CT2106
Object Oriented Programming

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Today's topics

- Equal Method
- Java.lang.Object
- Checking type of a variable
- Casting
- Type hierarchy
- Understanding basic inheritance
- Overriding

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equals

Your equals method should look like this

```
/**
 * version 1 of an equals method
 * @param  object  a parameter of type Bicycle
 * @returns true or false
 */
public boolean equals(Bicycle bike){

    //TODO - we will write the body here
    return false; // default return value
}
```

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How to use it (even though it's incomplete)

We would use it the same way we used the equals method of the String class

E.g.

```
Bicycle bike1 = new Bicycle(4,20);
Bicycle bike2 = new Bicycle(2,10);

if(bike2.equals(bike1)){
    System.out.println("true");
}else{
    System.out.println("false");
}
```

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Bicycle Equality

- What would make two Bicycle objects equal in terms of value?
- **Their state**. i.e. their field values: speed and gear
- The same applies for every object

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Your task

In the section marked //TODO in the equals method write code so that

```
/**
 * version 1 of an equals method
 * @param  object  a parameter of type Bicycle
 * @returns true or false
 */
public boolean equals(Bicycle bike){

    //TODO - write code as described below
    //If the speed AND the gear values of this bicycle object are equal (==)
    //to the speed AND gear values of the input Bicycle
    //return true else return false

    return false; // default return value
}
```

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equals

Your equals method should look like this

```
/**
 * version 1 of an equals method
 * @param  bike  a parameter of type Bicycle
 * @return    true or false
 */
public boolean equals(Bicycle bike){
    if(speed == bike.getSpeed() && gear == bike.getGear()){
        return true;
    }   //no need for an else statement
    return false; // default return value
}
```

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Test in CodePad (or in a main method)

```
public static void main(String[] args)
{
    Bicycle bike1 = new Bicycle(4,20);
    Bicycle bike2 = new Bicycle(2,10);

    if(bike2.equals(bike1)){
        System.out.println("true");
    }else{
        System.out.println("false");
    }

}
```

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Tip

Java has a shorthand for writing if/else statements

```
if(bike2.equals(bike1)){
        System.out.println("true");
}else{
        System.out.println("false");
}
```

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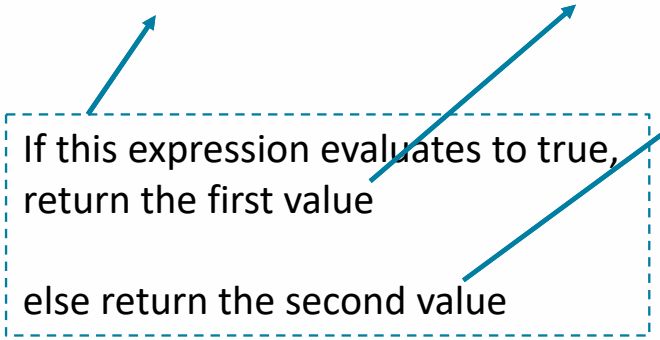
Tip: Ternary operator

It can be reduced to one line

```
System.out.println(bike2.equals(bike1)? "true”  :"false");
```



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Ok, so we cheated

- Our version of the equals method doesn't comply with the standard equals method expected by the Java language.
- It is nearly there but not quite
- To understand this fully we will encounter a fundamental concept in OOP **: inheritance**

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Correct version

- **All equals methods must have the following method signature**
- public boolean equals(Object object)

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V1 of equals method for Bicycle class

Your equals method should look like this

```
/**
 * version 1 of an equals method
 * @param  bike  a parameter of type Bicycle
 * @return    true or false
 */
public boolean equals(Bicycle bike){
    if(speed == bike.getSpeed() && gear == bike.getGear()){
        return true;
    }   //no need for an else statement
    return false; // default return value
}
```

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However

This version of the equals method **doesn't comply with the standard equals method expected by the Java language.**

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Correct version

The Java language has a standard signature for the equals method:

public boolean equals(java.lang.Object object)

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Version2 of equals method

```
37  /**
38   * version 2 of an equals method
39   * @param  object  a parameter of type Bicycle
40   * @returns true or false
41   */
42  public boolean equals(Object obj){
43
44      if(obj==null){
45         return false;
46      }
47
48      if (obj instanceof Bicycle){
49
50          Bicycle bike = (Bicycle)obj;
51
52          if(this.speed ==bike.getSpeed() && this.gear==bike.getGear()){
53              return true;
54          }
55
56      }
57      return false;
58  }
```

5 minute challenge

- Write down in pseudocode (or your own words) what you think this method is doing?
- Question to try to answer:
  - What is the meaning of **Object** in this piece of code?
  - Why is there a check for null?
  - What does the **instanceof** operator do?
  - What is happening in this line of code:
    - Bicycle bike = (Bicycle)obj;
- It may be helpful to contrast if with the previous version

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Checking for null

- Checking for a null value is very commonly done.
- It anticipates the program throwing a null pointer exception
- For example, the following code would throw a NullPointerException if we didn't check for null in the equals method

```
Bicycle bike1 = null;
Bicycle bike2 = new Bicycle(2,10);

System.out.println(bike2.equals(bike1)? "true" : "false");
```

