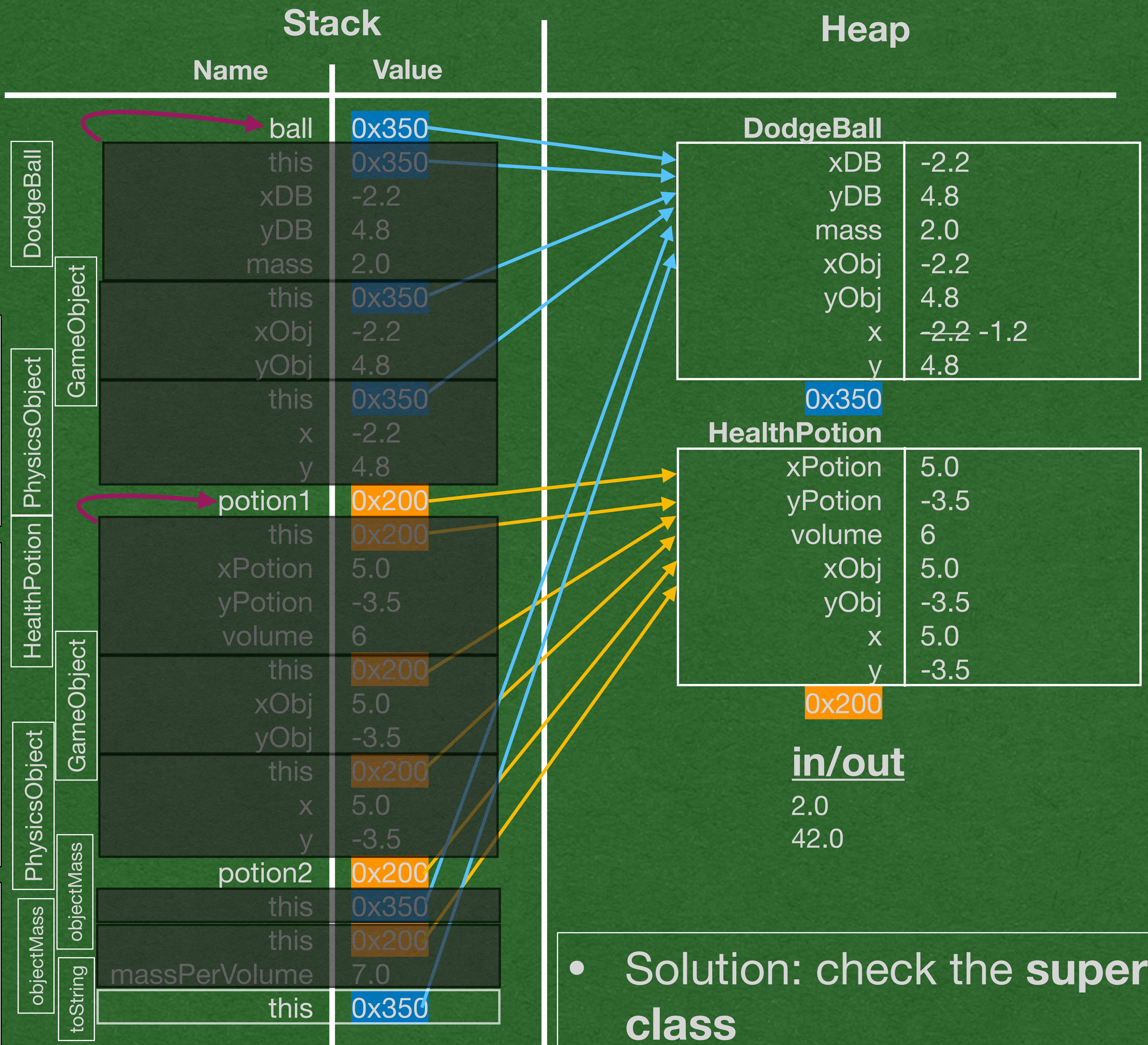
```scala
abstract class PhysicsObject(var x: Double, var y: Double) {}
```

```scala
abstract class GameObject(var xObj: Double, var yObj: Double)
  extends PhysicsObject(xObj, yObj) {
  def objectMass(): Double
  override def toString: String = {
    "("+this.x+", "+this.y+"); mass: " + this.objectMass()
  }
}
```

```scala
class DodgeBall(var xDB: Double, var yDB: Double, val mass:
Double) extends GameObject(xDB, yDB) {
  override def objectMass(): Double = {
    this.mass
  }
}
```

```scala
class HealthPotion(var xPotion: Double, var yPotion: Double,
                   val volume: Int)
  extends GameObject(xPotion, yPotion) {
  override def objectMass(): Double = {
    val massPerVolume: Double = 7.0
    this.volume * massPerVolume
  }
  override def toString: String = {
    "(" + this.x + ", " + this.y + "); volume: " + this.volume
  }
}
```

```scala
def main(args: Array[String]): Unit = {
  val ball: DodgeBall = new DodgeBall(-2.2, 4.8, 2)
  val potion1: HealthPotion = new HealthPotion(5.0, -3.5, 6)
  val potion2: HealthPotion = potion1
  ball.x += 1.0
  println(ball.objectMass())
  println(potion2.objectMass())
  println(ball.toString())
  println(potion1)
}
```



