CS102
Programming II

CLASS (PART - I)

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TOPICS

- Classes & objects
- Constructors
- **`this`** keyword
- Encapsulation
- **`static`** attributes and methods
- **`final`** attributes
- **`toString()`** method
- Object Composition
- **`equals()`** and **`instanceof`**

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CLASSES AND OBJECTS

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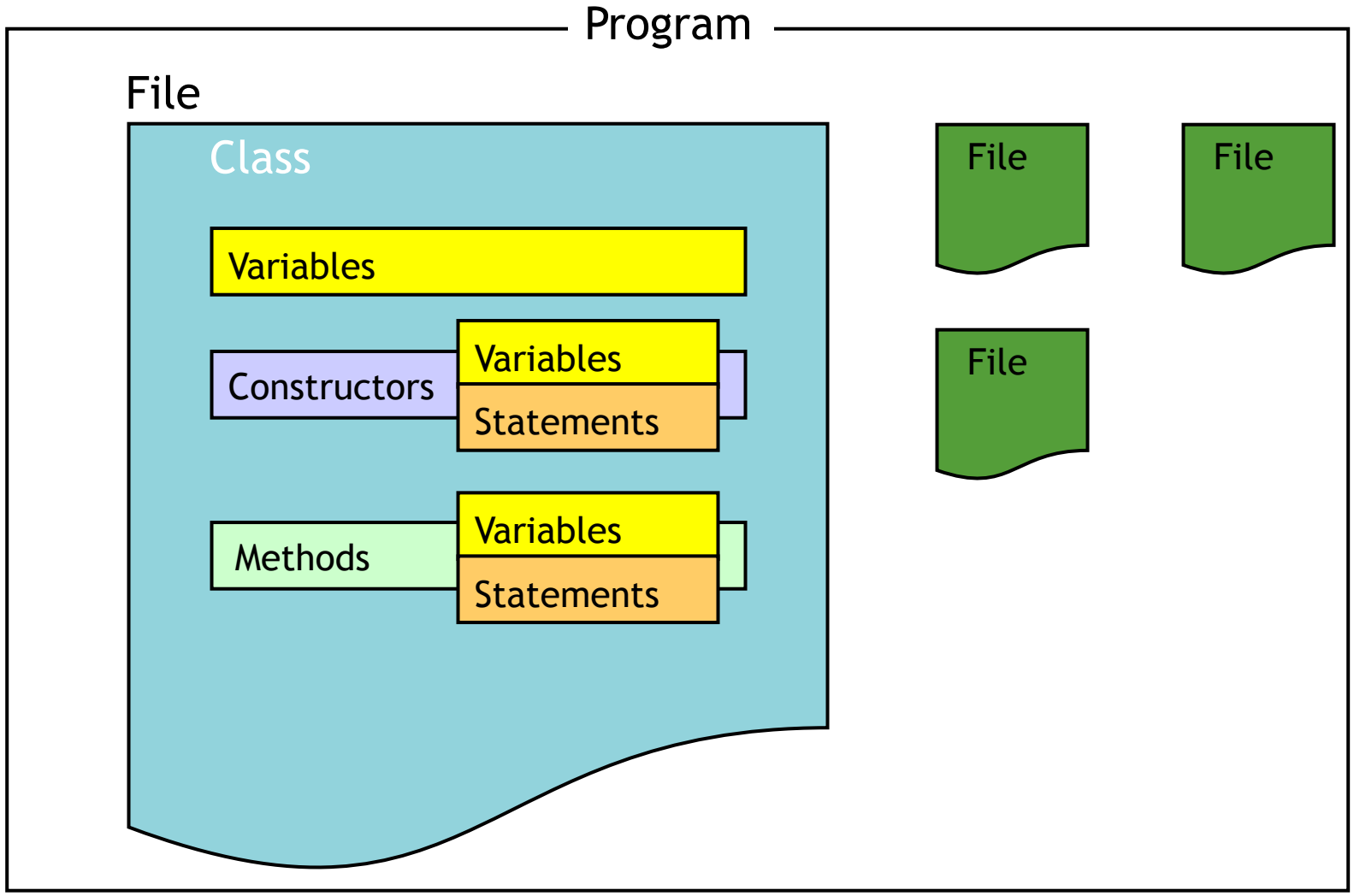
DIAGRAM OF PROGRAM STRUCTURE

- A program consists of one or more classes
- Typically, each class is in a separate .java file

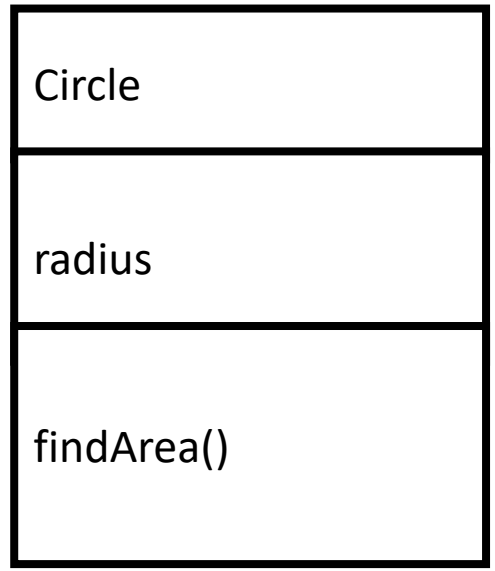


CLASSES

- A *class* is a collection of *attributes* (data) and *methods*

```
public class Circle {
   double radius = 1.0; //attribute

   double findArea(){ // method
     return radius * radius * 3.14159;
   }
}
```



CREATING OBJECTS

An object is an instance of a class.

```
ClassName objectReference = new ClassName();
```

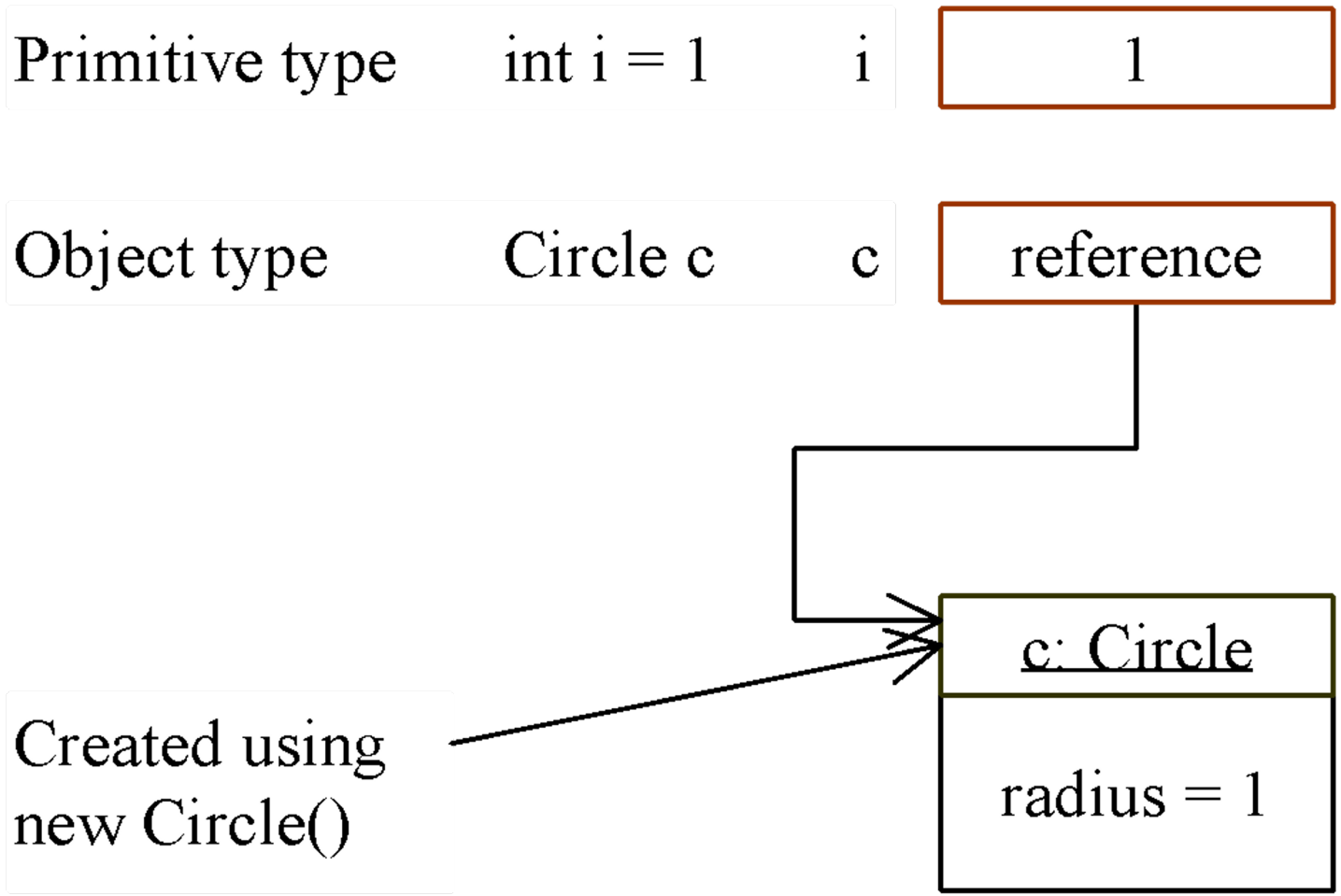
Example:

```
Circle myCircle = new Circle();
```

