# COMP2511

Tutorial 3

# Last Week's Tutorial

- Inheritance
- Method Overriding

# This Week’s Tutorial

- Domain Modelling
  - Creating UML diagrams to model classes and class relationships
- Testing
  - Writing JUnit tests
  - VSCode debugging tools
  - Exceptions
- Design by Contract

# Notices

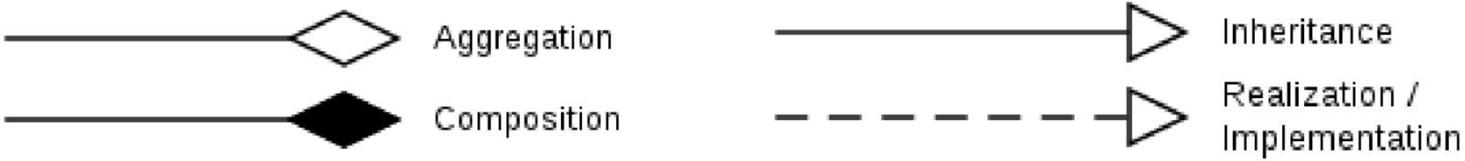
- Assignment 1 has been released on GitLab.
  - Before submitting, you should use `2511 dryrun ass1` on CSE servers to check that your project compiles.
- Keep an eye out for a form to preference your partner for Assignment 2 within the next week. Please fill this in regardless of whether you have a specific partner in mind.

# UML Diagrams

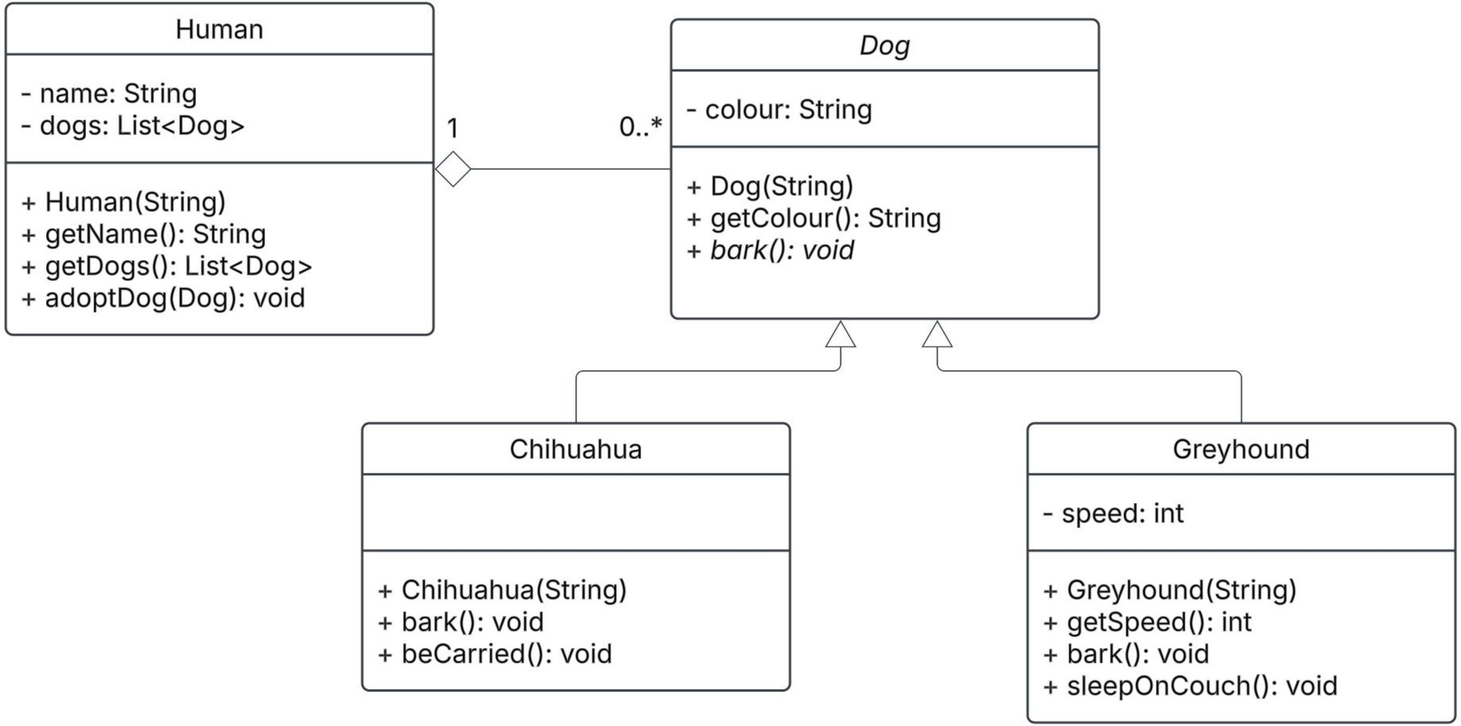
- **UML** (**U**nified **M**odeling **L**anguage) diagrams are commonly used to visually demonstrate the structure of a system in terms of its components (classes) and the relationships between each of the components.
- From a UML diagram, we should be able to tell a lot about the system, such as:
    - which classes are present in the system
    - what fields and methods each of the classes have
    - which classes are subclasses of other classes (**is-a** relationships)
    - which classes contain instances of other classes (**has-a** relationships) and the **cardinality** of the relationship (e.g. 1 car has 1 steering wheel, 1 class has many students, many students have 1 teacher)