Name	Value
ball	0x350
this	0x350
xDB	-2.2
yDB	4.8
mass	2.0
this	0x350
xObj	-2.2
yObj	4.8
this	0x350
x	-2.2
y	4.8
potion1	0x200
this	0x200
xPotion	5.0
yPotion	-3.5
volume	6
this	0x200
xObj	5.0
yObj	-3.5
this	0x200
x	5.0
y	-3.5
potion2	0x200
this	0x350
this	0x200
massPerVolume	7.0
this	0x350

DodgeBall

xDB	-2.2
yDB	4.8
mass	2.0
xObj	-2.2
yObj	4.8
x	~~-2.2~~ -1.2
y	4.8

0x350

HealthPotion

xPotion	5.0
yPotion	-3.5
volume	6
xObj	5.0
yObj	-3.5
x	5.0
y	-3.5

0x200

in/out

2.0
42.0

- Solution: check the **super class**
- DodgeBall **inherited** toString from GameObject

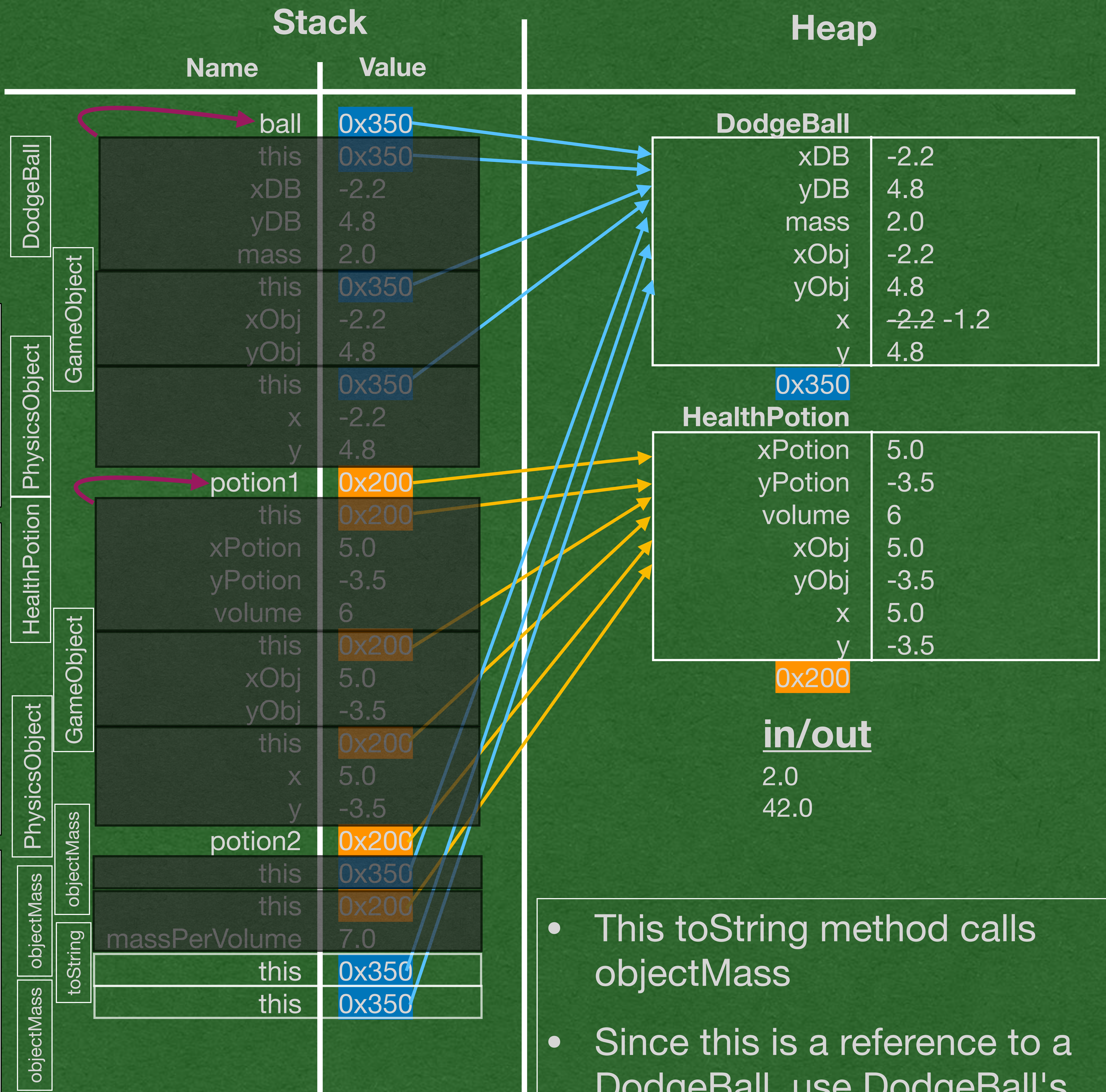
```
abstract class PhysicsObject(var x: Double, var y: Double) {}
```

```
abstract class GameObject(var xObj: Double, var yObj: Double)
  extends PhysicsObject(xObj, yObj) {
  def objectMass(): Double
  override def toString: String = {
    "("+this.x+", "+this.y+"); mass: " + this.objectMass()
  }
}
```

```
class DodgeBall(var xDB: Double, var yDB: Double, val mass:
Double) extends GameObject(xDB, yDB) {
  override def objectMass(): Double = {
    this.mass
  }
}
```

```
class HealthPotion(var xPotion: Double, var yPotion: Double,
                   val volume: Int)
  extends GameObject(xPotion, yPotion) {
  override def objectMass(): Double = {
    val massPerVolume: Double = 7.0
    this.volume * massPerVolume
  }
  override def toString: String = {
    "(" + this.x + ", " + this.y + "); volume: " + this.volume
  }
}
```

```
def main(args: Array[String]): Unit = {
  val ball: DodgeBall = new DodgeBall(-2.2, 4.8, 2)
  val potion1: HealthPotion = new HealthPotion(5.0, -3.5, 6)
  val potion2: HealthPotion = potion1
  ball.x += 1.0
  println(ball.objectMass())
  println(potion2.objectMass())
  println(ball.toString())
  println(potion1)
}
```



