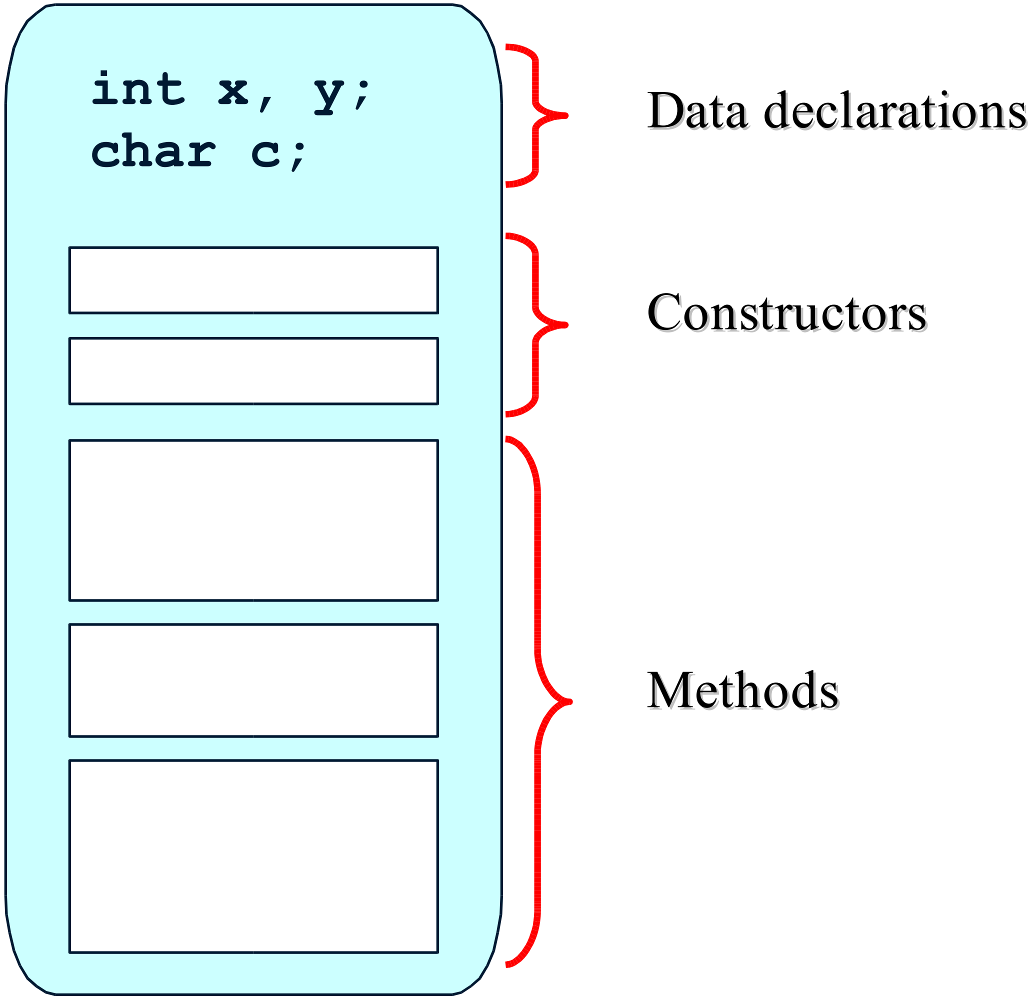
Object-Oriented Programming, Part 1

- Classes
- Methods
  - Argument and return value
  - Overloading
- Object Creation and Destruction
- Equality

Classes in Java

- A class encapsulates a set of properties
  - Some properties are hidden
  - The remaining properties are the interface of the class

```
class ClassName {
    dataDeclaration
    constructors
    methods
}
```