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instanceof

instanceof is an operator that is used to determine if variable is pointing to an object with a particular type;

```
if (bike2 instanceof Bicycle){
    System.out.println("true");
}else{
     System.out.println("false");
}
```

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instanceof

instanceof is an operator that is used to determine if a variable is pointing to an object with a particular type;

```
System.out.println(bike2 instanceof Bicycle? "true" : "false");
```

From now on I will use this notation to represent if/else examples

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Object

```
public boolean equals(Object obj)
```

Q: What is the parameter Object obj?
A: obj is variable whose type is **java.lang.Object**

Q: What is java.lang.Object?
A: It is a class that provides the **most generic definition** of an object in Java

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Java.lang.Object

- java.lang.Object is the **parent class** of every class in Java
- A Bicycle object is a Bicycle object AND a java.lang.Object object
- A String object is a String object AND a java.lang.Object object

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Let’s test these ideas

- Open BlueJ
- Create a new Project
- Download the Bicycle class from Blackboard
- Right-click on the BlueJ workbench, select “Add Class from File”
- Add the Bicycle class you have downloaded
- Compile

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Open BlueJ

Open the project where you have the Bicycle class defined
Make sure CodePad is open

```
Bicycle bike = new Bicycle(2,12);
Bicycle bike2 = new Bicycle(3,15);
Object anObject = new Bicycle(3,15);
Object obj = "Hello World"; // String object
```

Variable `anObject` of type Object is pointing to a Bicycle object

This is allowed because the Bicycle object is a Bicycle type and an Object type

All Java objects are an Object type

Object type is short for java.lang.Object type

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Open BlueJ

Variable	Var type	Object	Object Type
bike	Bicycle	New Bicycle(2,12)	Bicycle
bike2	Bicycle	New Bicycle(3,15)	Bicycle
anObject	Object	New Bicycle(3,15)	Bicycle
obj	Object	“Hello World”	String

```
Bicycle bike = new Bicycle(2,12);
Bicycle bike2 = new Bicycle(3,15);
Object anObject = new Bicycle(3,15);
Object obj = "Hello World"; // String object
```

Variables of type Object can point to any type of Object

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Using instanceof to check object type

```
boolean isBike = anObject instanceof Bicycle; // is the object referenced a Bicycle
isBike
    true   (boolean)
boolean isString = anObject instanceof String; // is the object referenced a String object
isString
    false   (boolean)
 isString = obj instanceof String; // is the object referenced a String object
isString
    true   (boolean)
```

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Using the new equals method

```
boolean isEqual = bike2.equals(anObject);
isEqual
    true   (boolean)
 isEqual = bike2.equals(obj);
isEqual
    false   (boolean)
```

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Casting

- Here we cast (convert) a variable from a higher type (Object) to a lower type (Bicycle)
- We do the same for the String
- This is allowed as
  - `anObject` points to a Bicycle object – we've checked this using `instanceof`
  - `obj` points to a String object - we've checked this using `instanceof`

```
Bicycle bike3 = (Bicycle)anObject;
String str5 = (String)obj;
```

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Note that it is the variable type that is being converted **not the object**

```
Bicycle bike3 = (Bicycle)anObject;
String str5 = (String)obj;
```

Variable	Var type	Object	Object Type
anObject	~~Object~~	New Bicycle(3,15)	Bicycle
obj	~~Object~~	“Hello World”	String

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Java organises all its classes in a class hierarchy

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Consider The Real World…

- Object
- Vehicle
- Car

- In the most general sense, **a single car** is an object.
- But more specifically, it is a vehicle
- And more specifically still, it is a car

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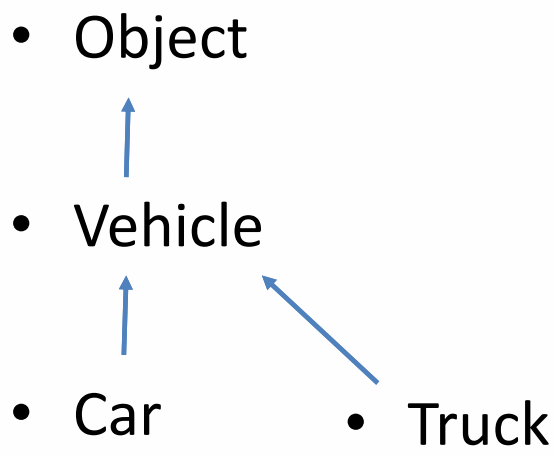
The Real World



- In the most general sense, a single truck is an object.
- But more specifically it is also a Vehicle
- And more specifically still it is a type of Truck