Stack

Name	Value
ball	0x350
this	0x350
xDB	-2.2
yDB	4.8
mass	2.0
this	0x350
xObj	-2.2
yObj	4.8
this	0x350
x	-2.2
y	4.8
potion1	0x200
this	0x200
xPotion	5.0
yPotion	-3.5
volume	6
this	0x200
xObj	5.0
yObj	-3.5
this	0x200
x	5.0
y	-3.5
potion2	0x200
this	0x350
this	0x200
massPerVolume	7.0
this	0x350
this	0x350

Heap

DodgeBall

xDB	-2.2
yDB	4.8
mass	2.0
xObj	-2.2
yObj	4.8
x	~~-2.2~~ -1.2
y	4.8

0x350

HealthPotion

xPotion	5.0
yPotion	-3.5
volume	6
xObj	5.0
yObj	-3.5
x	5.0
y	-3.5

0x200

in/out

```
2.0
42.0
```

- This toString method calls objectMass
- Since this is a reference to a DodgeBall, use DodgeBall's objectMass

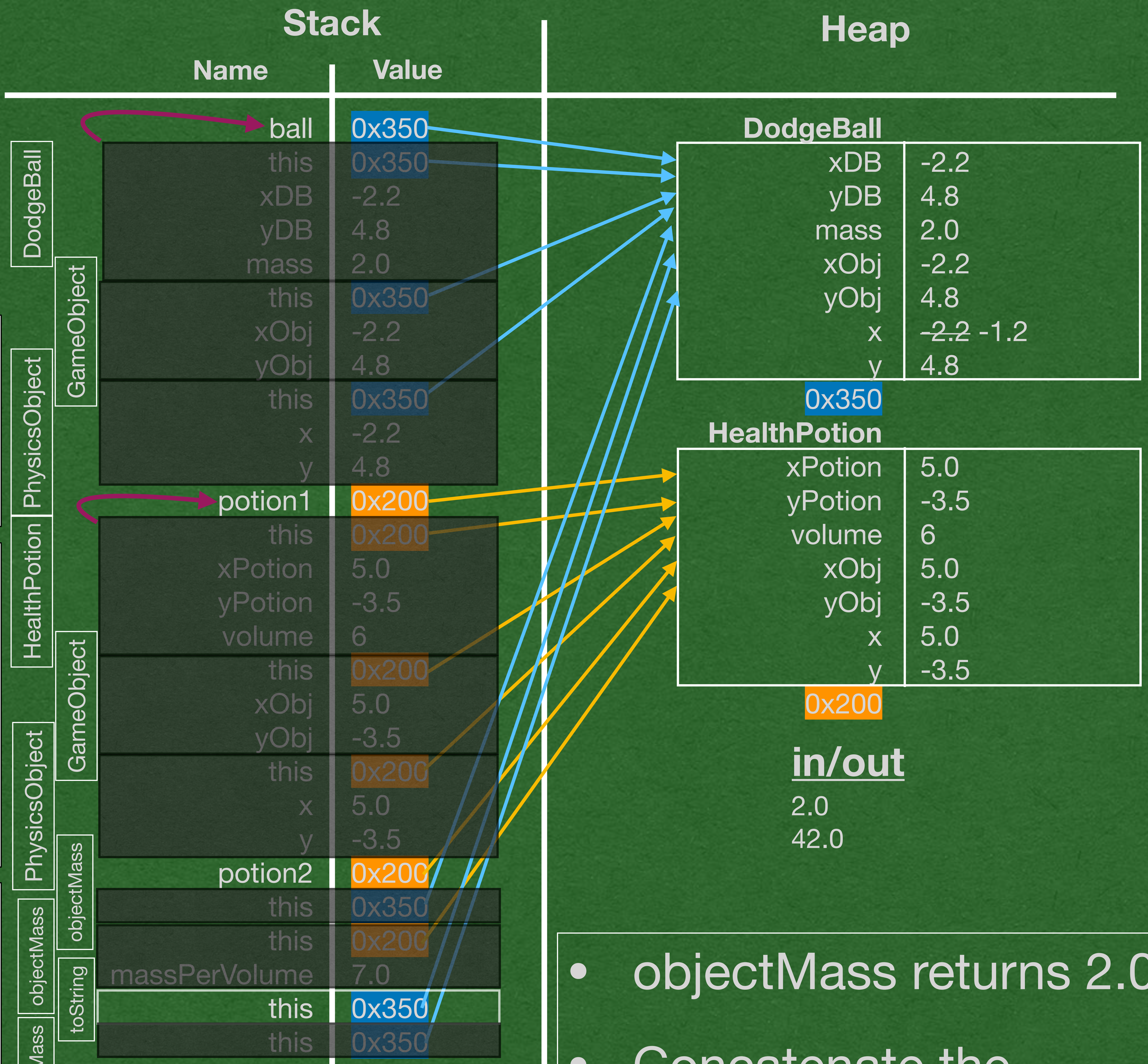
```
abstract class PhysicsObject(var x: Double, var y: Double) {}
```

```
abstract class GameObject(var xObj: Double, var yObj: Double)
  extends PhysicsObject(xObj, yObj) {
  def objectMass(): Double
  override def toString: String = {
    "("+this.x+", "+this.y+"); mass: " + this.objectMass()
  }
}
```

```
class DodgeBall(var xDB: Double, var yDB: Double, val mass:
Double) extends GameObject(xDB, yDB) {
  override def objectMass(): Double = {
    this.mass
  }
}
```

```
class HealthPotion(var xPotion: Double, var yPotion: Double,
                   val volume: Int)
  extends GameObject(xPotion, yPotion) {
  override def objectMass(): Double = {
    val massPerVolume: Double = 7.0
    this.volume * massPerVolume
  }
  override def toString: String = {
    "(" + this.x + ", " + this.y + "); volume: " + this.volume
  }
}
```

```
def main(args: Array[String]): Unit = {
  val ball: DodgeBall = new DodgeBall(-2.2, 4.8, 2)
  val potion1: HealthPotion = new HealthPotion(5.0, -3.5, 6)
  val potion2: HealthPotion = potion1
  ball.x += 1.0
  println(ball.objectMass())
  println(potion2.objectMass())
  println(ball.toString())
  println(potion1)
}
```