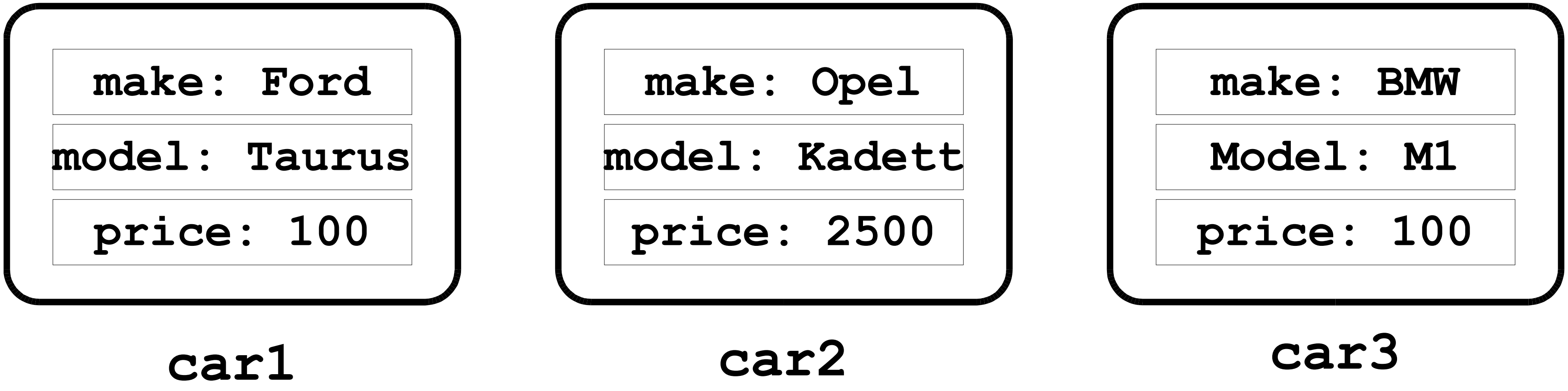
Example of a Class

```
public class Coin { // [Source Lewis and Loftus]
   public static final int HEADS = 0;
   public static final int TAILS = 1;
   private int face;
   public Coin ()   {        // constructor
      flip();
   }
   public void flip (){      // method “procedure”
      face = (int) (Math.random() * 2);
   }
   public int getFace (){    // method “function”
      return face;
   }
   public String toString(){ // method “function”
      String faceName;
      if (face == HEADS)
         faceName = "Heads";
      else
         faceName = "Tails";
      return faceName;
   }
}
```

Instance Variables

- An *instance variable* is a data declaration in a class. Every object instantiated from the class has its own version of the instance variables.

```
class Car {
   private String make;
   private String model;
   private double price;
}
```