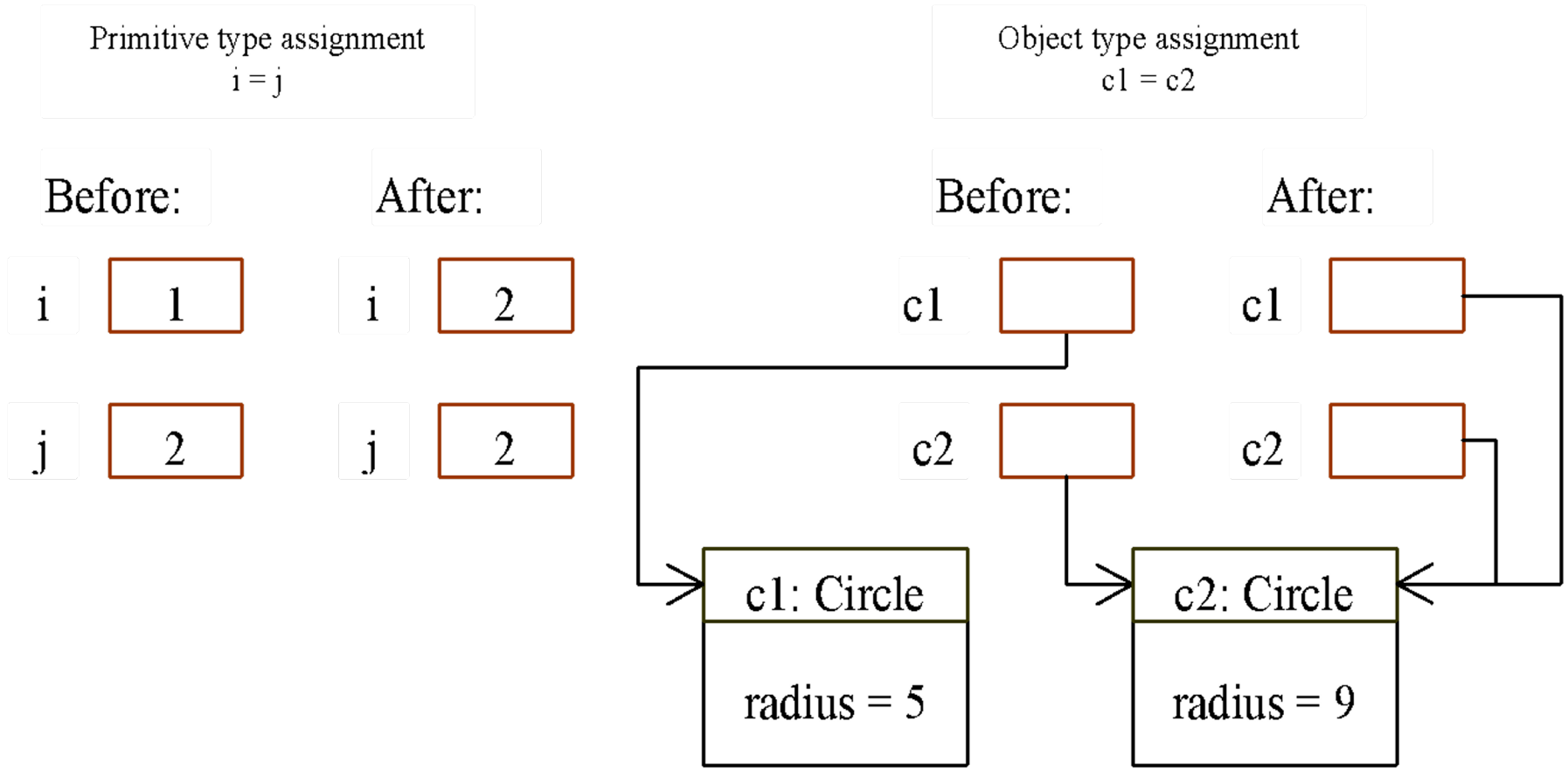
The object reference is assigned to the object reference variable.

`myCircle` is a object of class **`Circle`**

PRIMITIVE DATA TYPE VS OBJECT TYPES



PRIMITIVE DATA TYPE VS OBJECT TYPES



ACCESSING OBJECTS

- Referencing the object's data:

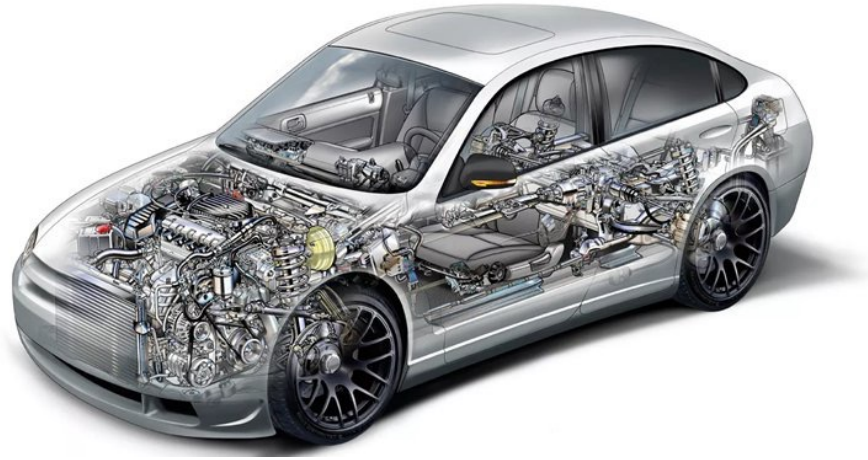
```
objectReference.data
myCircle.radius
```

- Invoking the object's method:

```
objectReference.method
myCircle.findArea()
```

EXERCISE

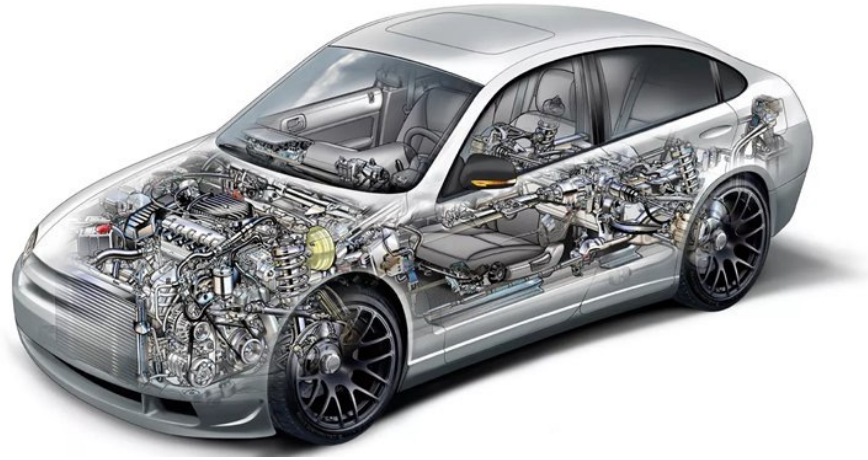
- Make a class called **`Car`**.
- It has two attributes, **`year`** and **`model`**.
- It has one method **`getYear`** that returns **`year`**.