Name	Value
ball	0x350
this	0x350
xDB	-2.2
yDB	4.8
mass	2.0
this	0x350
xObj	-2.2
yObj	4.8
this	0x350
x	-2.2
y	4.8
potion1	0x200
this	0x200
xPotion	5.0
yPotion	-3.5
volume	6
this	0x200
xObj	5.0
yObj	-3.5
this	0x200
x	5.0
y	-3.5
potion2	0x200
this	0x350
this	0x200
massPerVolume	7.0
this	0x350
this	0x350

DodgeBall

xDB	-2.2
yDB	4.8
mass	2.0
xObj	-2.2
yObj	4.8
x	~~-2.2~~ -1.2
y	4.8

0x350

HealthPotion

xPotion	5.0
yPotion	-3.5
volume	6
xObj	5.0
yObj	-3.5
x	5.0
y	-3.5

0x200

in/out

2.0
42.0

- objectMass returns 2.0
- Concatenate the Strings and return

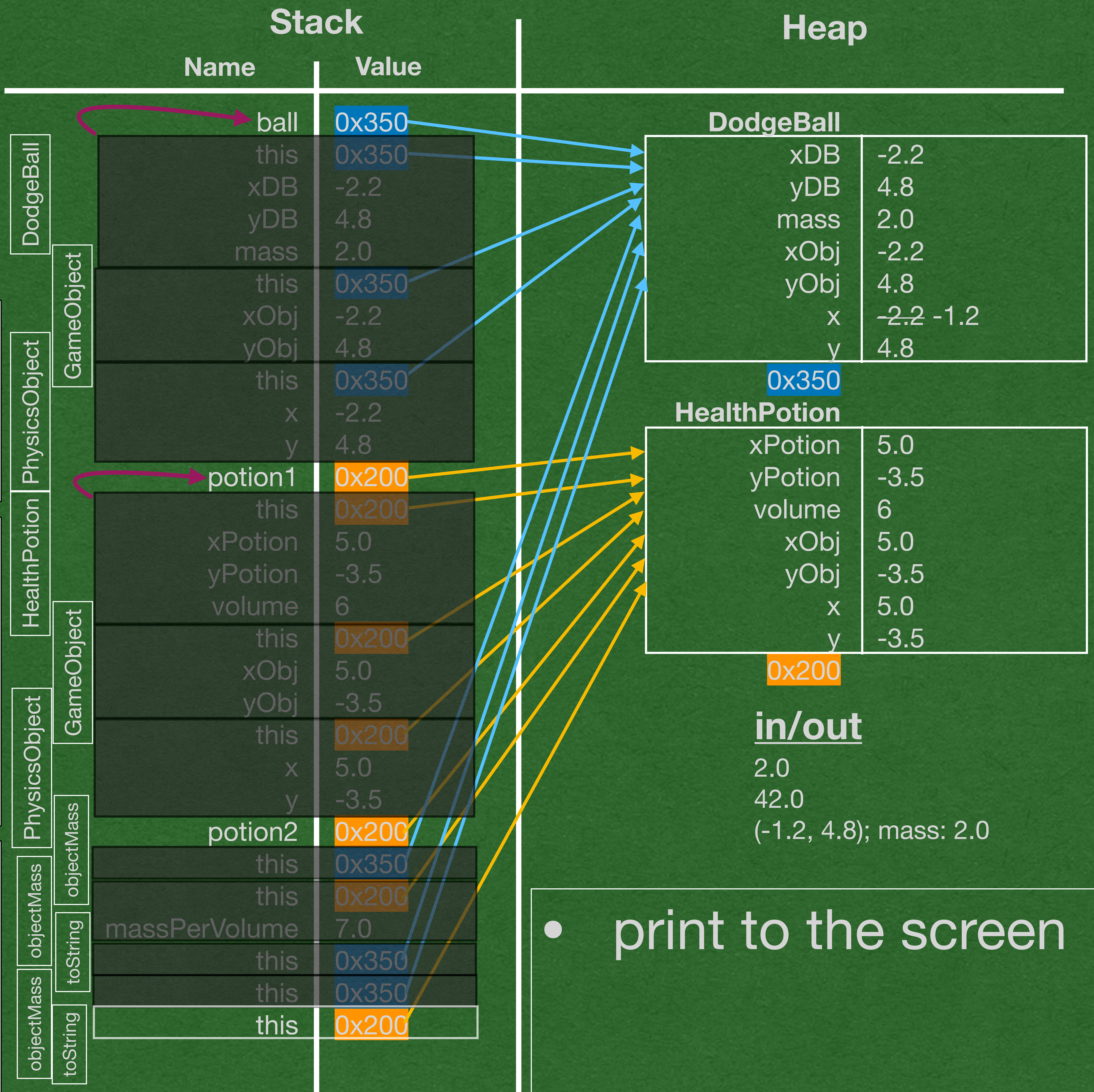
```
abstract class PhysicsObject(var x: Double, var y: Double) {}
```

```
abstract class GameObject(var xObj: Double, var yObj: Double)
  extends PhysicsObject(xObj, yObj) {
  def objectMass(): Double
  override def toString: String = {
    "("+this.x+", "+this.y+"); mass: " + this.objectMass()
  }
}
```

```
class DodgeBall(var xDB: Double, var yDB: Double, val mass:
Double) extends GameObject(xDB, yDB) {
  override def objectMass(): Double = {
    this.mass
  }
}
```

```
class HealthPotion(var xPotion: Double, var yPotion: Double,
                   val volume: Int)
  extends GameObject(xPotion, yPotion) {
  override def objectMass(): Double = {
    val massPerVolume: Double = 7.0
    this.volume * massPerVolume
  }
  override def toString: String = {
    "(" + this.x + ", " + this.y + "); volume: " + this.volume
  }
}
```

```
def main(args: Array[String]): Unit = {
  val ball: DodgeBall = new DodgeBall(-2.2, 4.8, 2)
  val potion1: HealthPotion = new HealthPotion(5.0, -3.5, 6)
  val potion2: HealthPotion = potion1
  ball.x += 1.0
  println(ball.objectMass())
  println(potion2.objectMass())
  println(ball.toString())
  println(potion1)
}
```