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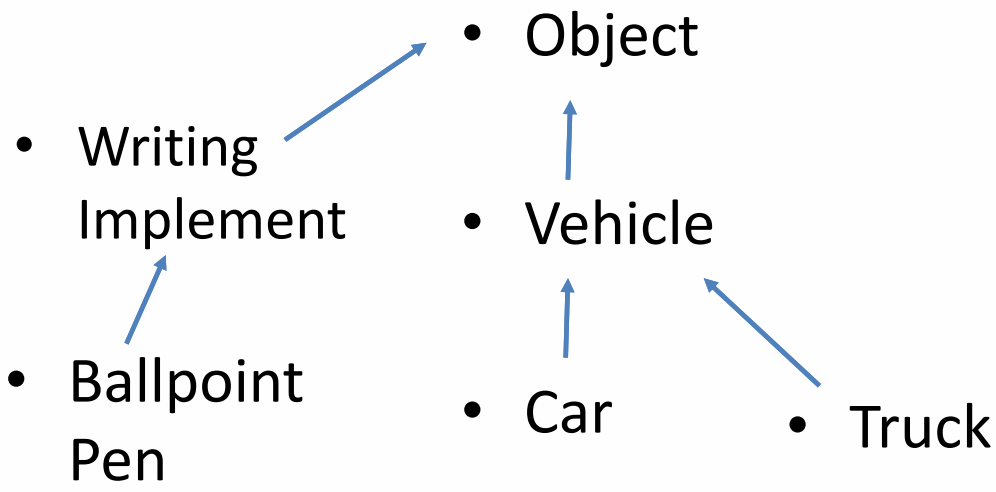
The Real World



- In the most general sense, **a ballpoint pen** is an object.
- But more specifically it is a writing implement
- And more specifically still it is a ballpoint pen

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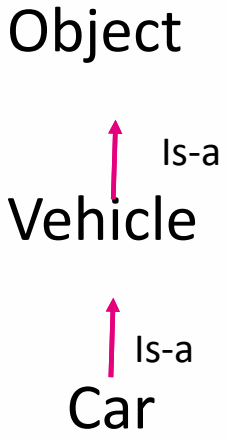
Is-a

- These relationships can be described as “is-a” relationships
- A car is-a vehicle; a vehicle is-a(n) object
- We can call the higher up types as **parent**s and the lower ones **children**
- Car **is a child** of Vehicle
- Vehicle **is a parent** of Car
- Object **is the parent** of Vehicle and Car



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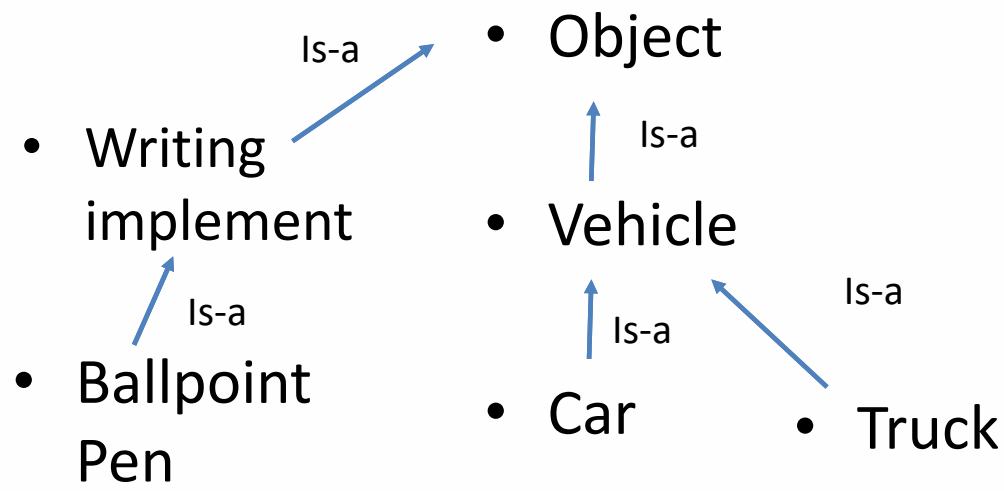
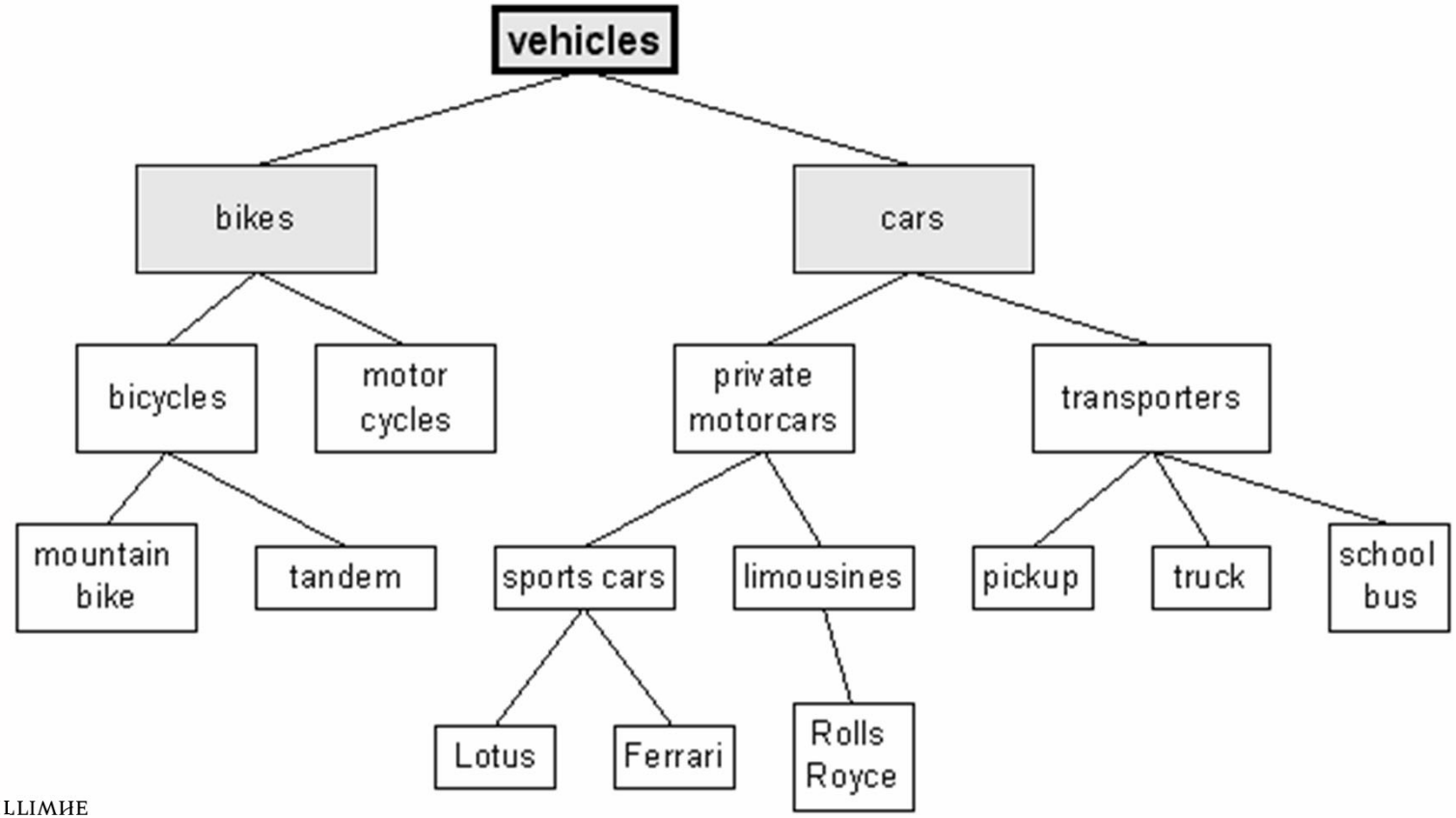
The Real World



