

Java: Composition, Inheritance, Interfaces

M250 24J Tutorial 05

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1 M250 Java: Composition, Inheritance, Interfaces: Tutorial Agenda

- Introductions
- Adobe Connect reminders
- *Adobe Connect* — if you or I get cut off, wait till we reconnect (or send you an email)
- Composition
- Inheritance, subclasses, superclasses
- Interfaces
- String Formatting
- JShell (optional)
- Some useful Web & other references
- Time: about 1 to 2 hours
- Do ask questions or raise points.
- Slides/Notes [M250Tutorial20240218InheritanceInterfacesPrsntn2023J/](#)

Introductions — Phil

- *Name* Phil Molyneux
- *Background*
 - Undergraduate: Physics and Maths (Sussex)
 - Postgraduate: Physics (Sussex), Operational Research (Brunel), Computer Science (University College, London)
 - Worked in Operational Research, Business IT, Web technologies, Functional Programming
- *First programming languages* [Fortran](#), [BASIC](#), [Pascal](#)
- *Favourite Software*
 - [Haskell](#) — pure functional programming language
 - Text editors [TextMate](#), [Sublime Text](#) — previously [Emacs](#)
 - Word processing in [L^AT_EX](#) — all these slides and notes

- [Mac OS X](#)

- *Learning style* — I read the manual before using the software

Introductions — You

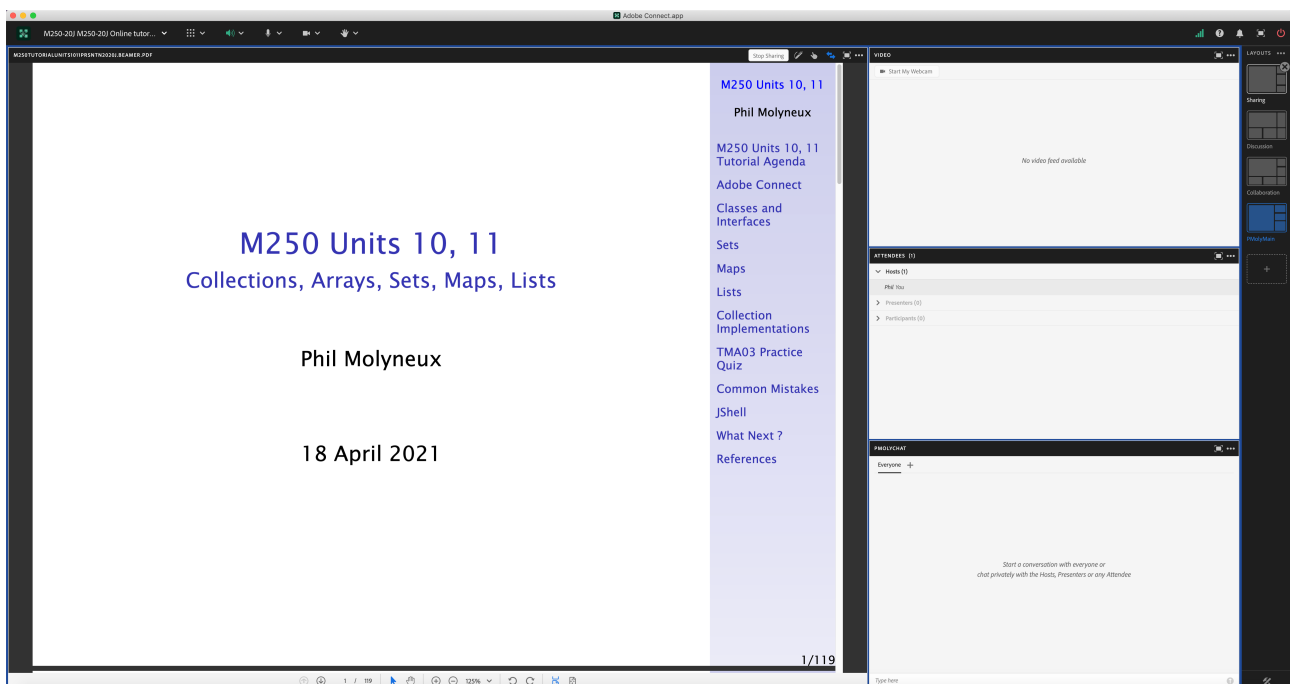
- *Name ?*
- *Favourite software/Programming language ?*
- *Favourite [text editor](#) or [integrated development environment \(IDE\)](#)*
- [List of text editors](#), [Comparison of text editors](#) and [Comparison of integrated development environments](#)
- *Other OU courses ?*
- *Anything else ?*

[ToC](#)