Stack

Name	Value
ball	0x350
this	0x350
xDB	-2.2
yDB	4.8
mass	2.0
this	0x350
xObj	-2.2
yObj	4.8
this	0x350
x	-2.2
y	4.8
potion1	0x200
this	0x200
xPotion	5.0
yPotion	-3.5
volume	6
this	0x200
xObj	5.0
yObj	-3.5
this	0x200
x	5.0
y	-3.5
potion2	0x200
this	0x350
this	0x200
massPerVolume	7.0
this	0x350
this	0x350
this	0x200

Heap

DodgeBall

xDB	-2.2
yDB	4.8
mass	2.0
xObj	-2.2
yObj	4.8
x	~~-2.2~~ -1.2
y	4.8

0x350

HealthPotion

xPotion	5.0
yPotion	-3.5
volume	6
xObj	5.0
yObj	-3.5
x	5.0
y	-3.5

0x200

in/out

```
2.0
42.0
(-1.2, 4.8); mass: 2.0
```

- print to the screen

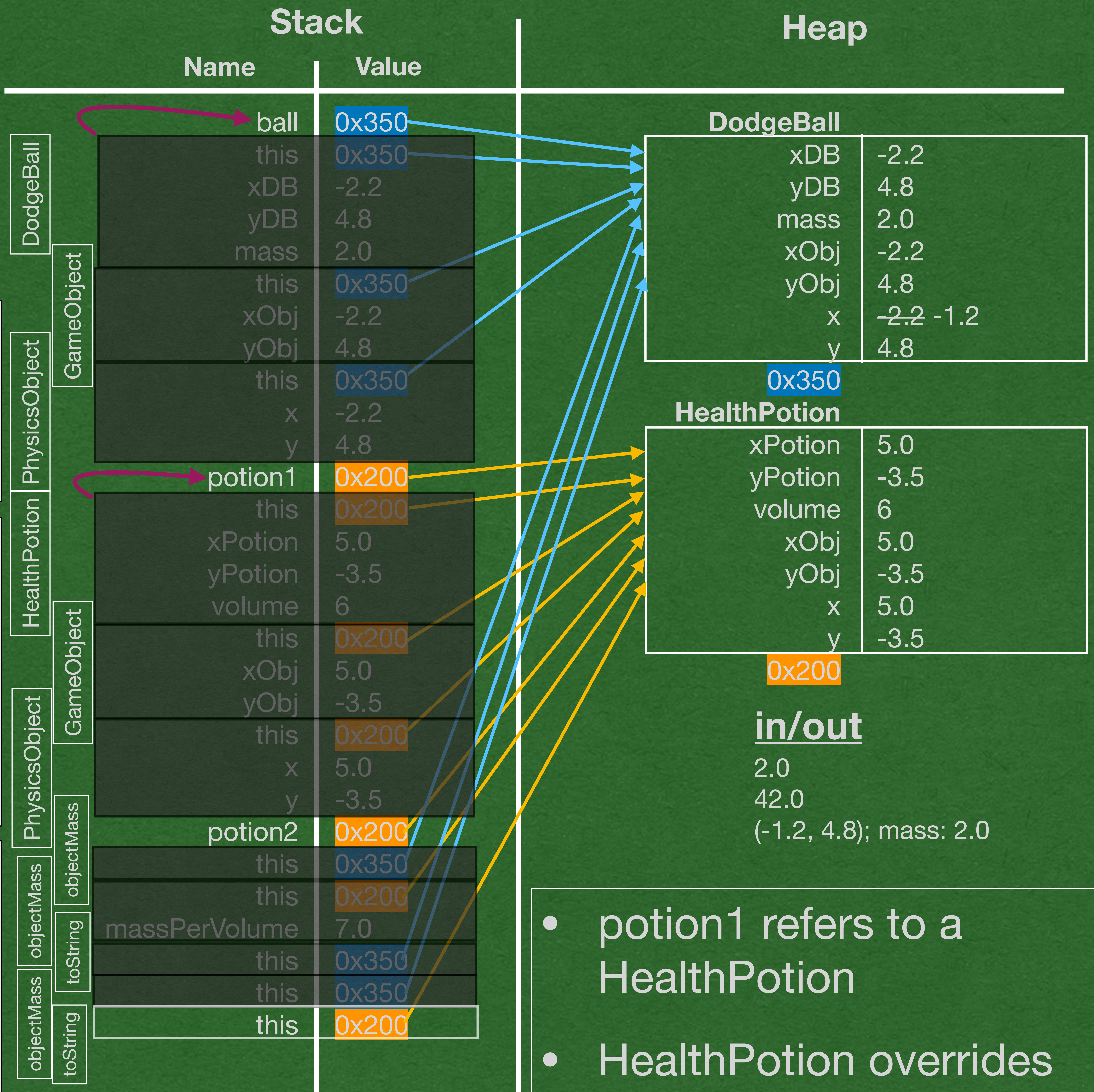
```
abstract class PhysicsObject(var x: Double, var y: Double) {}
```

```
abstract class GameObject(var xObj: Double, var yObj: Double)
  extends PhysicsObject(xObj, yObj) {
  def objectMass(): Double
  override def toString: String = {
    "("+this.x+", "+this.y+"); mass: " + this.objectMass()
  }
}
```

```
class DodgeBall(var xDB: Double, var yDB: Double, val mass:
Double) extends GameObject(xDB, yDB) {
  override def objectMass(): Double = {
    this.mass
  }
}
```

```
class HealthPotion(var xPotion: Double, var yPotion: Double,
                   val volume: Int)