EXERCISE/SOLUTION

```
public class Car {
   int year;
   String model;

   public int getYear(){
      return year;
   }
}
```



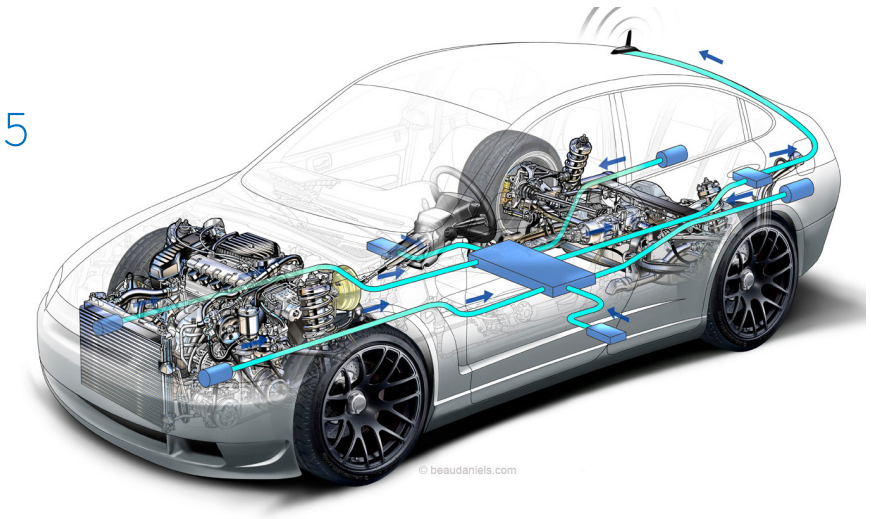
EXERCISE

- Make a tester program.
- Make an object **`A`** of type Car. Set **`year`** and **`model`** for the object.
- Get the value of **`year`** from object **`A`** and print it.

EXERCISE

- Make a tester program.
- Make an object **A** of type Car. Set **year** and **model** for the object.
- Get the value of **year** from object **A** and print it.

```
public static void main(String [] args){
   Car A = new Car();
   A.year = 2025;
   A.model = "Lexus 400";
   System.out.print(A.getYear());   //prints 2025
}
```



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CONSTRUCTORS

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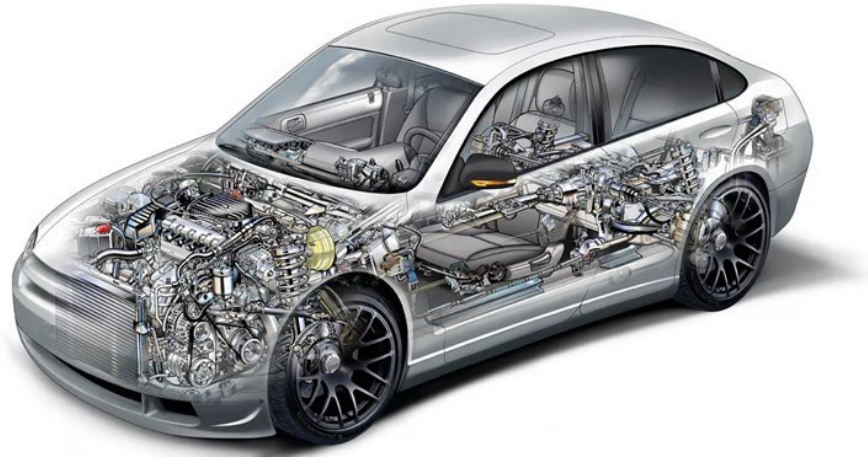
WHAT IS A CONSTRUCTOR?

- Constructor is a special method that gets invoked “automatically” at the time of object creation.
- Constructor is used for initializing objects with default values.
- Constructor has the same name as the class name.
- Constructor cannot return values.
- A class can have more than one constructor as long as they have different signature.

CONSTRUCTOR

```
public class Car {
   int year;
   String model;
   Car(){
      year = 2024;
      model = "Lexus";
   }
   public int getYear(){
      return year;
   }
}
```



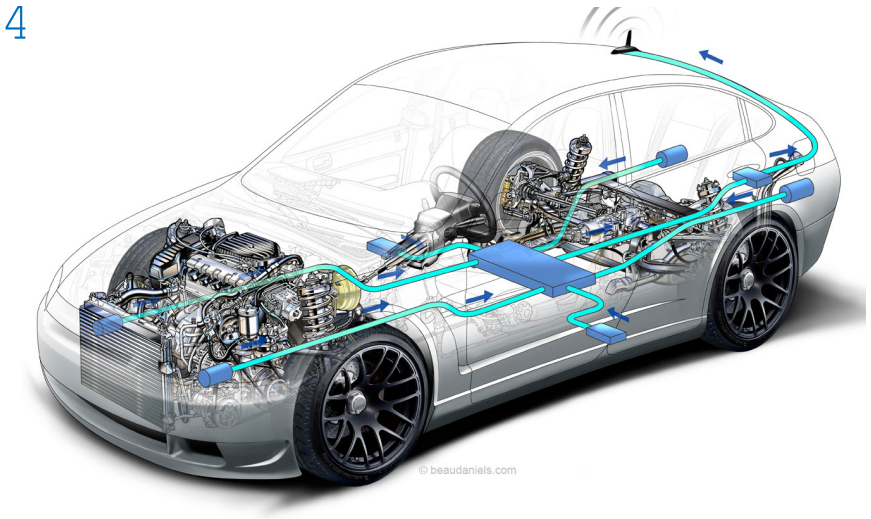
EXERCISE

- Modify the tester program. Make a object **B** of type **Car**. Use
- Get the value of **year** from object **B** and print it.

```
public static void main(String [] args){
   Car B = new Car();
   B.year = 2025;
   B.model = "Lexus 400";
   System.out.print(B.getYear()); // prints 2024

}
```

```
Car(){
    year = 2024;
    model = "Lexus";
  }
```



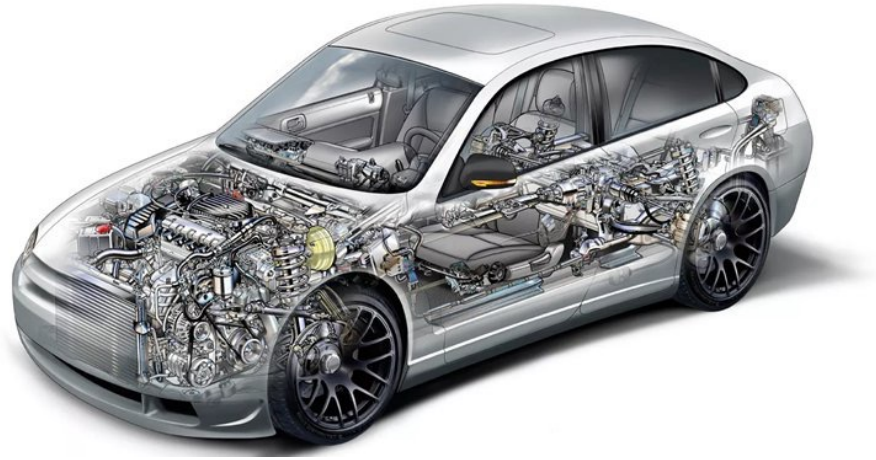
METHOD OVERLOADING

- Constructors all have the same name.
- Methods are distinguished by their signature:
  - name
  - number of arguments
  - type of arguments
  - position of arguments
- That means, a class can also have multiple usual methods with the same name.

CONSTRUCTOR OVERLOADING

```
public class Car {
   int year;
   String model;
   Car(){
      year = 2024;
      model = "Lexus";
   }
   Car(int y, String S){
      year = y;
      model = S;
   }
   public int getYear(){
      return year;
   }
}
```

←Overload



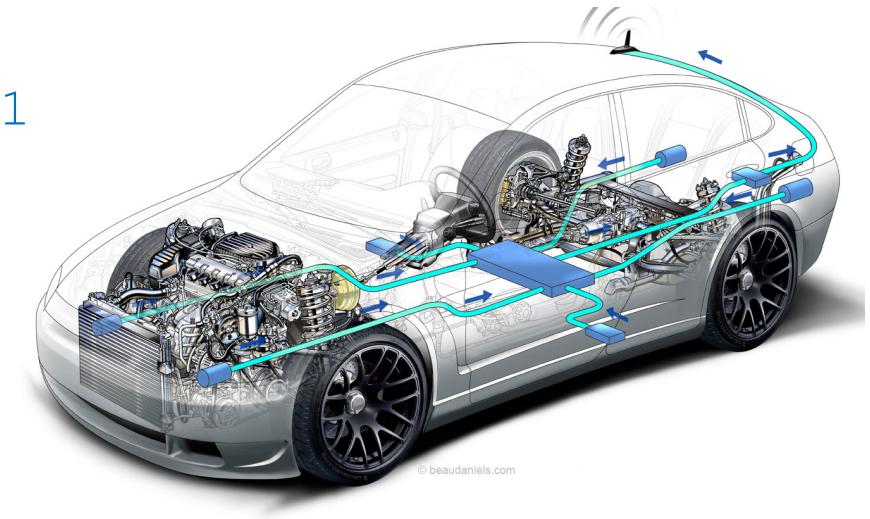
EXERCISE

- Modify the tester program. Make a object **C** of type **Car**.
- Get the value of **year** from object **C** and print it.

```
public static void main(String [] args){
   Car B = new Car();
   System.out.print(B.getYear()); // prints 2024

   Car C = new Car(2021, "Ford 150");
   System.out.print(C.getYear()); // prints 2021
}
```

```
Car(int y, String S){
   year = y;
   model = S;
}
```