# Relationships in UML Diagrams

- For inheritance/implementation, the arrow points to the **parent class** being inherited/**interface** being implemented.
- For 'has-a' relationships, the diamond is on the side of the container.
- Two types of 'has-a' relationships:
  - **Aggregation**: A contains B. B *can* exist independently of A (i.e. the existence of B is not directly tied to A). For example, a classroom has students.
  - **Composition**: A contains B. B *cannot* exist independently of A (i.e. the existence of B is directly tied to A). For example, a person has thoughts.



# UML Diagram Example



# Live Example: Domain Modelling

- A Car has one or more engines and a producer. The producer is a manufacturing company who has a brand name. Engines are produced by a manufacturer and have a speed. There are only two types of engines within UNSW's cars:
  - Thermal Engines, which have a default max speed of 114, although they can be produced with a different max speed, and the max speed can change to any value between 100 and 250.
  - Electrical Engines, which have a default max speed of 180. This is the speed at which they are produced, and the max speed can change to any value that is divisible by 6.
- Cars are able to drive to a particular location x, y.

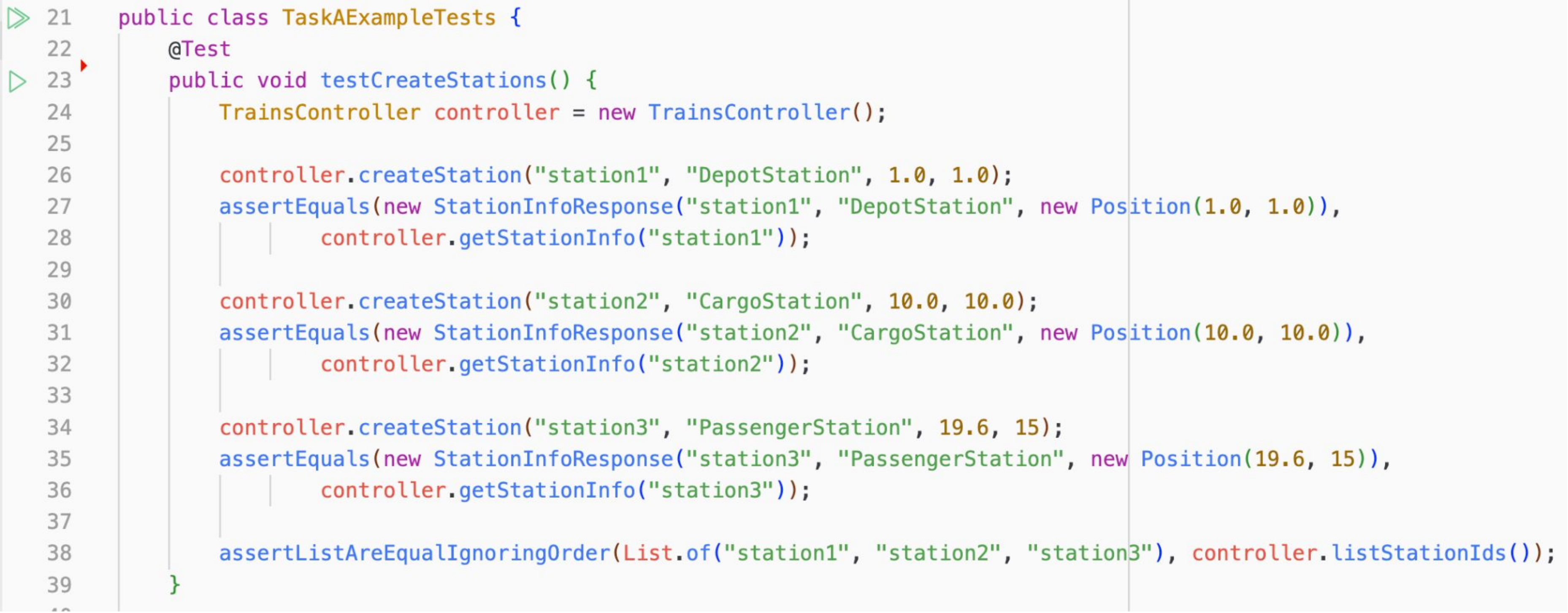
Additionally, we want to model the behaviour of a time travelling car, as well as time travelling for any vehicle. A ‘time travelling vehicle’ stays in the same location but travels to a LocalDateTime.

