

---

---

# COMP2511

## Tutorial 2

---

---

# Last Week's Tutorial

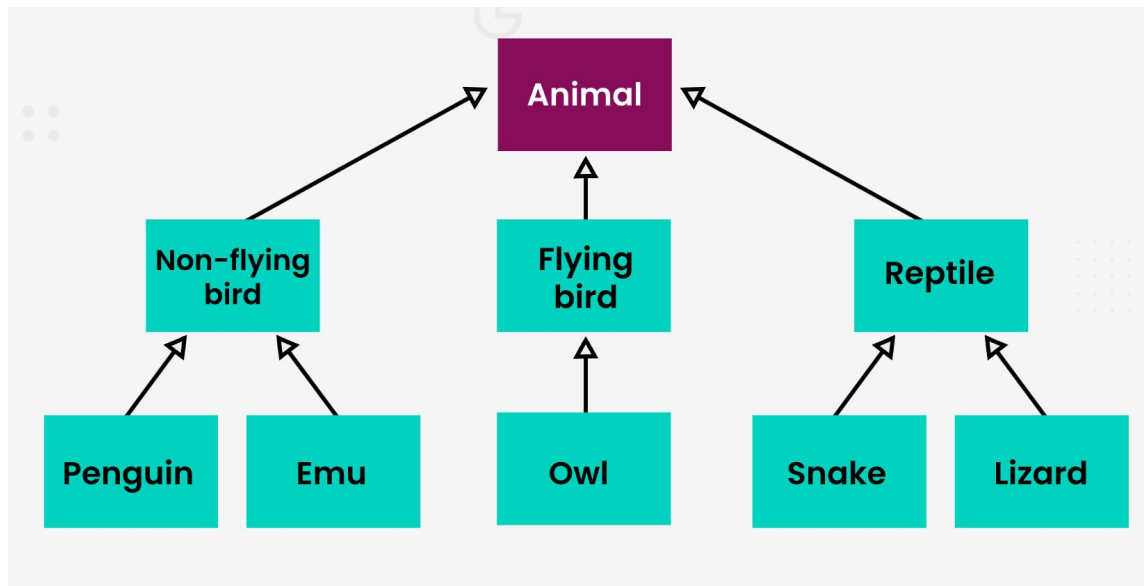
- Course Introduction
- Introduction to Java
- Introduction to Classes

# This Week's Tutorial

- Inheritance
- Method Overriding
- Interfaces and Abstract Classes (if time permits)
- Polymorphism (if time permits)

# Inheritance

- At its core, inheritance is about reusing existing classes to create new classes. Think of these new classes as **extensions** of another class.



# Inheritance

- **Inheritance** refers to the use of an existing class as a basis for the creation of a new class, by making the new class have a copy of **every** field and method from the existing class.
  - The class that inherits another class is referred to as the **subclass/child class**, while the class being inherited from is referred to as the **superclass/parent class**.
  - Inheritance doubles-up as a way for us to reuse code *and* extend upon existing systems.
    - If you were modelling two related classes A and B with a lot of shared attributes, you could capture all of the shared attributes in a parent class and make A and B inherit this parent class (**less repetition**).
    - If you had to add behaviour on top of an existing class, you could create a new subclass of the existing class, which contains the new functionality (**extensibility**).