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THIS

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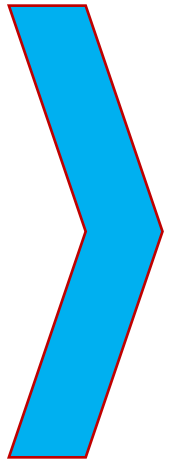
`this` KEYWORD

- **this** keyword is used to refer to the class itself
- It must be used to **differentiate attributes names from parameter names** when they have the same names

this KEYWORD

```
public class Car {
   int year;
   String model;
   Car(){
      year = 2024;
      model = "Lexus";
   }
   Car(int year, String model){
      year = year;
      model = model;
   }
   public int getYear(){
      return year;
   }
}
```



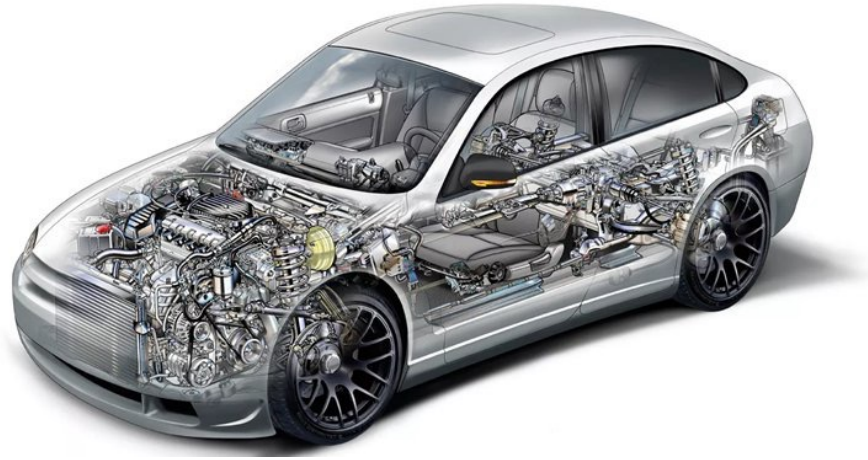
```
public class Car {
   int year;
   String model;
   Car(){
      year = 2024;
      model = "Lexus";
   }
   Car(int year, String model){
      this.year = year;
      this.model = model;
   }
   public int getYear(){
      return year;
   }
}
```

COPY CONSTRUCTOR

- A **copy constructor** is a constructor that creates an object using another object of the same Java class.
- It helps when we want to make a **deep copy** of an existing object.
- **Deep copy:** copies all attributes from one object to another.

COPY CONSTRUCTOR

```
public class Car {
   int year;
   String model;
   Car(){
      year = 2024;
      model = "Lexus";
   }
   Car(Car C){
      if(C!=null){
         this.year = C.year;
         this.model = C.model;
      }
   }
   public int getYear(){
      return year;
   }
}
```



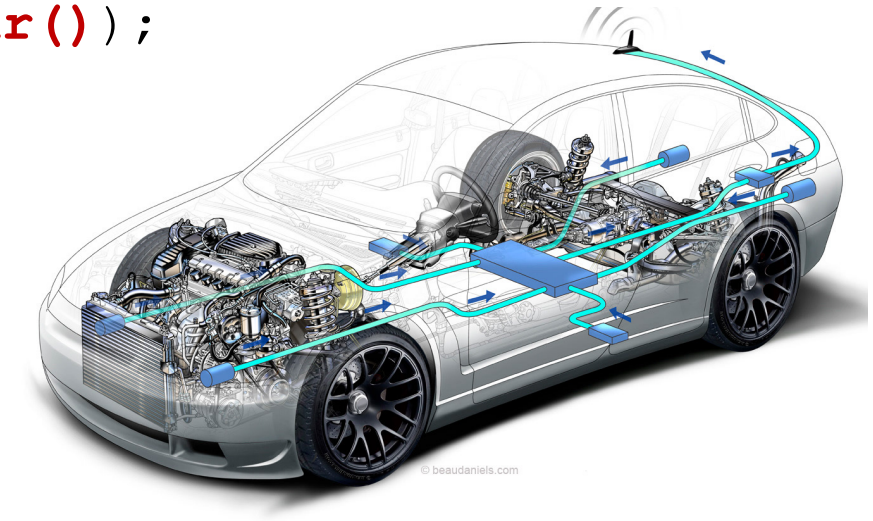
EXERCISE

- Make two objects **D1, D2** of type **Car**.
- Copy **D1** to **D2**.

```
Car(){
    year = 2024;
    model = "Lexus";
 }
```

```
Car(Car C){
    if(C!=null){
      this.year = C.year;
      this.model = C.model;
    }
 }
```

```
public static void main(String [] args){
   Car D1 = new Car();
   Car D2 = new Car(D1);
   System.out.println(D1.model +" "+ D1.getYear()); // prints Lexus 2024
   System.out.println(D2.model +" " + D2.getYear());
   // also prints Lexus 2024
}
```



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ENCAPSULATION

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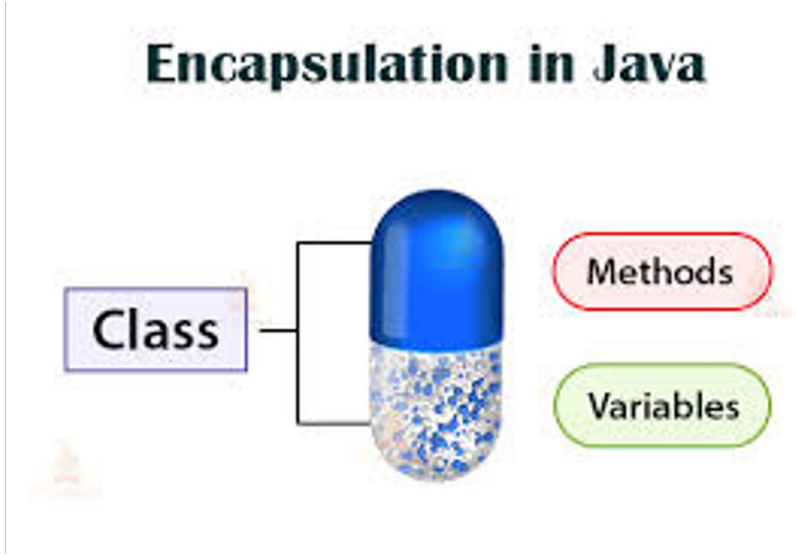
WHAT IS ENCAPSULATION?

- Encapsulation is the ability of an object to hide its data and methods.
- A fundamental principle of OOP (Object Oriented Programming).

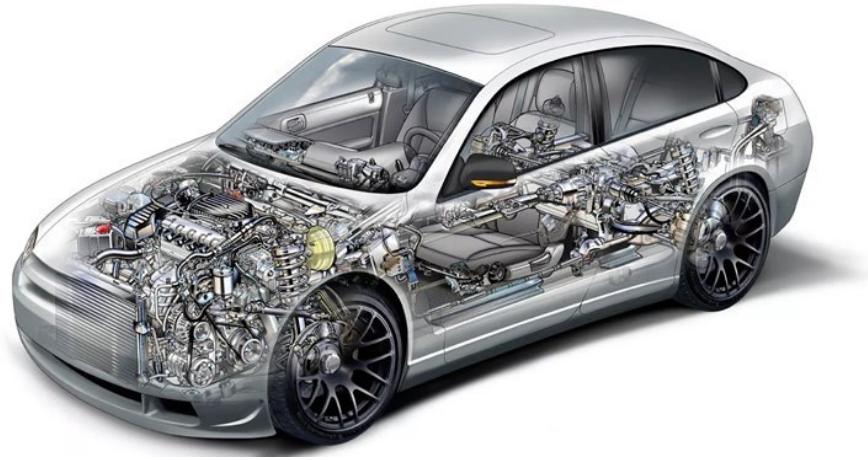


DERIVED CLASS CAN RESTRICT VISIBILITY?