**Create a UML diagram which models the domain.**

# Testing - JUnit

- JUnit is the main testing framework we use in this course, similar to what Jest is to COMP1531.
- Each testing suite is separated into its own class, and each of the methods defined in that class will be the individual unit tests.
  - For example, if you were making a test suite to test Task 1 of Assignment 1, this could be put in a file called `Task1Tests.java`, and a method in the class could be `testCreateTrain()`.
- Unit tests are identified using the `@Test` tag over method names, like the `@Override` tag for method overriding.
  - This tag lets your extensions recognise methods as tests, allowing you to run them by clicking a button.
- In each unit test, you can perform logic similar to how you would write a main function - conditions are checked using **assertions**, like `assertEquals()`, `assertTrue()` and `assertThrows()`. If any assertion in a unit test fails, the whole test fails.

# Testing - JUnit Example (from Assignment 1)

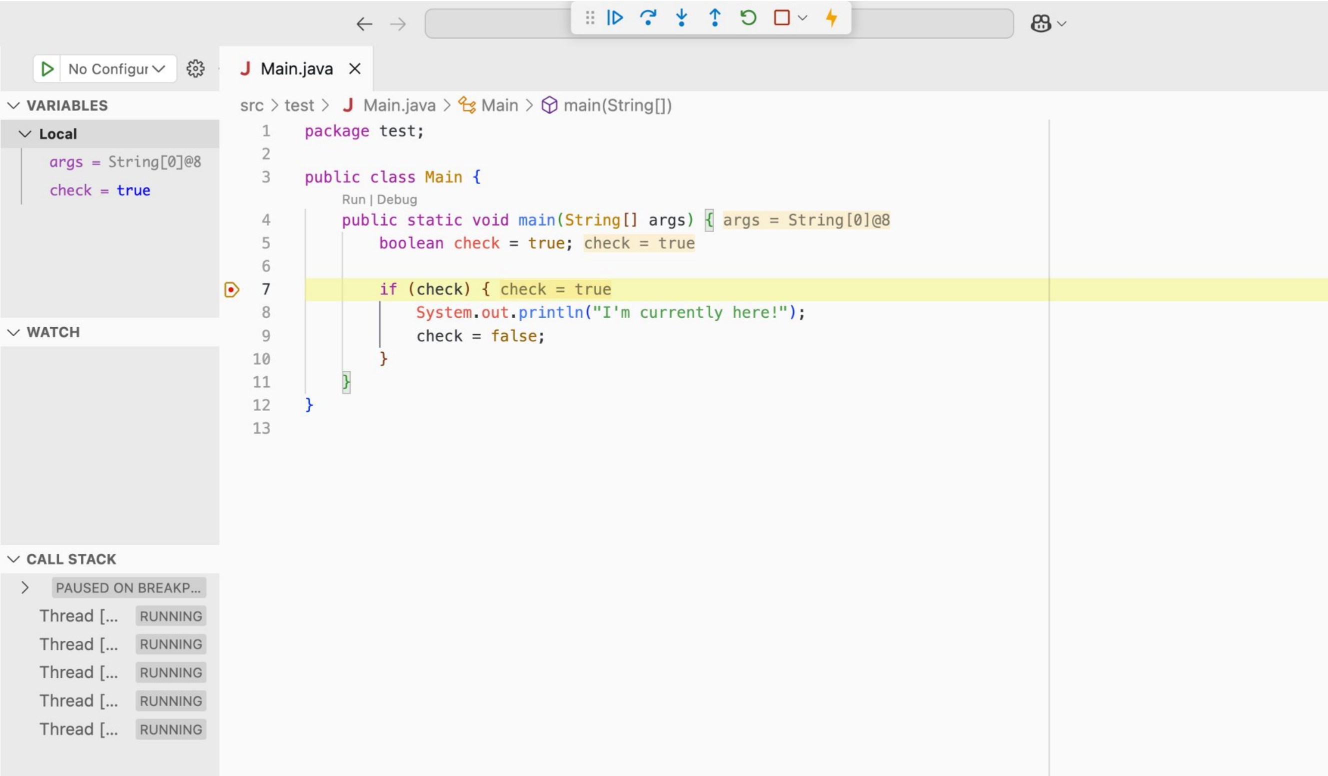


```java
public class TaskAExampleTests {
    @Test
    public void testCreateStations() {
        TrainsController controller = new TrainsController();

        controller.createStation("station1", "DepotStation", 1.0, 1.0);
        assertEquals(new StationInfoResponse("station1", "DepotStation", new Position(1.0, 1.0)),
                controller.getStationInfo("station1"));

        controller.createStation("station2", "CargoStation", 10.0, 10.0);
        assertEquals(new StationInfoResponse("station2", "CargoStation", new Position(10.0, 10.0)),
                controller.getStationInfo("station2"));

        controller.createStation("station3", "PassengerStation", 19.6, 15);
        assertEquals(new StationInfoResponse("station3", "PassengerStation", new Position(19.6, 15)),
                controller.getStationInfo("station3"));

        assertListAreEqualIgnoringOrder(List.of("station1", "station2", "station3"), controller.listStationIds());
    }
```