  extends GameObject(xPotion, yPotion) {
  override def objectMass(): Double = {
    val massPerVolume: Double = 7.0
    this.volume * massPerVolume
  }
  override def toString: String = {
    "(" + this.x + ", " + this.y + "); volume: " + this.volume
  }
}
```

```
def main(args: Array[String]): Unit = {
  val ball: DodgeBall = new DodgeBall(-2.2, 4.8, 2)
  val potion1: HealthPotion = new HealthPotion(5.0, -3.5, 6)
  val potion2: HealthPotion = potion1
  ball.x += 1.0
  println(ball.objectMass())
  println(potion2.objectMass())
  println(ball.toString())
  println(potion1)
}
```



Stack

Name	Value
ball	0x350
this	0x350
xDB	-2.2
yDB	4.8
mass	2.0
this	0x350
xObj	-2.2
yObj	4.8
this	0x350
x	-2.2
y	4.8
potion1	0x200
this	0x200
xPotion	5.0
yPotion	-3.5
volume	6
this	0x200
xObj	5.0
yObj	-3.5
this	0x200
x	5.0
y	-3.5
potion2	0x200
this	0x350
this	0x200
massPerVolume	7.0
this	0x350
this	0x350
this	0x200

Heap

DodgeBall

xDB	-2.2
yDB	4.8
mass	2.0
xObj	-2.2
yObj	4.8
x	~~-2.2~~ -1.2
y	4.8

0x350

HealthPotion

xPotion	5.0
yPotion	-3.5
volume	6
xObj	5.0
yObj	-3.5
x	5.0
y	-3.5

0x200

in/out

2.0
42.0
(-1.2, 4.8); mass: 2.0

- potion1 refers to a HealthPotion
- HealthPotion overrides the GameObject toString