- **Private** – Protected and public members of base class are private in derived class.
- **Protected** – Protected and public members of base class are protected in derived class.
- **Public** – Protected and public members of base class are protected and public in derived class.
- Private members of base class are NOT visible in derived class.

ENCAPSULATION

```
public class Car {
   private int year;
   public String model;
   Car(){
      year = 2024;
      model = "Lexus";
   }
   public int getYear(){
      return year;
   }
}
```

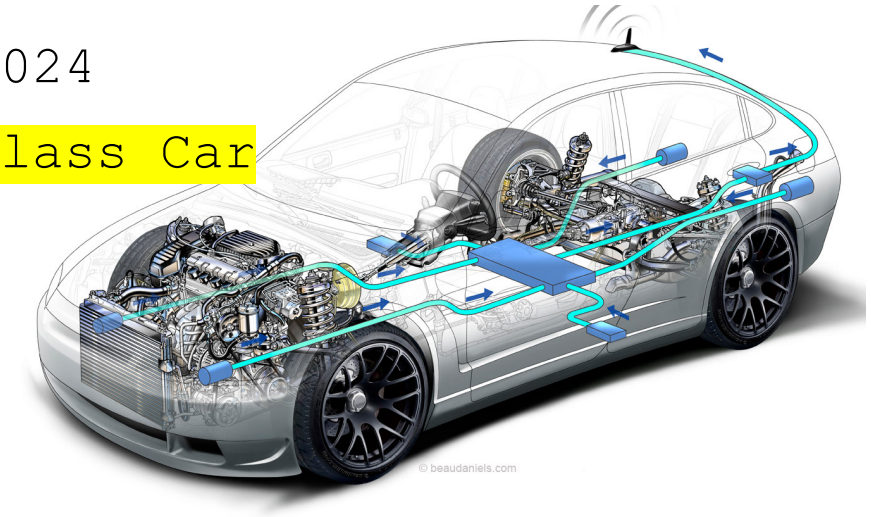


EXERCISE

- Modify the tester program. Make a object **D** of type **Car**.
- Get the value of **year** from object **D** and print it.
- Modify the value of **year** (try it!)
- Modify the value of **model**.

```
public static void main(String [] args){
   Car D = new Car();
   System.out.println(D.getYear()); // prints 2024
   D.year = 2030;   //ERROR: private member of class Car
   D.model = "Toyota"; //ok !!
}
```

```
Car(){
    year = 2024;
    model = "Lexus";
  }
```

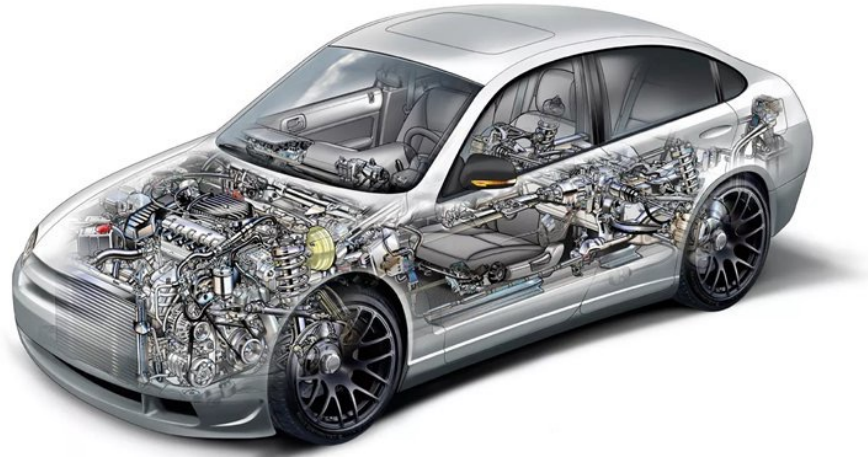


GETTERS AND SETTERS

- A **getter** is a method that extracts information.
- A **setter** is a method that inserts information.
- **Getters** and **setters** can be used even without underlying matching variables

EXAMPLE

```
public class Car {
   private int year;
   public String model;
   Car(){
      year = 2024;
      model = "Lexus";
   }
   public int getYear(){                  //getter
      return year;
   }
   public void setYear(int year){   //setter
      this.year = year;
   }
}
```

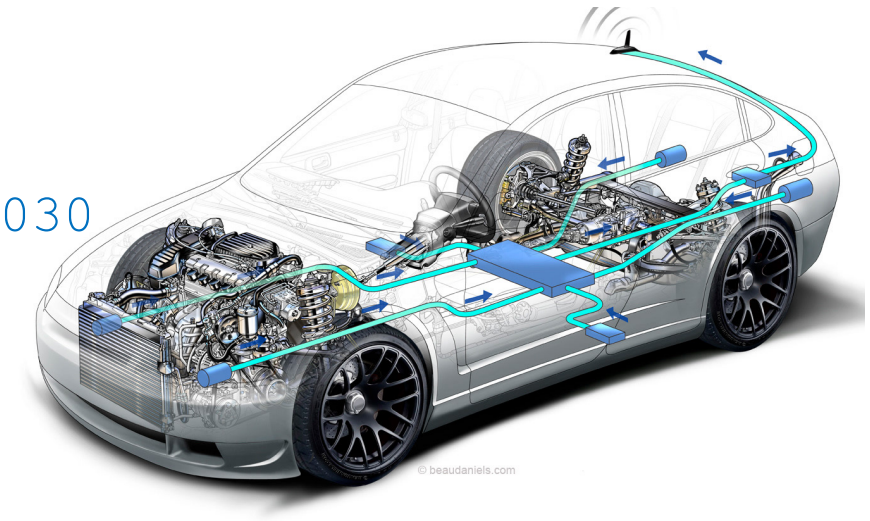


EXERCISE

- Modify the tester program. Make a object **E** of type **Car**.
- Set the value of **year** of object **E** to 2030.
- Print the value of **year** using the getter.

```
public static void main(String [] args){
   Car E = new Car();
   System.out.println(E.getYear()); // prints 2024
   E.year = 2030; //Error: private member
   E.setYear(2030);
   System.out.println(E.getYear()); // prints 2030
}
```

```
Car(){
    year = 2024;
    model = "Lexus";
  }
```



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STATIC

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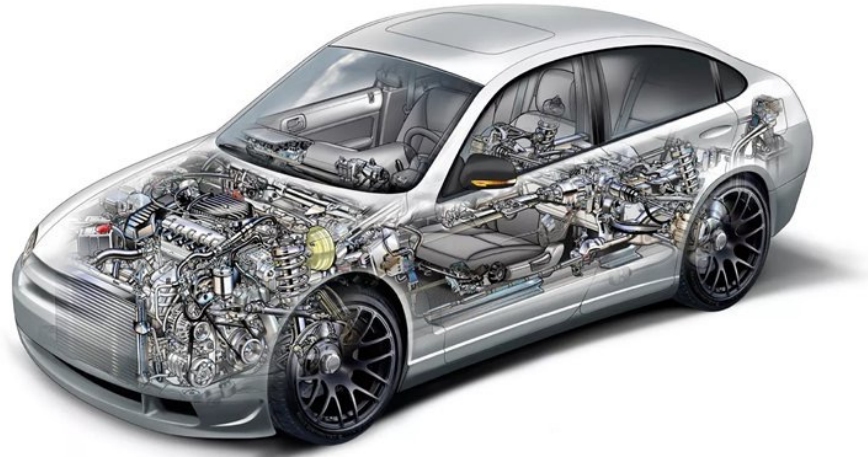
STATIC

- **static class member** is a member that belongs to the **class itself**, rather than to individual objects (instances) of that class.
- There are two main types:
  - **static attribute** (class attribute)
  - **static method** (class method)

STATIC ATTRIBUTE

```
public class Car {
  private int year;
  public String model;
  public static int numberOfCars = 0;
  Car(int year, String model){
    this.year = year;
    this.model = model;
    numberOfCars++;
  }
  public int getYear(){              //getter
    return year;
  }
  public void setYear(int year){   //setter
    this.year = year;
  }
}
```