# Testing - IDE Debugging

- At this point in the course, your main method of debugging has most likely been through using print statements.
- We have access to some more advanced debugging techniques that allow us to step through the execution of the program, like GDB for C.
- A **breakpoint** is a specific spot in your code where you would like to intentionally pause execution.
  - In VS Code, they can be set on the *glyph margin*, which is to the left of each of the line numbers.
  - By running your code in **debug mode**, you can stop execution at breakpoints, allowing you to inspect the state of variables and the function call stack, and also to step through the program to analyse the control flow of the program (if statements, while loops...).

# Testing - IDE Debugging Example

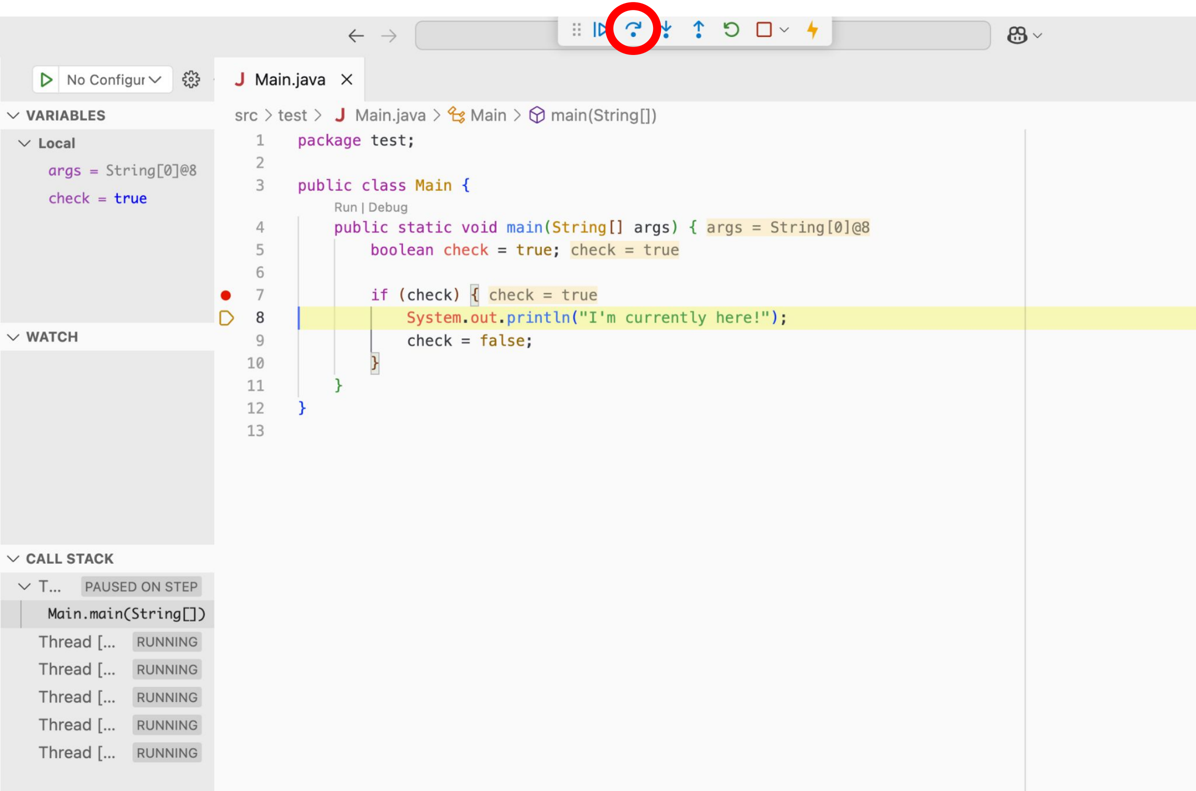


```
args = String[0]@8
check = true
```

```
package test;

public class Main {
    Run | Debug
    public static void main(String[] args) { args = String[0]@8
        boolean check = true; check = true

        if (check) { check = true
            System.out.println("I'm currently here!");
            check = false;
        }
    }
}
```

```
PAUSED ON BREAKP...
Thread [...   RUNNING
Thread [...   RUNNING
Thread [...   RUNNING
Thread [...   RUNNING
Thread [...   RUNNING
```