We see these concept hierarchies all over the non-Java world



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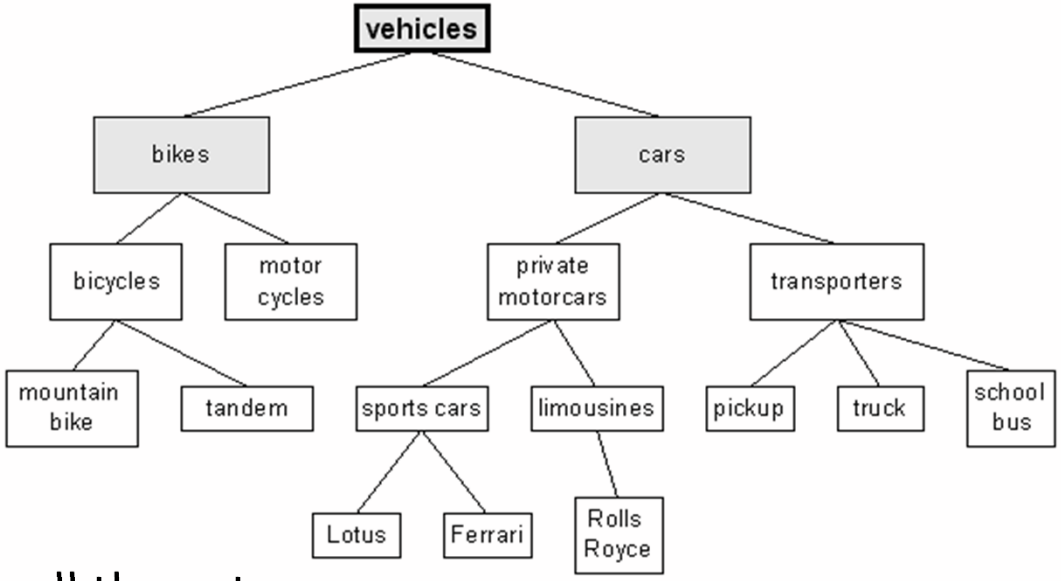
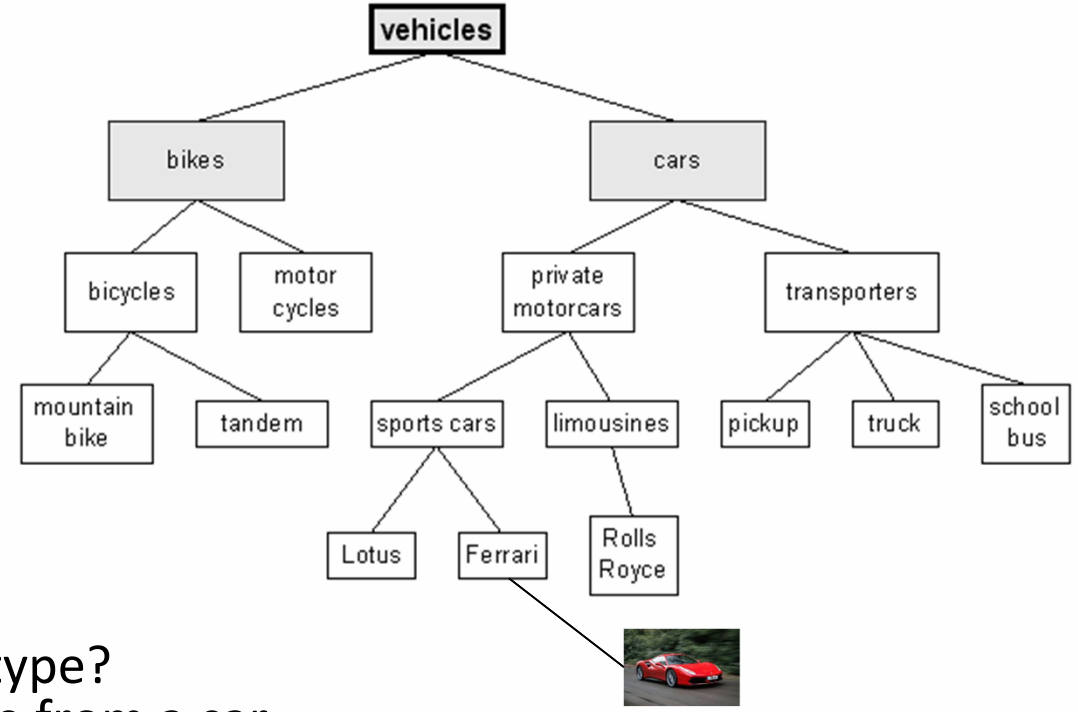
Ferrari 488