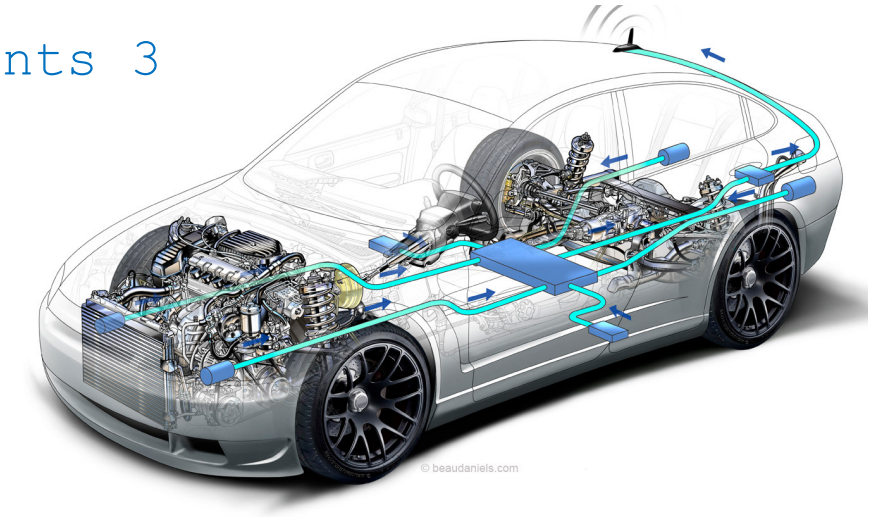
static means numberOfCars belong to class **Car** and not objects



STATIC CLASS MEMBER TESTER

```
public static void main(String [] args){
   Car C1 = new Car(2021, "Lexus");
   //numberofCars is now 1
   Car C2 = new Car(2022, "Ford 150");
   //numberofCars is now 2
   Car C3 = new Car(2026, "BMW X6");
   //numberofCars is now 3
   System.out.println(Car.numberOfCars); // prints 3
}
//We don't need an object because
//numberOfCars belongs to the class.
```

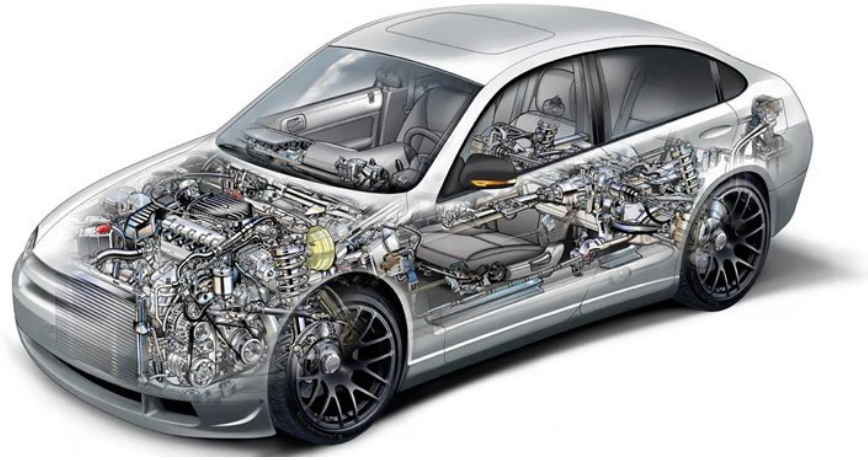
```
Car(int year, String model){
   this.year = year;
   this.model = model;
   numberOfCars++;
 }
```



STATIC METHOD

```
public class Car {
  private int year;
  public String model;
  private static int numberOfCars = 0;
  Car(int year, String model){
    this.year = year;
    this.model = model;
    numberOfCars++;
  }
  public int getYear(){              //getter
    return year;
  }
  public void setYear(int year){   //setter
    this.year = year;
  }
  public static int getNumberOfCars(){ //static getter
    return numberOfCars;
  }
}
```

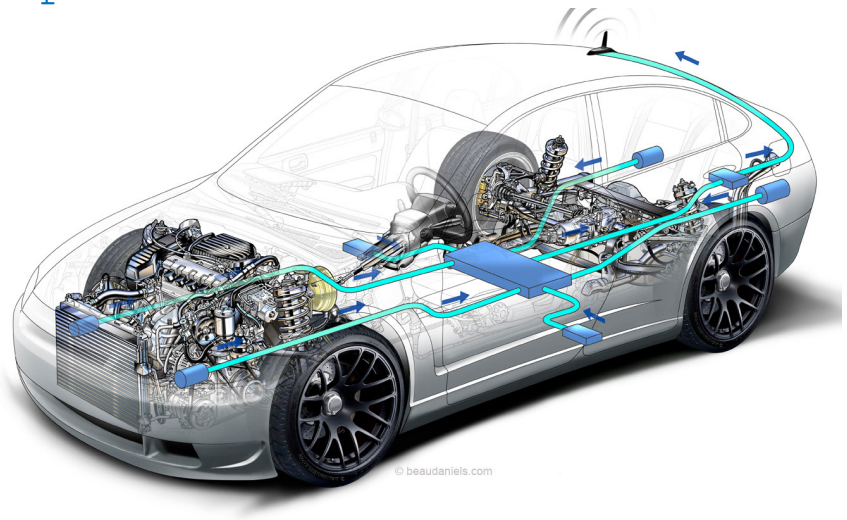
static means numberOfCars belong to class **Car** and not objects



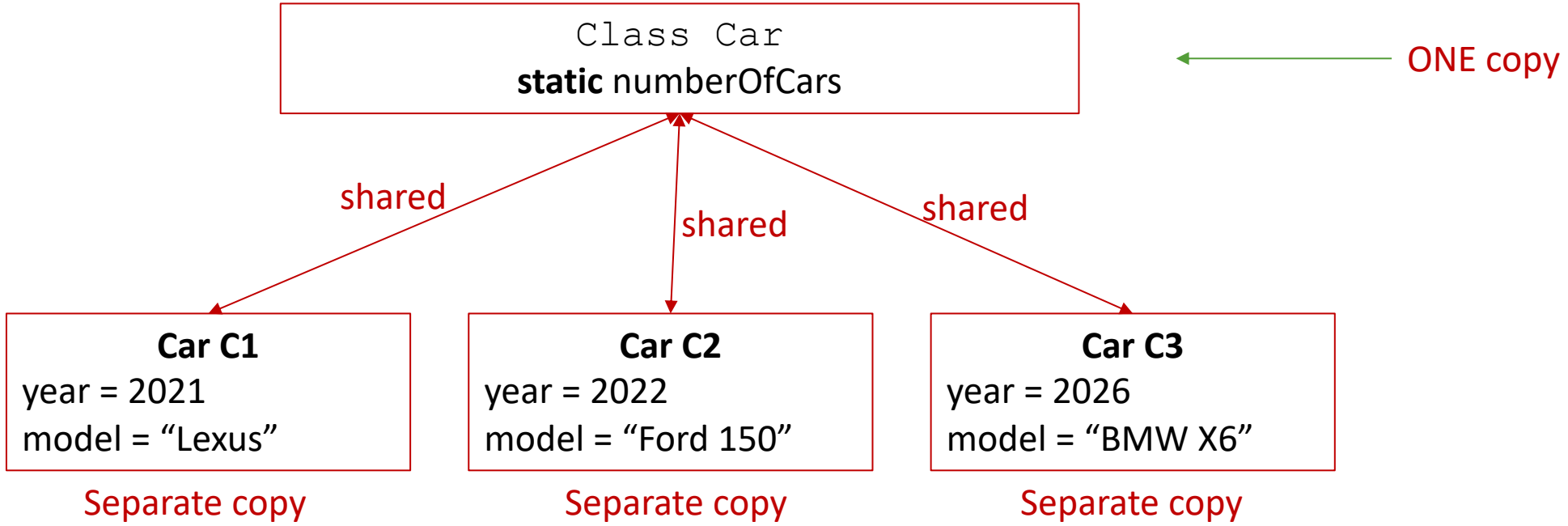
STATIC METHOD TESTER

```
public static void main(String [] args){
   Car C1 = new Car(2021, "Lexus");
   Car C2 = new Car(2022, "Ford 150");
   Car C3 = new Car(2026, "BMW X6");
   //numberofCars is now 3
   System.out.println(Car.numberOfCars); // ERROR private member
   System.out.println(Car.getNumberOfCars()); // prints 3
}
//We don't need an object because
//numberOfCars belongs to the class.
```

```
Car(int year, String model){
   this.year = year;
   this.model = model;
   numberOfCars++;
 }
```



STATIC SUMMARY



Instance member → one copy for every object.
Static member → one copy for the entire class.

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FINAL

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FINAL

- In Java, **`final` means "cannot be changed"** after it has been assigned.