make: Ford
model: Taurus
price: 100

car1

make: Opel
model: Kadett
price: 2500

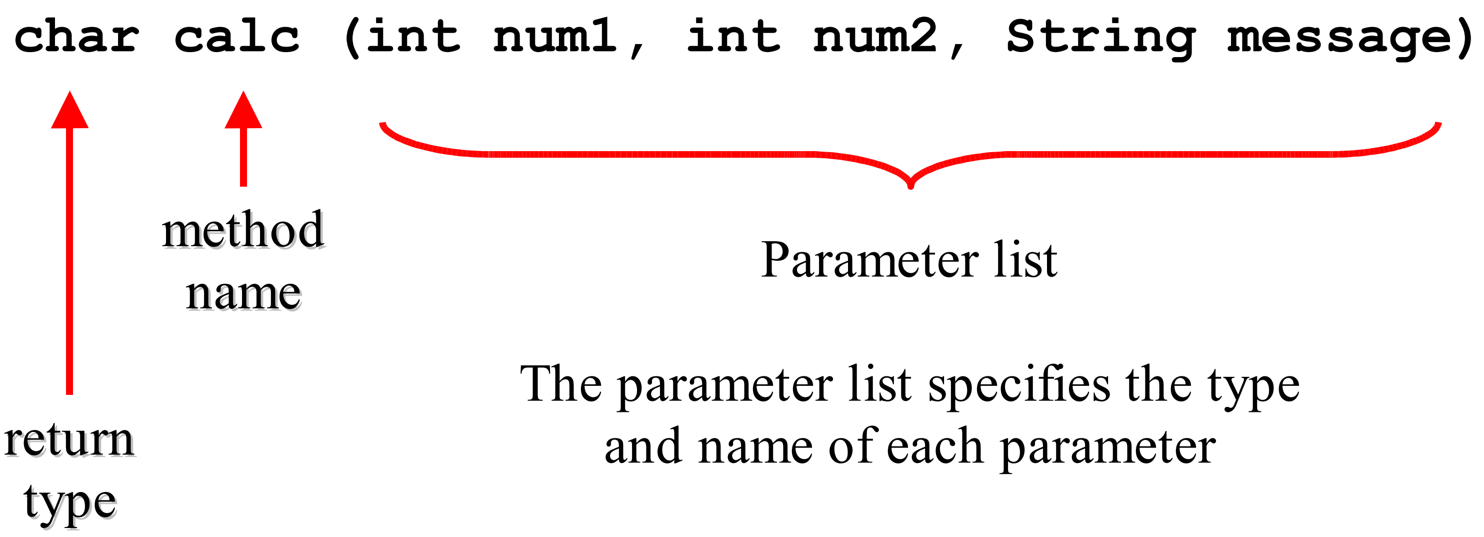
car2

make: BMW
Model: M1
price: 100

car3

Methods in Java

- A *method* is a function or procedure that reads and/or modifies the state of the class.
  - A function returns a value (a procedure does not).
  - A procedure has side-effects, e.g., change the state of an object.



```
char calc (int num1, int num2, String message)
```

return type

method name

Parameter list

The parameter list specifies the type and name of each parameter

The name of a parameter in the method declaration is called a *formal argument*

Methods in Java, cont.

- All methods have a return type
  - **`void`** for procedures
  - A primitive data type or a class for functions
- The return value
  - Return stop the execution of a method and jumps out
  - Return can be specified with or without an expression
- Parameter are pass-by-value
  - Class parameter are passed as a reference

```
public double getPrice() {
   return price;
}
public void increaseCounter() {
   counter = counter + 1;
   //return;
}
```

```
public double getError() {
   double a = 0;
   a++;
   // compile-error
}
```

Method in Java, Example

```
public class Car{
   // snip
   /** Calculates the sales price of the car */
    public int salesPrice(){
        return (int)price;
    }
    /** Calculates the sales price of the car */
    public int salesPrice(int overhead){
        return (int)price + overhead;
    }
    /** Calculates the sales price of the car */
    public double salesPrice(double overheadPercent){
        return price + (overheadPercent * price);
    }

    /** Overwrites the toString method */
    public String toString(){
        return "make " + getMake() + " model "
               + getModel() + " price " + getPrice();
    }
}
```

Method in Java, Example, cont

- What is wrong here?

```java
public class Car{
   // snip
   /** Calculates the integer sales price of the car */
    public int salesPrice(){
        return (int)price;
    }
    /** Calculates the double sales price of the car */
    public double salesPrice(){
        return (double)price;
    }

   public static void main(String[] args){
      Car vw = new Car(“VW”, “Golf”, 1000);
      vw.salesPrice();
   }
}
```

Scope

```
public int myFunction (){                // start scope 1
   int x = 34;
   // x is now available
   {                                     // start scope 2
      int y = 98;
      // both x and y are available
      // cannot redefine x here compile-time error
   }                                     // end scope 2
   // now only x is available
   // y is out-of-scope
   return x;
}                                        // end scope 1
```

- The redefinition of **`x`** in scope 2 is allowed in C/C++

Object Creation in General

- Object can be created by
  - Instantiating a class
  - Copying an existing object
- Instantiating
  - *Static*: Objects are constructed and destructed at the same time as the surrounding object.
  - *Dynamic*: Objects are created by executing a specific command.
- Copying
  - Often called *cloning*

Object Destruction in General

- Object can be destructed in two way.
  - *Explicit*, e.g., by calling a special method or operator (C++).
  - *Implicit*, when the object is no longer needed by the program (Java).

- Explicit
  - An object in use can be destructed.
  - Not handling destruction can cause memory leaks.
- Implicit
  - Objects are destructed automatically by a *garbage collector.*
  - There is a performance overhead in starting the garbage collector.
  - There is a scheduling problem in when to start the garbage collector.

Object Creation in Java

- *Instantiazion*: A process where storage is allocated for an "empty" object.
- *Initialization*: A process where instances variables are assigned a start value.

- Dynamic instantiazion in Java by calling the **`new`** operator.
- Static instantiazion is *not* supported in Java.
- Cloning implemented in Java via the method **`clone()`** in class **`java.lang.Object`**.

- Initialization is done in *constructors* in Java
  - Very similar to the way it is done in C++

Object Destruction in Java

- Object destruction in Java is implicit an done via a *garbage collector*.
  - Can be called explicitely via **`System.gc()`**.

- A special method **`finalize`** is called immediately before garbage collection.
  - Method in class **`Object`**, that can be redefined.
  - Takes no parameters and returns **`void`**.
  - Used for releasing resources, e.g., close file handles.
  - Rarely necessary, e.g., "dead-conditions" for error dection purposes.