a. vehicle
b. car
c. private car
d. sports car
e. Ferrari



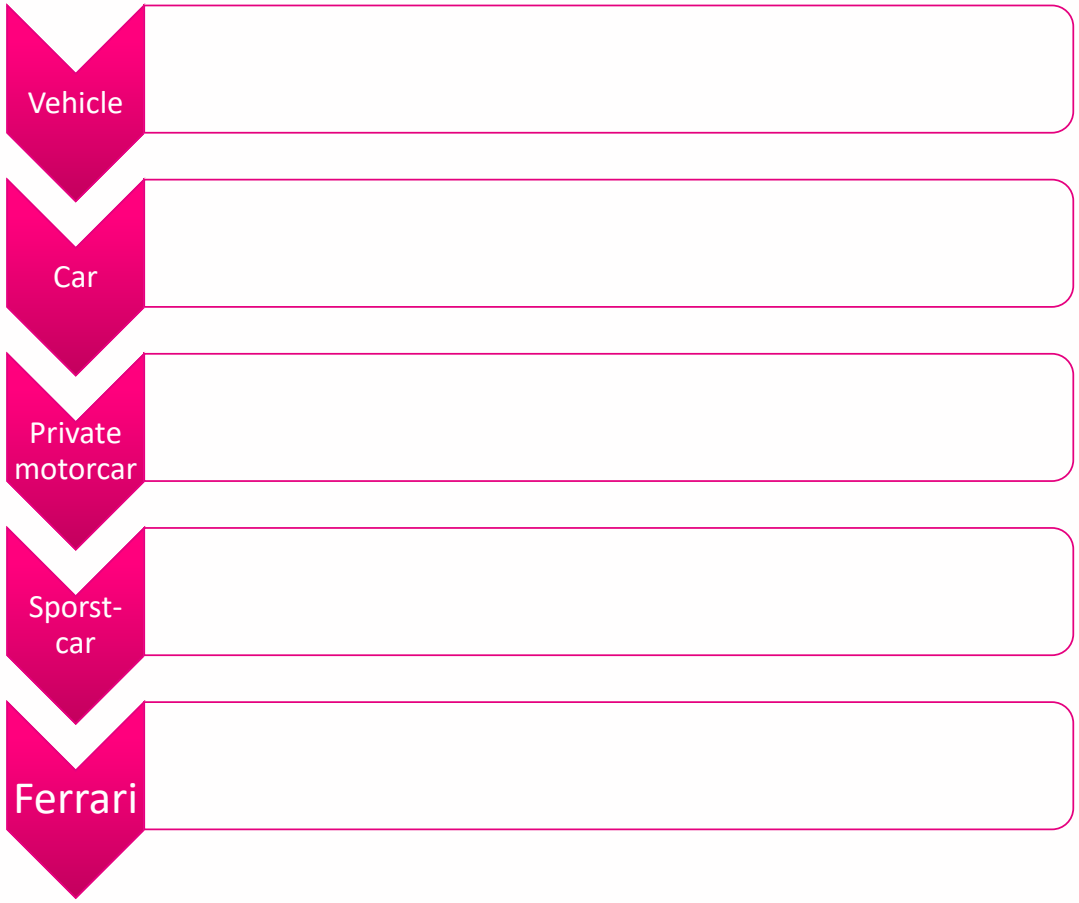
Ferrari 488 has **is-a** relationships with all these types
Its most specific type is Ferrari
Its most generic type is vehicle