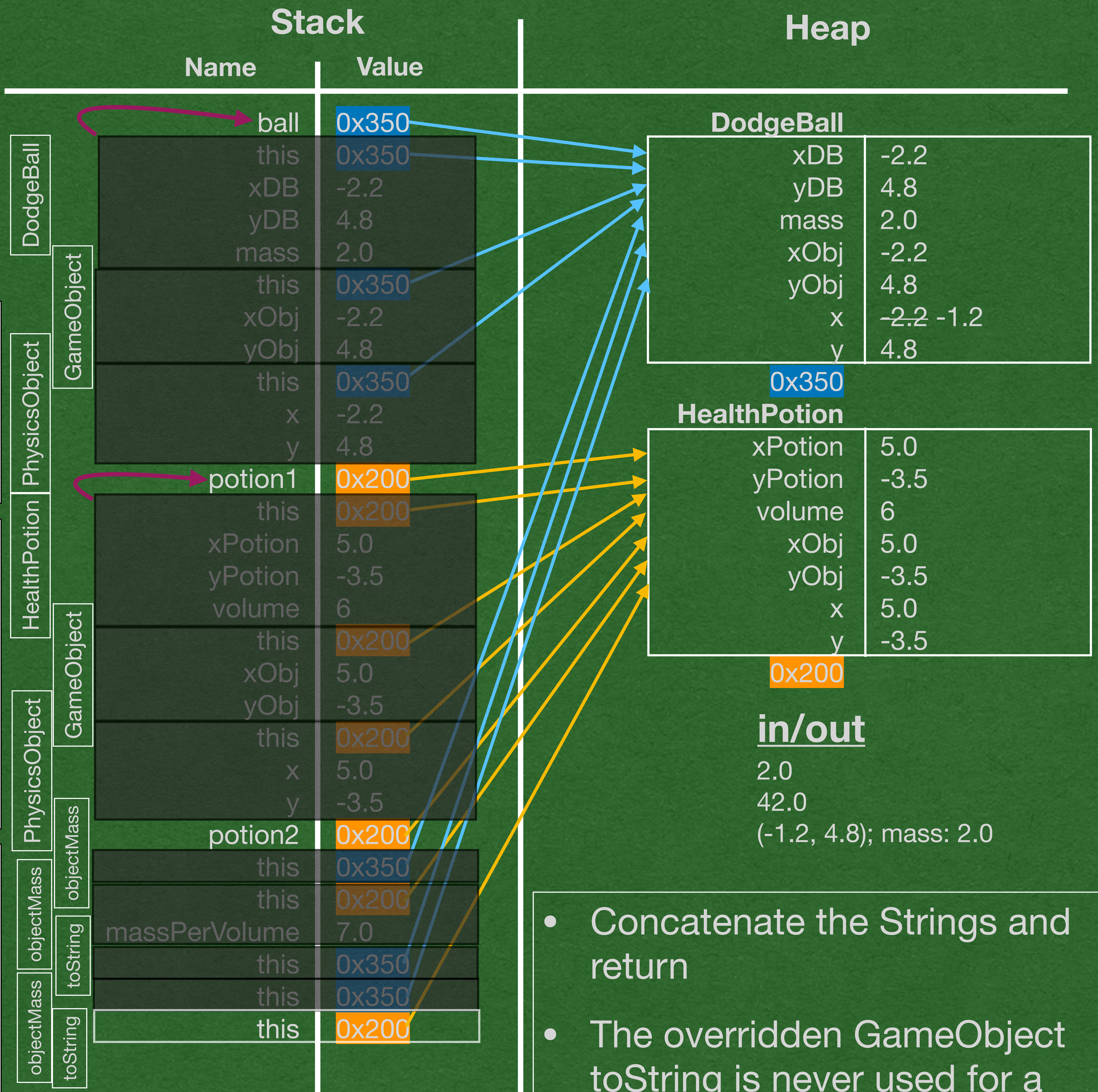
```
abstract class PhysicsObject(var x: Double, var y: Double) {}
```

```
abstract class GameObject(var xObj: Double, var yObj: Double)
  extends PhysicsObject(xObj, yObj) {
  def objectMass(): Double
  override def toString: String = {
    "("+this.x+", "+this.y+"); mass: " + this.objectMass()
  }
}
```

```
class DodgeBall(var xDB: Double, var yDB: Double, val mass:
Double) extends GameObject(xDB, yDB) {
  override def objectMass(): Double = {
    this.mass
  }
}
```

```
class HealthPotion(var xPotion: Double, var yPotion: Double,
                   val volume: Int)
  extends GameObject(xPotion, yPotion) {
  override def objectMass(): Double = {
    val massPerVolume: Double = 7.0
    this.volume * massPerVolume
  }
  override def toString: String = {
    "(" + this.x + ", " + this.y + "); volume: " + this.volume
  }
}
```

```
def main(args: Array[String]): Unit = {
  val ball: DodgeBall = new DodgeBall(-2.2, 4.8, 2)
  val potion1: HealthPotion = new HealthPotion(5.0, -3.5, 6)
  val potion2: HealthPotion = potion1
  ball.x += 1.0
  println(ball.objectMass())
  println(potion2.objectMass())
  println(ball.toString())
  println(potion1)
}
```



Stack

Name	Value
ball	0x350
this	0x350
xDB	-2.2
yDB	4.8
mass	2.0
this	0x350
xObj	-2.2
yObj	4.8
this	0x350
x	-2.2
y	4.8
potion1	0x200
this	0x200
xPotion	5.0
yPotion	-3.5
volume	6
this	0x200
xObj	5.0
yObj	-3.5
this	0x200
x	5.0
y	-3.5
potion2	0x200
this	0x350
this	0x200
massPerVolume	7.0
this	0x350
this	0x350
this	0x200

Heap

DodgeBall

xDB	-2.2
yDB	4.8
mass	2.0
xObj	-2.2
yObj	4.8
x	~~-2.2~~ -1.2
y	4.8

0x350

HealthPotion

xPotion	5.0
yPotion	-3.5
volume	6
xObj	5.0
yObj	-3.5
x	5.0
y	-3.5

0x200

in/out

2.0
42.0
(-1.2, 4.8); mass: 2.0

- Concatenate the Strings and return
- The overridden GameObject toString is never used for a HealthPotion