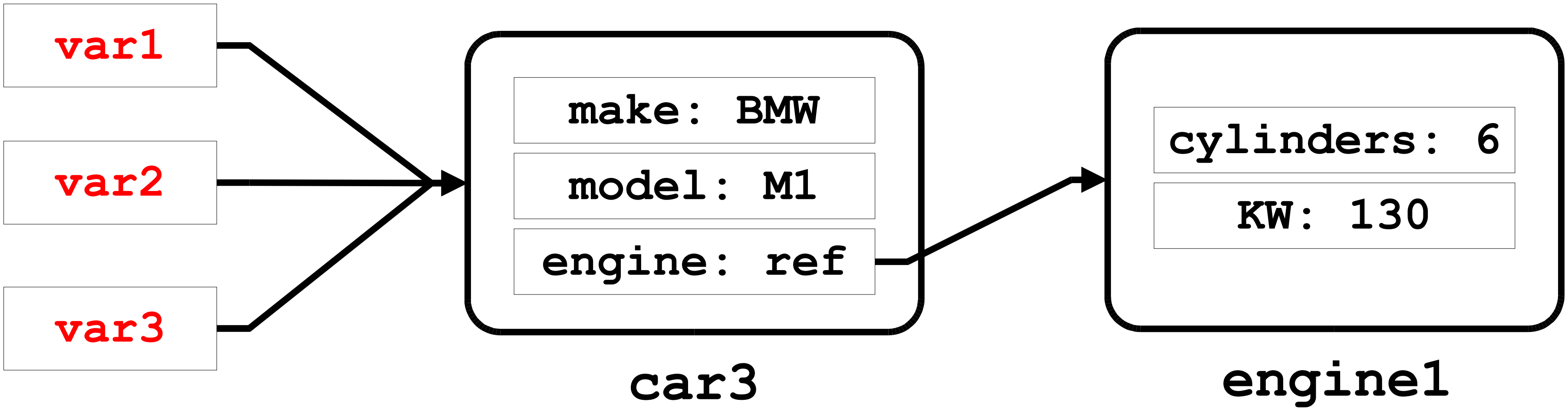
Objects and References

- Variables of non-primitive types that are not initialized have the special value **`null`**.
  - Test: **`var1 == null`**
  - Assignment: **`var2 = null`**

Object have identity but no name,

  - i.e., not possible to identify an object O1 by the name of the variable referring to O1.

- *Aliasing*: Many variables referring to the same object



Constructors in Java

- A *constructor* is a special method where the instance variables of a newly created object are initialized with “reasonable” start values.

- A class must have a constructor
  - A default is provided implicitly (no-arg constructor).
- A constructor must have the same name as the class.
- A constructor has no return value.
  - That's why it is as special method
- A constructor can be overloaded.
- A constructor can call other methods (but not vice-versa).
- A constructor can call other constructors (via **`this`**).

Constructors in Java, cont.

- Every class should have a programmer defined constructor, that explicitly guarantees correct initialization of new objects.

```java
// redefined Coin class
public class Coin {
   public static final int HEADS = 0;
   public static final int TAILS = 1;
   private int face;
   // the constructor
   public Coin ()   {
      face = TAILS;
      // method in object
      flip();
      // method on other object
      otherObject.doMoreInitialization();
   }
}
```

Constructors and Cloning in Java

```
public class Car {
    // instance variables
    private String make;
    private String model;
    private double price;
    /** The default constructor */
    public Car() {
        this("", "", 0.0); // must be the first thing
    }
    /** Construtor that assigns values to instance vars */
    public Car(String make, String model, double price) {
        this.make = make;
        this.model = model;
        this.price = price;
    }

    /** Cloning in Java overwrites the Object.clone() */
    public Object clone() {  // note the return type
        return new Car(make, model, price);
    }
}
```

Constructor Initialization

```
public class Garage {
   Car car1 = new Car();
   static Car car2 = new Car();  // created on first access
}
```

```
public class Garage1 {
   Car car1;
   static Car car2;
   // Explicit static initialization
   static {
      car2 = new Car();
   }
}
```

Constructor vs. Method

Similarities

- Can take arguments
  - all pass-by-value
- Can be overloaded
- Access modifiers can be specified (e.g., **`private`** or **`public`**)
- Can be **`final`** (covered later)

Dissimilarties

- Has fixed name (same as the class)
- No return value
  - "returns" a reference to object
- Special call via new operator
  - **`new Car()`**
  - Cannot be called by methods
- Default constructor can by synthesised by the system
- Cannot be declared **`static`**
  - it is in fact a static method!