a. vehicle
b. car
c. private car
d. sports car
e. Ferrari

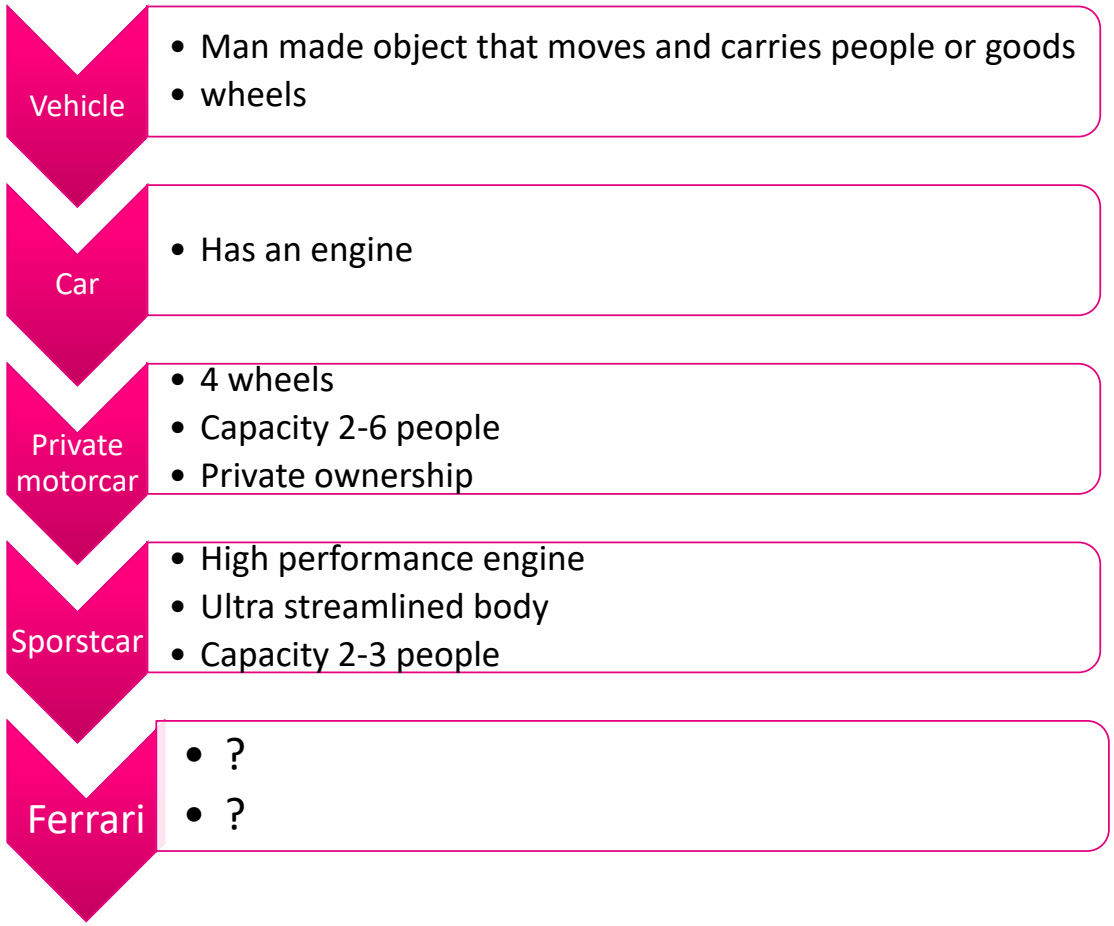


Question: what distinguishes each type?
E.g. a car from a sports car, a vehicle from a car

What are features and behaviours of each



What are features and behaviours of each:



Key idea in a class hierarchy

- The top of the hierarchy represents the **most generic attributes and behaviours**
- The bottom (the leaves) represent the **most specific attributes and behaviours**

- **Each level inherits and customises the attributes and behaviours from the level above it**