# Testing - IDE Debugging Example



```java
package test;

public class Main {
    public static void main(String[] args) { args = String[0]@8
        boolean check = true; check = true

        if (check) { check = true
            System.out.println("I'm currently here!");
            check = false;
        }
    }
}

```

# Exceptions

- An **exception** is an event that occurs when an error is encountered during the execution of a program.
  - When the error occurs, an *exception object* containing information about the error is created and **thrown** to the runtime system for it to handle.
  - In simpler terms, you can think of exceptions as flags that something has gone wrong, such as division by zero or trying to dereference null.
- In Java, exceptions are classified into two categories:
  - **Checked exceptions**, which need to be included in a method's signature if it can potentially be thrown and caught in a *try-catch* block (eg. `IOException`).
  - **Unchecked exceptions**, which do not need to be included in a method's signature or caught in a try-catch block (eg. `ArithmeticException`, `IllegalArgumentException`).

# Live Example: Debugging (Pt. 1)

- The Wondrous Sequence is generated by the simple rule:
  - If the current term is even, the next term is half the current term.
  - If the current term is odd, the next term is three times the current term, plus 1.
  - For example, the sequence generated by starting with 3 is [3, 10, 5, 16, 8, 4, 2, 1].
  - If the starting term is 1, then an empty list is returned.
- Inside **src/wondrous** there is an implementation of this algorithm, and a single test for the function which currently fails.
- Use the debug tools and the given algorithm to determine why the test is failing, and fix the bug.

# Live Example: Debugging (Pt. 2)

- Are we confident that the implementation is completely bug-free now? Create a new unit test for a potentially untested case.
- Alongside the above, modify the method such that if `start` is less than 1, an `IllegalArgumentException` is thrown. Write a corresponding test for this inside WondrousTest.
  - In many cases when we throw an exception we need to update the method signature and existing tests but here we don't - why is this?

# Defensive Programming vs. Design by Contract

- **Defensive Programming** is a programming approach that accounts for unforeseen circumstances, and tries to ensure that programs will behave predictably despite unexpected inputs or user actions.
    - For example, checking for null inputs in every method before any logic is performed.
    - This approach makes programs more secure and robust, but it could potentially obscure the main logic of the program and be redundant.
- **Design by Contract** is an approach where your code is written around a set of clear and well-defined specifications, which *when adhered to* guarantees correct and expected behaviour.
    - For example, you would not need to perform any null checks if it is explicitly stated in the requirements (contract) that null will not be given as an input.
    - This can make a program's logic clearer, but makes it vulnerable when this contract is not abided to.

# Design by Contract

- In the context of a method,
  - a **precondition** is a condition on the **input** that the method will perform as expected.
  - a **postcondition** is a guarantee on what the method will output/perform, *given that the precondition holds*.
  - an **invariant** is a property of the system that is guaranteed to be maintained once the method has been performed.
    - this property can change *during* the method's execution, the importance is that it should hold once the method is completed.
- Essentially, if someone defines a precondition for a specific method and it isn't satisfied when the method is executed, then they can no longer make any assumptions about the correctness of the method.