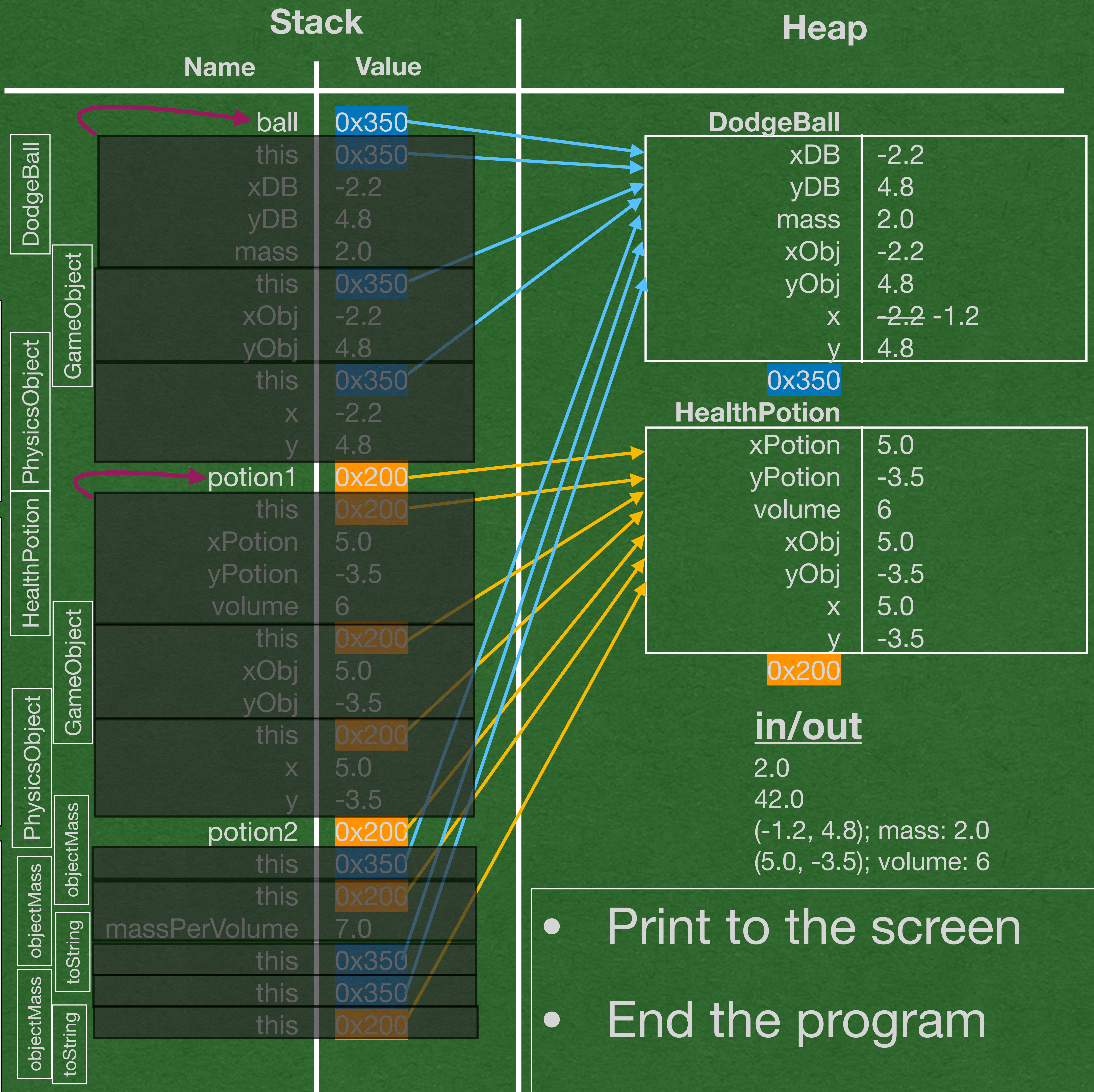
```
abstract class PhysicsObject(var x: Double, var y: Double) {}
```

```
abstract class GameObject(var xObj: Double, var yObj: Double)
  extends PhysicsObject(xObj, yObj) {
  def objectMass(): Double
  override def toString: String = {
    "("+this.x+", "+this.y+"); mass: " + this.objectMass()
  }
}
```

```
class DodgeBall(var xDB: Double, var yDB: Double, val mass:
Double) extends GameObject(xDB, yDB) {
  override def objectMass(): Double = {
    this.mass
  }
}
```

```
class HealthPotion(var xPotion: Double, var yPotion: Double,
                   val volume: Int)
  extends GameObject(xPotion, yPotion) {
  override def objectMass(): Double = {
    val massPerVolume: Double = 7.0
    this.volume * massPerVolume
  }
  override def toString: String = {
    "(" + this.x + ", " + this.y + "); volume: " + this.volume
  }
}
```

```
def main(args: Array[String]): Unit = {
  val ball: DodgeBall = new DodgeBall(-2.2, 4.8, 2)
  val potion1: HealthPotion = new HealthPotion(5.0, -3.5, 6)
  val potion2: HealthPotion = potion1
  ball.x += 1.0
  println(ball.objectMass())
  println(potion2.objectMass())
  println(ball.toString())
  println(potion1)
}
```



Stack

Name	Value
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xDB	-2.2
yDB	4.8
mass	2.0
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xObj	-2.2
yObj	4.8
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potion1	0x200
this	0x200
xPotion	5.0
yPotion	-3.5
volume	6
this	0x200
xObj	5.0
yObj	-3.5
this	0x200
x	5.0
y	-3.5
potion2	0x200
this	0x350
this	0x200
massPerVolume	7.0
this	0x350
this	0x350
this	0x200

Heap

DodgeBall

xDB	-2.2
yDB	4.8
mass	2.0
xObj	-2.2
yObj	4.8
x	~~-2.2~~ -1.2
y	4.8

0x350

HealthPotion

xPotion	5.0
yPotion	-3.5
volume	6
xObj	5.0
yObj	-3.5
x	5.0
y	-3.5

0x200

in/out

```
2.0
42.0
(-1.2, 4.8); mass: 2.0
(5.0, -3.5); volume: 6
```

- Print to the screen
- End the program
- End the lecture