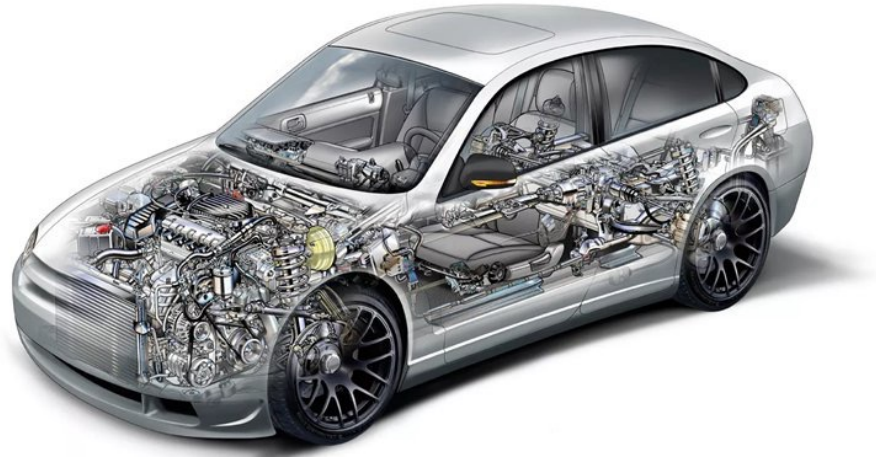
`static` → shared by the class

`final` → cannot be changed

`static final` → one shared value that cannot be changed

FINAL ATTRIBUTE

```
public class Car {
  private int year;
  public String model;
  public final int MAX_NUMBER_OF_CARS = 100;
  Car(int year, String model){
    this.year = year;
    this.model = model;
  }
  public int getYear(){              //getter
    return year;
  }
  public void setYear(int year){   //setter
    this.year = year;
  }
}
```

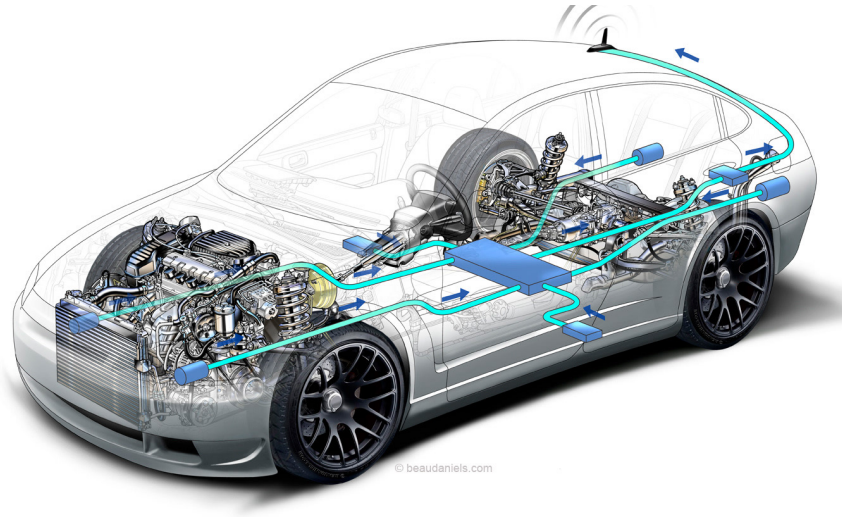


FINAL ATTRIBUTE CHANGE TESTER

```
public static void main(String [] args){
   Car C1 = new Car(2021, "Lexus");
   Car C2 = new Car(2022, "Ford 150");
   Car C3 = new Car(2026, "BMW X6");
   System.out.println(C3.MAX_NUMBER_OF_CARS ); // prints 100
   C3.MAX_NUMBER_OF_CARS = 10; // Changing final is NOT ALLOWED
}
```

//It is commonly used for **constants**. Example:

```
//public static final int MAX_SPEED = 120;
```



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TOSTRING()

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THE TOSTRING METHOD

- The special method toString:

  Tells Java how to convert your object into a String as needed.

  Is called when an object is printed or concatenated to a String.

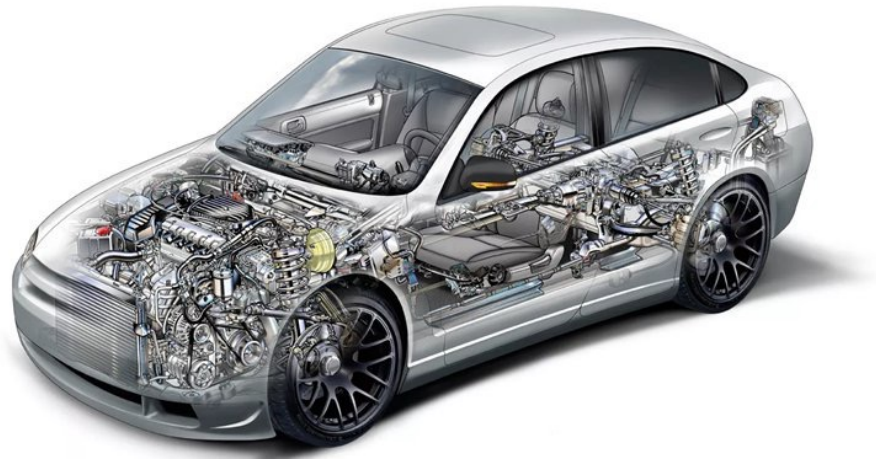
- Every class has a toString, even if it isn't in your code.

  The default toString returns the class's name followed by a hexadecimal (base-16) number:

  ```
  "Car@9e8c34"
  ```

TOSTRING

```
public class Car {
   int year;
   String model;
   Car(int year, String model){
      this.year = year;
      this.model = model;
   }
   public String toString(){
      return "(" + year + ", " + model + ")" ;
   }
}
```



TOSTRING TESTER

- Demostrate usage of toString()

```
public static void main(String [] args){
   Car C1 = new Car(2021, "Lexus");
   Car C2 = new Car(2022, "Ford 150");
   System.out.println(C1.toString());  // prints: (2021, Lexus)

   System.out.println(C2);  // prints: (2022, Ford 150)
}
```

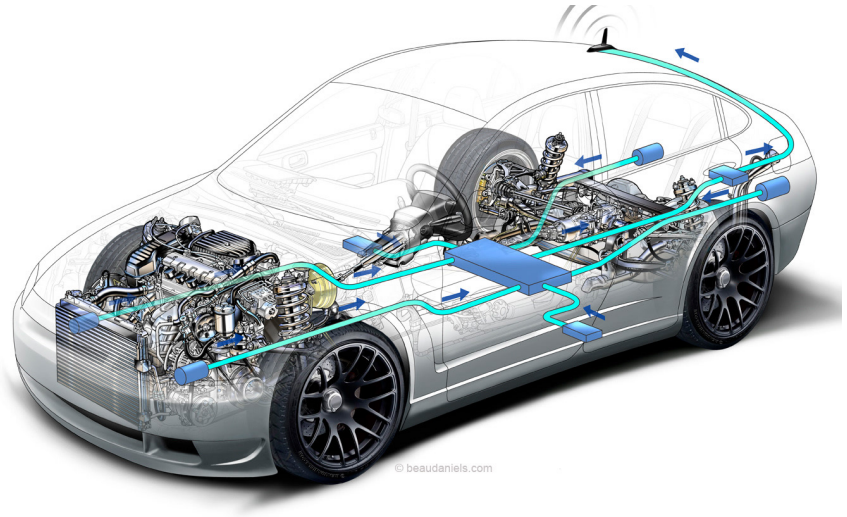
//toString() returns a string. So we can call the toString through the object

```
//C1.toString();
```

//printing an object also calls the toString() method (Override) of that object.

```
//C1;
```

//We study (Override) later.