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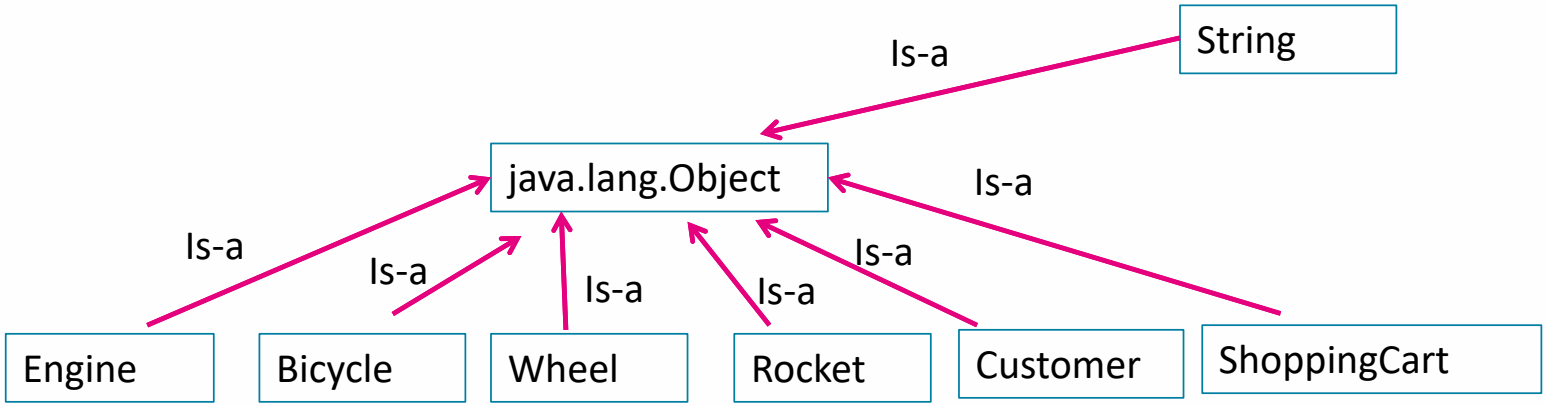
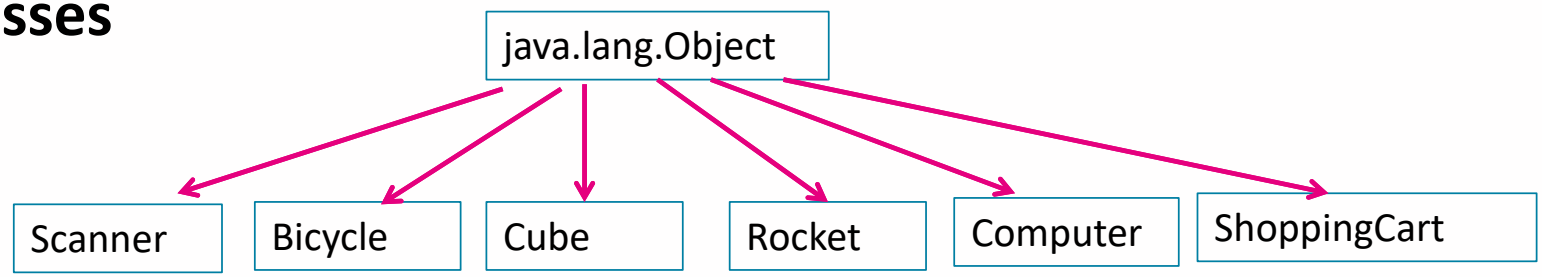
Back to Java

- Java.lang.Object is **THE superclass**, the parent of all classes in Java
- Every class in Java has java.lang.Object as its superclass (its parent)



Superclass

- In Java all child, or sub-classes **inherit** properties and methods from their **superclasses**



- All the classes shown above inherit (receive) methods from the superclass java.lang.Object
- Even though these methods may not be shown in the Class code – they are still available to objects of the Class

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OOP Inheritance

- The means by which objects automatically receive features (fields) and behaviours (methods) from their **superclasses**

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Java.lang.Object

- **equals is one of the methods provided by java.lang.Object**
- Look up the java.lang.Object class definition on the Web:
- http://docs.oracle.com/javase/8/docs/api/java/lang/Object.html

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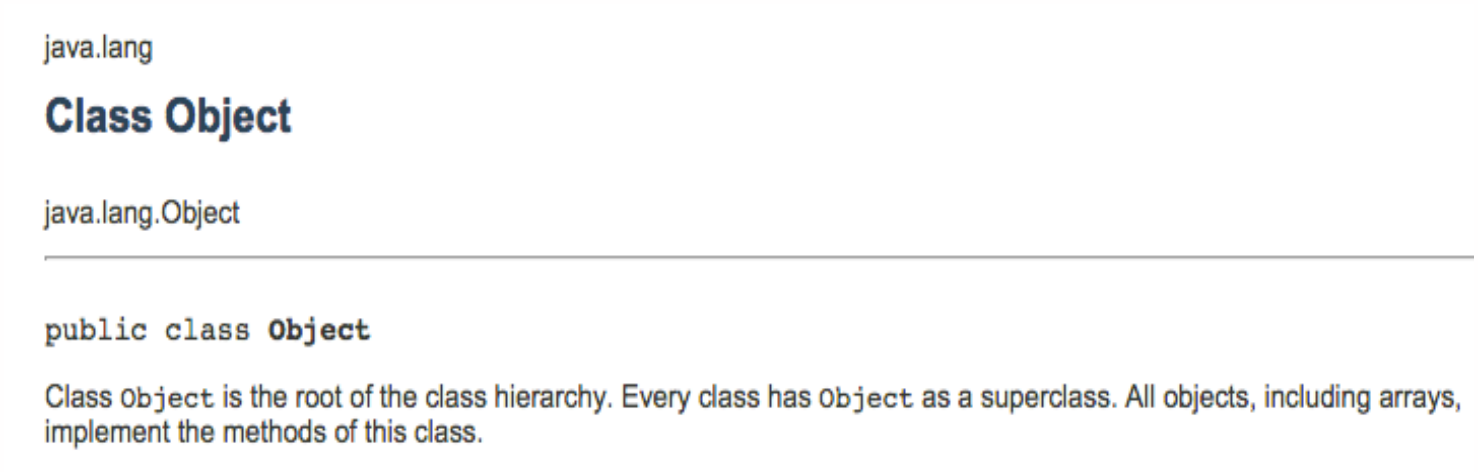
http://docs.oracle.com/javase/8/docs/api/java/lang/Object.html