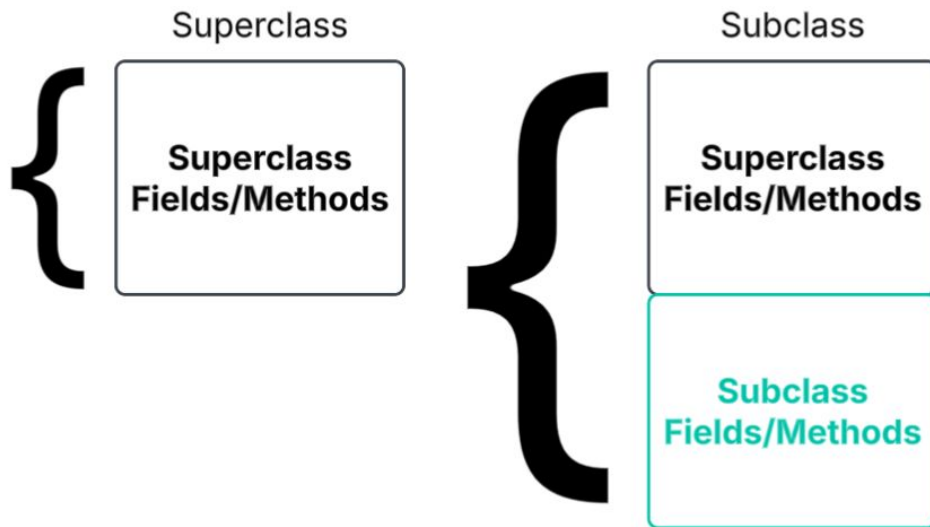
# Inheritance

- Inheritance enforces an **'is-a'** relationship between a subclass and its superclass.
  - **If B is a subclass of A, then an instance of B is also an instance of A.** Use this as a litmus test to determine if inheritance is appropriate! e.g. a Cat is an Animal.
  - A subclass should be able to do the same things as its superclass, most likely more.
- All classes in Java are subclasses of the `Object` class.
- In Java, the **`extends`** keyword makes a class inherit from another.

```
public class Animal {  
    // some animal fields and methods ...  
}  
  
class Cat extends Animal {  
    // some cat fields and methods ...  
}
```

# Inheritance

- Think of parent classes and subclasses like this; the subclass is the parent class with more stuff 'attached' on top.



# Quiz: Inheritance

- Suppose Cat is a subclass of Animal. Are each of the following valid?

```
public static void main(String[] args) {  
    Animal a = new Cat();  
}
```

Yes; all Cats are Animals.

```
public static void main(String[] args) {  
    Cat c = new Animal();  
}
```

No; not all Animals are Cats.

```
public static void main(String[] args) {  
    List<Animal> l = new ArrayList<Animal>();  
    l.add(new Cat());  
}
```

Yes; all Cats are Animals.



# Live Example: JavaDoc and Inheritance

- Review the **Employee** class in src/employee, which has been documented with JavaDoc.
  - How do you write JavaDoc?
  - Should code should always have comments/JavaDoc?
  - What is meant by the term "self-documenting code"?
- Create a **Manager** class that is a subclass of Employee and has a field for the manager's hire date.
  - What constructor(s) should we define for the Manager class?
  - Demonstrate how VSCode can generate getters and setters automatically.
  - Why might adding certain getters and setters be bad design?
- [KEY TAKEAWAYS] Writing JavaDoc, subclass creation, thinking about abstraction.

# Type-Checking in Java

- **Remember!** If we have a class A which has a subclass B, instances of B are instances of A.
  - This also applies for inheritance that goes deeper down (*transitivity*). For example, if C was a subclass of B, then instances of C are also instances of A (and B, and C).
- Keeping this in mind, if we want to check if an object is an instance of A **or any subclasses of A**, we use the **instanceof** keyword.
  - For example: `a instanceof A` returns true if the object a is of type A or any of its subclasses, and false otherwise.
- If we want to make an exact comparison on an object's class ignoring subclass relationships, we can compare using the `getClass()` method.
  - For example: `a.getClass() == b.getClass()` returns true if a and b are instances of the same exact class, and false otherwise.

# Method Overriding

- **Important!** A subclass inherits **all** of its superclass' fields and methods. Private fields/methods cannot be accessed, but are technically still there.
  - If class A defines a (public) method `doSomething()` and class B extends A, then `doSomething()` can also be invoked from instances of class B.
- A subclass can provide its own implementation of a method inherited from its superclass, effectively **overriding** its original functionality.
  - The method being overridden by the subclass needs to have the same **method signature** as the one in the superclass (exact same method name and parameters).
- All overridden methods should have the `@Override` tag on top.
  - This is not strictly enforced by the Java compiler, but is best practice. It helps to explicitly declare your intent to override a method and prevent bugs (eg. notifying you if you are trying to override a method that does not exist, or using the wrong method signature).