Object Descrution in Java, cont.

```
class MemoryUsage{         /** Dummy class to take up mem */
   int id;                 /** Id of object */
   String name;            /** Name of object */
   MemoryUsage(int id){    /** Constructor */
      this.id = id;
      this.name = "Name: " + id;
   }
   /** Overwrite the finalize method */
   public void finalize(){
      System.out.println("Goodbye cruel world " + this.id);
   }
}
public class Cleanup{
   public static void main(String[] args){
      for (int i = 0; i < 999; i++){
         // allocate and discard
         MemoryUsage m = new MemoryUsage(i);
         if (i % 100 == 0){ System.gc(); }
      }
   }
}
```

Value vs. Object

- A *value* is a data element without identity that cannot change state.
- An *object* is an encapsulated data element with identity, state, and behavior.

- An object can behave like value (or record). Is it a good idea?

- Values in Java are of the primitive type **`byte`**, **`short`**, **`int`**, **`long`**, **`float`**, **`double`**, **`boolean`**, and **`char`**.
- Wrapper classes exists in Java for make the primitive type act as objects.

Strings in Java

- Strings in Java are of the class **`String`**.
- Objects of class **`String`** behave like values.

- Characteristics of Strings
  - The notation "fly" instantiates the class String and initialize it with the values "f"', "l", and "y".
  - The class **`String`** has many different constructors.
  - Values in a string cannot be modified (use **`StringBuffer`** instead).
  - Class **`String`** redefines the method **`equals()`** from class **`Object`**.

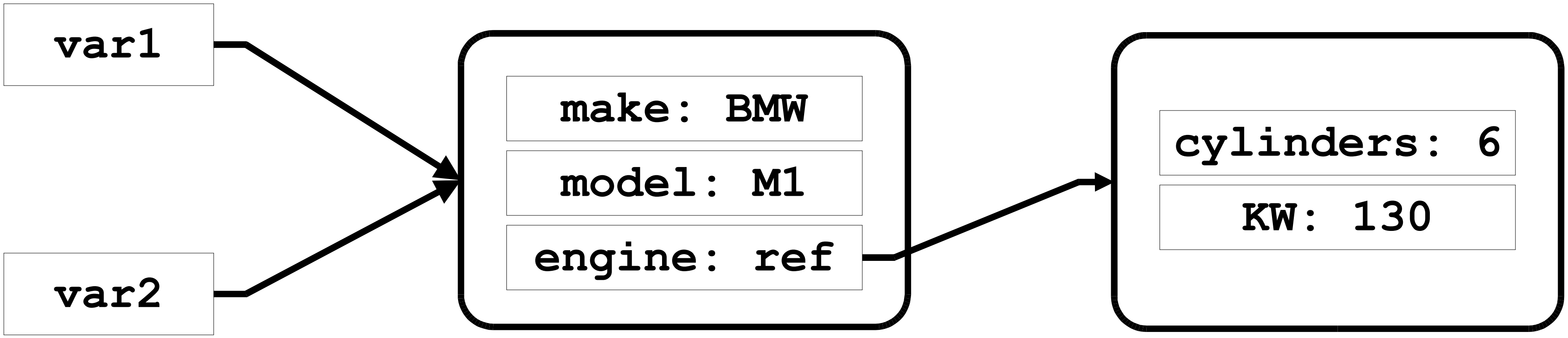
Equality

- Are the references **a** and **b** equal?

- *Reference Equality*
  - Returns whether **a** and **b** points to the same object.
- *Shallow Equality*
  - Returns whether **a** and **b** are structurally similar.
  - One level of objects are compared.
- *Deep Equality*
  - Returns where **a** and **b** have object-networks that are structurally similar.
  - Multiple level of objects are compared recursively.