java.lang

Class Object

java.lang.Object

```
public class Object
```

Class `Object` is the root of the class hierarchy. Every class has `Object` as a superclass. All objects, including arrays, implement the methods of this class.

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java.lang

Class Object

Methods

Modifier and Type	Method and Description
`protected Object`	**`clone()`** Creates and returns a copy of this object.
`boolean`	**`equals(Object obj)`** Indicates whether some other object is "equal to" this one.
`protected void`	**`finalize()`** Called by the garbage collector on an object when garbage collection determines that there are no more references to the object.
`Class<?>`	**`getClass()`** Returns the runtime class of this `Object`.
`int`	**`hashCode()`** Returns a hash code value for the object.
`void`	**`notify()`** Wakes up a single thread that is waiting on this object's monitor.
`void`	**`notifyAll()`** Wakes up all threads that are waiting on this object's monitor.
`String`	**`toString()`** Returns a string representation of the object.
`void`	**`wait()`** Causes the current thread to wait until another thread invokes the **`notify()`** method or the **`notifyAll()`** method for this object.
`void`	**`wait(long timeout)`** Causes the current thread to wait until either another thread invokes the **`notify()`** method or the **`notifyAll()`** method for this object, or a specified amount of time has elapsed.
`void`	**`wait(long timeout, int nanos)`** Causes the current thread to wait until another thread invokes the **`notify()`** method or the **`notifyAll()`** method for this object, or some other thread interrupts the current thread, or a certain amount of real time has elapsed.

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Generic methods

- All the methods provided by java.lang.Object are *generic*
- They only relate *to* java.lang.Object but not to the subclasses
- When a subclass inherits these methods, it needs to customise them
- This is why we have to write own version of equals() for the Bicycle class
- **Overriding:** when you write your own version of a method that you have inherited from a superclass

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Overriding

When overriding a method, you must keep every part of the method signature the same
You only change the code in method body

```
37  /**
38   * version 2 of an equals method
39   * @param  object  a parameter of type Bicycle
40   * @returns true or false
41   */
42  public boolean equals(Object obj){
43
44      if(obj==null){
45         return false;
46      }
47
48      if (obj instanceof Bicycle){
49
50          Bicycle bike = (Bicycle)obj;
51
52          if(this.speed ==bike.getSpeed() && this.gear==bike.getGear()){
53              return true;
54          }
55
56      }
57      return false;
58  }
```

Method signature

Method Body

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Overriding rules

- **Overriding** a method means creating a specific version of a method inherited from a parent (superclass) class
- The only rule is that you keep the **signature** of the method the same
- Its name (e.g. equals)
- Its parameter types and order
- Its access level (e.g. public, protected)
- Its return type (e.g. boolean)

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This is called an **Annotation**. Your code will compile and run without it. But is considered good practice to annotate the methods that are *overridden* versions inherited from the superclass

```
51  /**
52   * version 2 of an equals method
53   * @param  object a parameter of type Bicycle
54   * @returns true or false
55   */
56  @Override
57  public boolean equals(Object obj){
58
59      if(obj==null){
60          return false;
61      }
62
63      if (obj instanceof Bicycle){
64
65          Bicycle bike = (Bicycle)obj;
66
67          if(this.speed ==bike.getSpeed() && this.gear==bike.getGear()){
68              return true;
69          }
70
71      }
72      return false;
73  }
```

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After this week's work, you should know how to:

- Write an equals method with the correct signature for any object
- Explain what java.lang.Object is
- Explain why you may need to check if a reference variable points to null
- Write an expression that uses **instanceof** to check the type (class) of an object
- Explain the concept of superclass and subclass
- Explain that the type of a reference variable can differ from the type of the object it points to
- Following from the last point, explain that the type of the variable can only be of a class (type) higher in the class hierarchy that the object that it points to
- Object obj = new Bicycle(2,14);
- Explain the basic idea of inheritance: properties and methods are received (inherited) from the superclass(es)
- Explain and demonstrate that subclasses can specialise and create their own versions of methods inherited from the superclass. This is called **overriding.** Inherited methods that are customised by the subclass are said to be "overridden"

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