# Design by Contract and LSP

- The **Liskov Substitution Principle** (LSP) is an important concept in OOP, which states that everywhere an instance of a superclass is used, swapping it out for an instance of its subclass should not affect the correctness of the program.
- Contracts are inherited from superclasses to their subclasses.
- This means that:
  - **preconditions** in the subclass must either stay the same or be **loosened**,
  - **postconditions** in the superclass must either stay the same or be **tightened**.

# Design by Contract and LSP

- Suppose B is a subclass of A. Is the inheritance in the following examples valid?
  - A has a method with a precondition that it accepts integers between 0-50. B overrides the method to accept any integer between 0-100.
    - This is valid. Any input that satisfies the preconditions of A's method also satisfies the preconditions of B's method.
    - The other way around would be invalid!
  - A has a method with a postcondition that it returns a sorted list of integers. B overrides the method to return an unsorted list.
    - This is invalid, as an unsorted list is not a sorted list so the postcondition is not satisfied by B's method.
    - The other way around would be valid!

# Live Example: Design by Contract

- In **src/people**, there are a few classes which represent the people at a university.
  - Briefly discuss the preconditions and postconditions of the constructors, getters and setters in Person.java.
  - Fill in the preconditions and postconditions for setSalary in Person.java.
  - Discuss the validity of the subclasses of Person, and why they are/aren't valid subclasses.
  - Fix any issues identified.
  - [KEY TAKEAWAYS] Reasoning with preconditions and postconditions, exploring its relationship with inheritance

# Assignment 1 Tips

- If you are unsure of anything on the spec, make sure to ask on the forum or use the sample implementation!
- If you have not started yet, taking the time to read the spec is already a huge step forward.
    - 45% of your mark will be based on the quality of your design, which you can only start thinking about once you know what you have to do!
    - Thinking about your design is something you can do while doing basically anything else; you do not have to be in front of a computer coding to do this!
    - I would heavily recommend having a read of the whole spec before creating sketches/drafts of your design, so that you can easily adapt your code as you move through the tasks (i.e. think of the longer term consequences of your design choices).

# Assignment 1 Tips

- Do lots of testing (which we have covered today)!
    - It’s likely that you’ll have to scrap certain ideas and change lots of things around as you create your design and complete the assignment. This is a very natural part of the process!
    - While refactoring, you can only be confident that you haven’t messed up your logic if you are consistently testing your code and have a good test suite.
    - While only a small portion (5%) of the marks are awarded for testing, it’s very likely that the effort you put into your tests will have a correlation to the amount of autotests you pass (i.e. your automark).
- Remember that with design, there’s not always just one correct answer.
    - I will be looking to see that you have outlined and justified your specific design choices in your blog, rather than marking based off of a checklist.

# Extra Material

# Code Example - Method Overriding and Static Fields

- Review the UniStudent and Point classes in **src/review**. What will each class' main methods output?
    - [KEY TAKEAWAYS] Understanding when an implementation of a non-static method is determined (dynamic dispatch), how a static field works

# [EXTENSION] Method Hiding

- Can static methods be overridden?
  - No, since static methods belong to specific classes.
  - Method overriding is associated with re-defining the functionality of a method defined in an earlier class, but this makes no sense if those methods belong to the earlier class itself, rather than concrete instances…
- Can static methods be inherited?
  - Perhaps surprisingly, yes!
  - This is because you can still call a static method from a concrete instance of the class. This is bad practice however, so you shouldn’t really run into this in the wild.
- With this in mind, is there something *similar* to method overriding for static methods?

# [EXTENSION] Method Hiding

- If a subclass defines a static method with the **same method signature** as a static method in the superclass, then the method in the subclass *hides* the one in the superclass.
- If a concrete instance of a class calls a static method, the actual method called depends on its **static type**, or **type of reference**.
  - This is distinct to method *overriding*, where the actual method called is determined by the type of the actual object, and is determined dynamically (i.e. at run-time, rather than at compile-time through static checks). This mechanism is known as **dynamic dispatch**, and is used for all non-static methods in Java.

# [EXTENSION] Code Example - Method Hiding

- Review the UniStudent class in **src/hiding**. What will the main method output? How does this differ to the functionality of UniStudent in **src/review**?
    - [KEY TAKEAWAYS] Understanding when an implementation of a static method is determined (static dispatch)