# Quiz: Method Overriding

- What does the following code output?

```
class A {  
    public void print1() {  
        System.out.println("Hello from A!");  
    }  
  
    public void print2() {  
        System.out.println("Hello again from A!");  
    }  
}  
  
class B extends A {  
    @Override  
    public void print1() {  
        System.out.println("Hello from B!");  
    }  
}
```

```
public class Main {  
    public static void main(String[] args) {  
        A a = new A();  
        B b = new B();  
        a.print1();  
        b.print1();  
        b.print2();  
    }  
}
```

## Quiz: Method Overriding

- `a.print1()` prints "Hello from A!", nothing new.
- `b.print1()` prints "Hello from B!", since this method has been overridden.
- `b.print2()` prints "Hello again from A!", since this method has not been overridden.

```
Hello from A!  
Hello from B!  
Hello again from A!
```

# Live Example: Method Overriding (Pt. 1)

- Recall that all classes in Java are subclasses of the Object class, so it inherits all of Object's methods.
- One of these inherited methods is `toString()`.
  - What does Object's implementation of `toString()` do?
  - What would actually be useful to include in the result of `toString()`?
- Override the `toString()` method in the Employee and Manager classes defined earlier. How can we reuse code from Employee's `toString()` while writing Manager's `toString()`?
- [KEY TAKEAWAYS] Overriding methods, reusing superclass methods.

# Live Example: Method Overriding (Pt. 2)

- What is a suitable criterion for two objects to be considered equal?
  - If two objects are instances of the same exact class and have all corresponding fields equal, we can consider them to be equal.
  - There are other ways to define equality, but we will take the above as the definition.
- Does the `==` operator abide by this definition of equality between objects? If not, how does it actually determine equality?
- Another method all classes inherit from Object is `equals()`.
  - What does Object's implementation of `equals()` do?
  - What would we want our implementation of `equals()` to do?
- Override the `equals()` method in the Employee and Manager classes defined earlier. How can we reuse code from Employee's `equals()` while writing Manager's `equals()`?
- [KEY TAKEAWAYS] Same as Pt. 1, type-checking, safe type-casting.

# Abstract Classes

- An **abstract class** is a class that *cannot be instantiated*. They allow methods without concrete implementations to be declared, called abstract methods.
- They essentially act as templates to declare a common structure between any subclasses that derive off of it (remember both fields and methods are inherited down!).
  - This is useful for when you want to create a parent class capturing a bunch of common fields and methods, but this class doesn't make sense as a concrete object (e.g. Animal).
  - Concrete classes that inherit abstract methods must provide the concrete implementations for those methods (otherwise the code cannot compile).
  - Concrete implementations can still be defined within abstract classes.



# Interfaces

- An **interface** is essentially a *contract* prescribing a list of methods. Any class that **implements** the interface must provide the concrete implementation for these prescribed methods.
- Interfaces cannot be instantiated like (concrete) classes can.
- Each class in Java can have only one superclass, but can implement as many interfaces as it would like.

# Polymorphism

- **Polymorphism** is the ability to use a **common interface** across **different types/classes** to invoke certain functionality, regardless of how that functionality is implemented in each of the classes.
  - Here, 'interfaces' is a general term, not specifically the interfaces we just talked about. Abstract classes and interfaces provide very useful ways to apply polymorphism by 'prescribing' specific methods that should be invocable.
  - In other words, it is the ability to interact with different objects in the same exact way, despite any differences in how they choose to do things.
  - This captures the essence of well designed object-oriented code; polymorphism provides a simple, yet flexible way to interact with the objects of a system.

# Code Example: Polymorphism

- Since the A class from earlier defines a method called `print1()`, we know that any objects of type A (or subclasses of A) must also have this method (overridden or not).
- If we store a list of objects of type A (which can also store subclasses of A), `print1()` must be common between all of these objects. Hence, we are guaranteed to be able to call it; the actual behaviour of the method differs across objects, depending on their actual class!

```
public class Main {  
    public static void main(String[] args) {  
        A a = new A();  
        B b = new B();  
        A c = new B();  
        List<A> myList = List.of(a, b, c);  
        for (A elem : myList) {  
            elem.print1();  
        }  
    }  
}
```

```
Hello from A!  
Hello from B!  
Hello from B!
```

# Live Example: Polymorphism

- Look at the code in the src/languages package, which models multiple students learning different languages.
  - When does it make sense for a class to be abstract?
  - What is the difference between an abstract class and an interface? Why would you use one or the other?
  - Refactor the code to improve its quality.
- [KEY TAKEAWAYS] Interface and abstract class syntax, recognising where the use of either is applicable

# Access Modifiers

	default	private	protected	public
Same Class	Yes	Yes	Yes	Yes
Same package subclass	Yes	No	Yes	Yes
Same package non-subclass	Yes	No	Yes	Yes
Different package subclass	No	No	Yes	Yes
Different package non-subclass	No	No	No	Yes