- *Reference Equality* ⇒ *Shallow Equality* ⇒ *Deep Equality*

Equality Examples



var1

var2

make: BMW

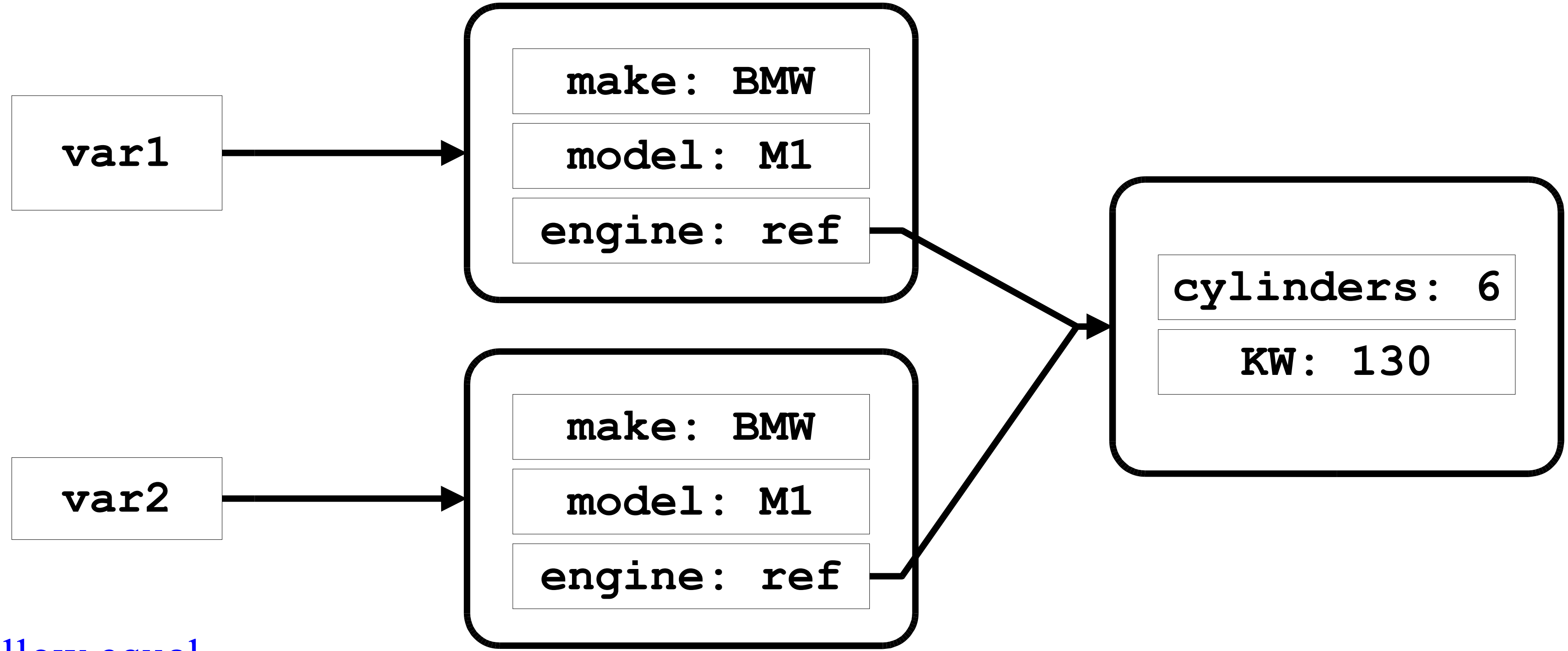
model: M1

engine: ref

cylinders: 6

KW: 130

reference equal



var1

var2

make: BMW

model: M1

engine: ref

make: BMW

model: M1

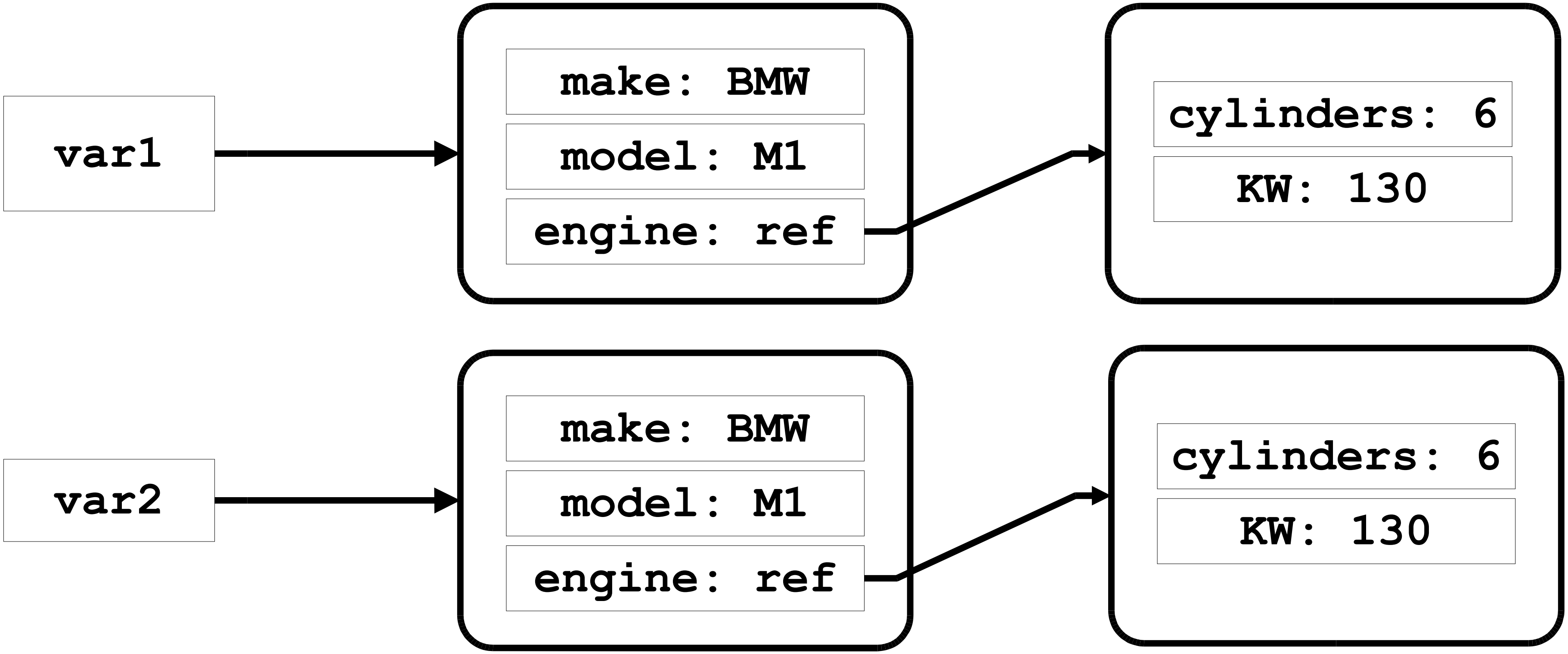
engine: ref

cylinders: 6

KW: 130

shallow equal

Equality Examples, cont.



deep equal

Types of Equality in Java

- ==
  - Equality on primitive data types
    - `8 == 7`
    - `'b' == 'c'`
  - Reference equality on object references
    - `onePoint == anotherPoint`
  - Strings are special

```
String s1 = "hello"; String s2 = "hello";
 if (s1 == s2){
        System.out.println(s1 + " equals" + s2);}
```

- **`equals`**
  - Method on the class **`java.lang.Object`**.
  - Default works like reference equality.
  - Can be refined in subclass
    - `onePoint.equals(anotherPoint)`

equals example

```
public class Car {
    // snip
    /** Gets the make inst variable(helper function). */
    public String getMake() {
        return make;
    }
    // snip

    /**
     * Implements the equals method
     * @see java.lang.Object#equals(java.lang.Object)
     */
    public boolean equals(Object o) {
        return o instanceof Car // is it a Car object?
            && ((Car) o).getMake() == this.make
            && ((Car) o).getModel() == this.model
            && ((Car) o).getPrice() == this.price;
            // relies on “short circuiting”
    }
```

Summary

- Instance variables
- Strings are treated specially in Java
- Methods
  - All computation should be done in methods
  - Overloading is generally a good thing
- Initialization is critical for objects
  - Java guarantees proper initialization using constructors
  - Source of many errors in C
- Java helps clean-up with garbage collection
  - Only memory is clean, close those file handles explicitly!
  - No memory leaks, "show stopper" in a C/C++ project!
- Equality (three types of equality)

Arrays in Java

- Not pointers like in C,
- Bounds checking at run-time

-
  ```
  int[] numbers;  // equivalent
  int   number[];
  ```
- `int[] numbers = {1, 2, 3, 4, 5, 6, 7};`
  - The size is fixed at compile-time!
- `int[] numbers = new Integer[getSize()];`
  - The size is fixed at run-time!
  - Cannot be resized

```
for (int i = 0; i < numbers.length; i++){
   System.out.println(numbers[i]);
}
```