CS102 Programming II

COMPOSITION

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COMPOSITION

- A class can have references to objects of other classes as members
- Sometimes referred to as a *has-a* relationship

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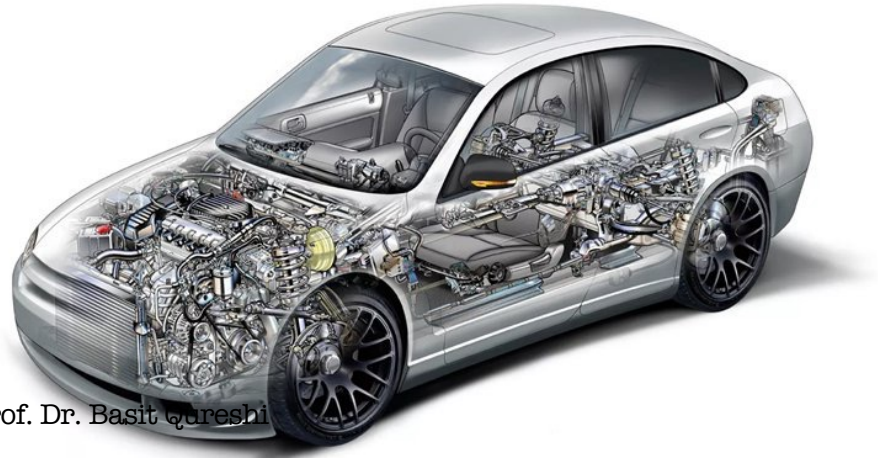
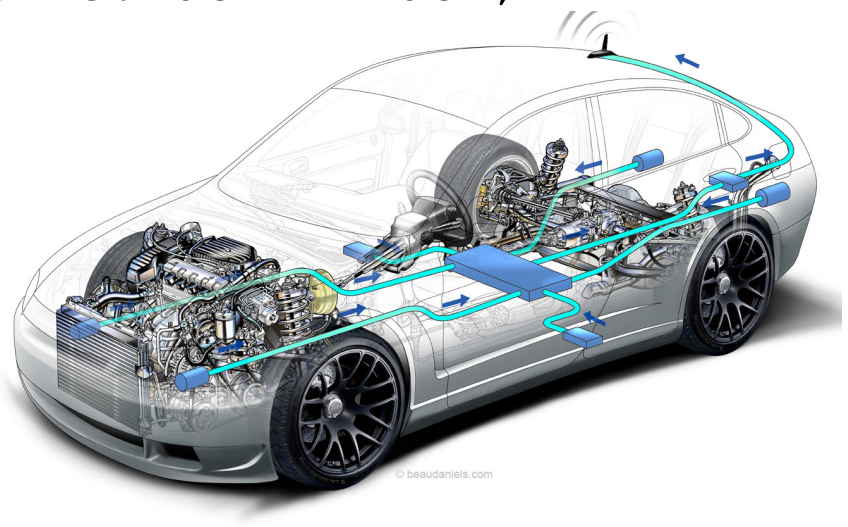
TOSTRING

```
public class Car {
   int year;
   String model;
   Engine e;
   Car(){ //initialize attributes
   }
   Car(int year, String model){
      this.year = year;
      this.model = model;
   }
}
```



```
public class Engine {
   int hp;
   String fuel;
   Engine() {//initialize attributes


   }
   Engine(int hp, String fuel){
      this.hp = 10;
      this.fuel = fuel;
   }
}
```



TOSTRING

```
public class Car {
   int year;
   String model;
   Engine e;
   Car(int year, String model){
      this.year = year;
      this.model = model;
   }
}
```

```
public class Engine {
   int hp;
   String fuel;
   Engine(int hp, String fuel){
      this.hp = hp;
      this.fuel = fuel;
   }
}
```

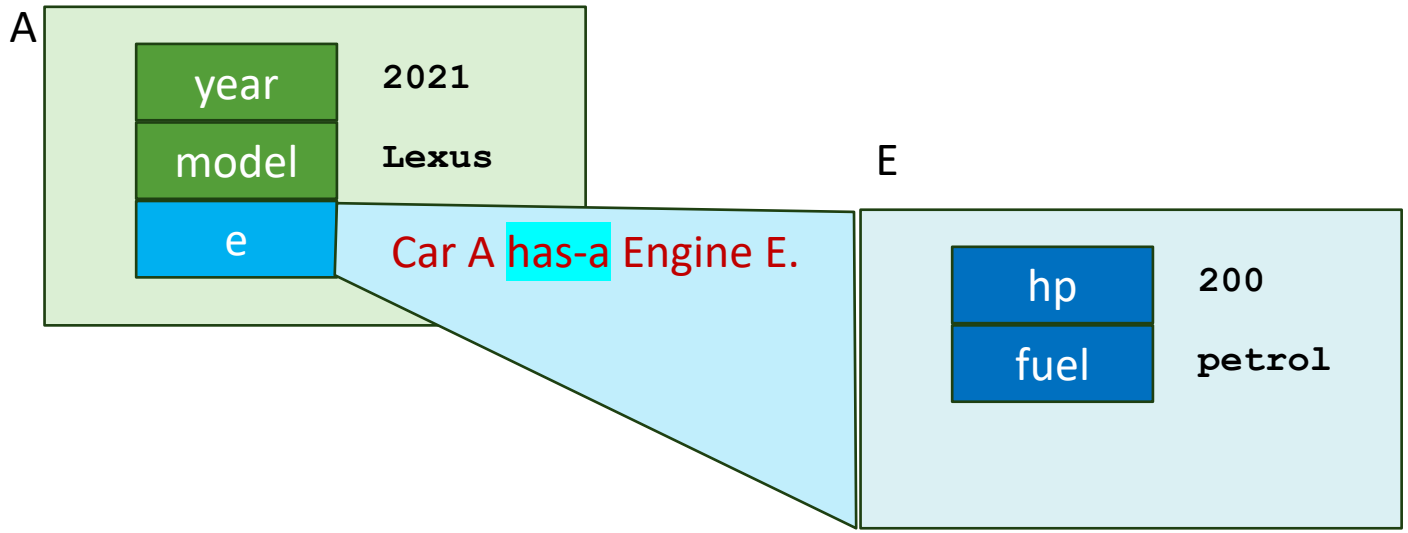
Every **Car** has-a **Engine**.

Engine is a class. **e** is object of class **Engine**, which is a attribute of class **Car**.

COMPOSITION TESTER

- Make a Car object and initialize the composed object of Engine class

```
public static void main(String [] args){
   Car A = new Car(2021, "Lexus");
   Engine E = new Engine(200, "petrol");
  A.e = E;
  }
```



Methods of class Engine can be available to object A.e

CS102 Programming II

EQUALS AND INSTANCEOF

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CLASS **Object**

- In java, all types of objects have a **superclass** named **`Object`**.
  - Every class implicitly `extends Object.`

    // we study extends later!!
- The Object class defines several methods:
  - `public String toString()`

    Used to print the object.
  - `public boolean equals(Object other)`

    Compare the object to any other for equality.

CLASS Object

- You can store any object in a variable of type `Object`.

```
Object o1 = new Car(2020, "G.M.C.);
Object o2 = "hello there";
Object o3 = new Scanner(System.in);
```

- An `Object` variable only knows how to do general things.

```
String s = o1.toString();          // ok
int len = o2.length();             // error
String line = o3.nextLine();       // error
```

- You can write methods that accept an `Object` parameter.

```
public void example(Object o) {
    if (o != null) {
        System.out.println("You passed " + o.toString());
    }
}
```

CLASS Object

- The == operator does not work well with objects.
  - == compares references to objects, not their state.
  - Example:

```
Car c1 = new Car(2020, "GMC");
Car c2 = new Car(1999, "Ford");
if (c1 == c2) {    // false
    System.out.println("equal");
}
```

equals

- The `equals` method compares the state of objects.

```
if (str1.equals(str2)) {
    System.out.println("the strings are equal");
}
```

- But if you write a class, its `equals` method behaves like `==`

```
if (c1.equals(c2)) {    // false :-(
    System.out.println("equal");
}
```

This is the behavior we inherit from class **`Object`**. Java doesn't understand how to compare `Car` by default.

TYPE-CASTING OBJECTS

- Solution: *Type-cast* the object parameter to a `Car`.

```
public boolean equals(Object o) {
    Car other = (Car) o; ←type casting
    return year == o.year && model == o.model;
}
```

- Casting objects is different than casting primitives.
  - Tells the compiler to *assume* that `o` refers to a `Car` object.

instanceof

```
if (variable instanceof type) {
    statement(s);
}
```

- Asks whether a variable refers to an object of a given type.
  - Used as a `boolean` test.
  - Examples:

```
String s = "hello";
Car c1 = new Car();
```

expression	result
`s instanceof Car`	`false`
`s instanceof String`	`true`
`c1 instanceof Car`	`true`
`c1 instanceof String`	`false`
`c1 instanceof Object`	`true`
`s instanceof Object`	`true`
`null instanceof String`	`false`

instanceof

```
public boolean equals(Object o) {
    if (o instanceof Car) {
        // o is a Car; cast and compare it
        Car other = (Car) o;
        return year==o.year && model == o.model;
    } else {
        // o is not a Car; cannot be equal
        return false;
    }
}
```