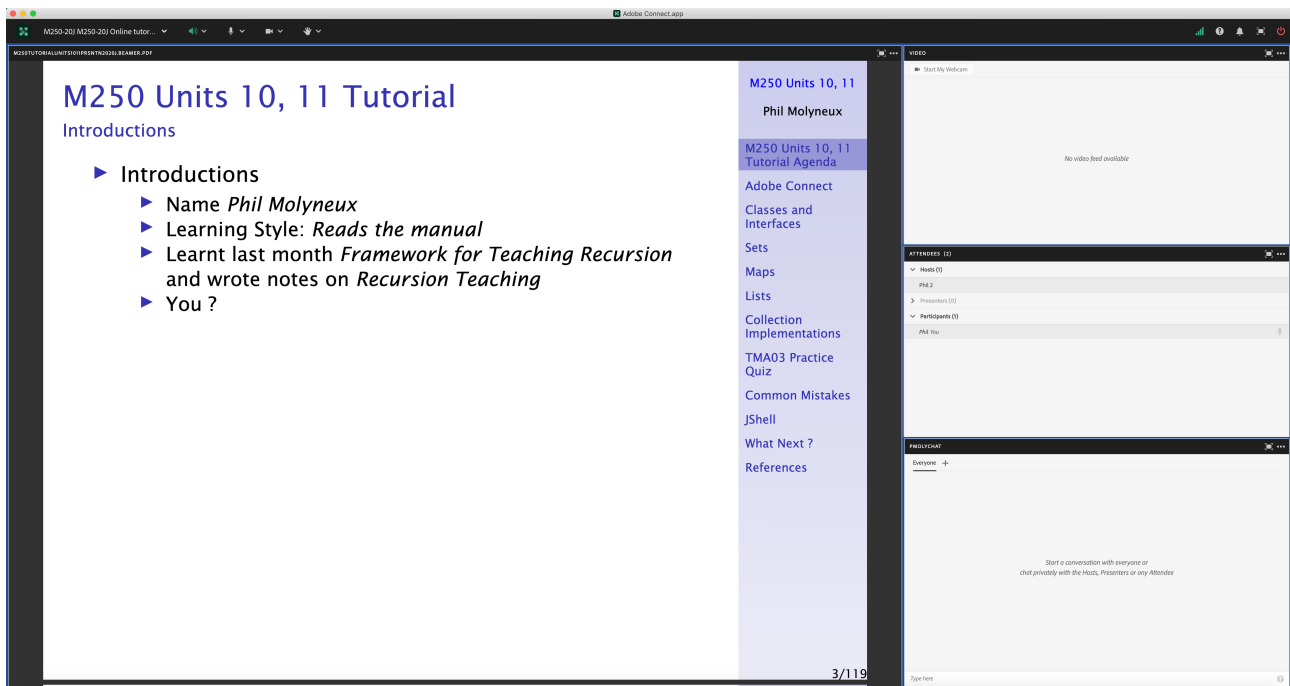
2 Adobe Connect Interface and Settings

2.1 Adobe Connect Interface

Adobe Connect Interface — Host View



Adobe Connect Interface — Participant View



2.2 Adobe Connect Settings

Adobe Connect — Settings

- **Everybody** **Menu bar** **Meeting** **Speaker & Microphone Setup**
- **Menu bar** **Microphone** **Allow Participants to Use Microphone** ✓
- Check Participants see the entire slide including slide numbers bottom right **Workaround**
 - **Disable Draw** **Share pod** **Menu bar** **Draw icon**
 - **Fit Width** **Share pod** **Bottom bar** **Fit Width icon** ✓
- **Meeting** **Preferences** **General** **Host Cursor** **Show to all attendees**
- **Menu bar** **Video** **Enable Webcam for Participants** ✓
- Do not *Enable single speaker mode*
- Cancel hand tool
- Do not enable green pointer
- **Recording** **Meeting** **Record Session** ✓
- **Documents** Upload PDF with drag and drop to share pod
- Delete **Meeting** **Manage Meeting Information** **Uploaded Content** and **check filename** **click on delete**

Adobe Connect — Access

- **Tutor Access**

TutorHome **M269 Website** **Tutorials**

Cluster Tutorials **M269 Online tutorial room**

Tutor Groups **M269 Online tutor group room**

Module-wide Tutorials > M269 Online module-wide room

- **Attendance**

TutorHome > Students > View your tutorial timetables

- **Beamer Slide Scaling** 440% (422 x 563 mm)

- **Clear Everyone's Status**

Attendee Pod > Menu > Clear Everyone's Status

- **Grant Access** and send link via email

Meeting > Manage Access & Entry > Invite Participants...

- **Presenter Only Area**

Meeting > Enable/Disable Presenter Only Area

Adobe Connect — Keystroke Shortcuts

- [Keyboard shortcuts in Adobe Connect](#)
- **Toggle Mic**  + **M** (Mac), **Ctrl** + **M** (Win) (On/Disconnect)
- **Toggle Raise-Hand status**  + **E**
- **Close dialog box**  (Mac), **Esc** (Win)
- **End meeting**  + ****

2.3 Adobe Connect — Sharing Screen & Applications

- **Share My Screen** > **Application tab** > **Terminal** for [Terminal](#)
- **Share menu** > **Change View** > **Zoom in** for mismatch of screen size/resolution (Participants)
- (Presenter) Change to 75% and back to 100% (solves participants with smaller screen image overlap)
- Leave the application on the original display
- Beware blue hatched rectangles — from other (hidden) windows or contextual menus
- Presenter screen pointer affects viewer display — beware of moving the pointer away from the application
- First time: **System Preferences** > **Security & Privacy** > **Privacy** > **Accessibility**

2.4 Adobe Connect — Ending a Meeting

- *Notes for the tutor only*
- **Student:** **Meeting** > **Exit Adobe Connect**
- **Tutor:**
- **Recording** **Meeting** > **Stop Recording** ✓
- **Remove Participants** **Meeting** > **End Meeting...** ✓

- Dialog box allows for message with default message:
 - *The host has ended this meeting. Thank you for attending.*
- **Recording availability** In course Web site for joining the room, click on the eye icon in the list of recordings under your recording — edit description and name
- **Meeting Information**   — can access a range of information in Web page.
- **Delete File Upload**    select file(s) and click 
- **Attendance Report** see course Web site for joining room

2.5 Adobe Connect — Invite Attendees

- **Provide Meeting URL**    
- **Allow Access without Dialog**    provides new browser window with *Meeting Information*  
- Check *Anyone who has the URL for the meeting can enter the room*
- Default *Only registered users and accepted guests may enter the room*
- **Reverts to default next session but URL is fixed**
- Guests have blue icon top, registered participants have yellow icon top — same icon if URL is open
- See [Start, attend, and manage Adobe Connect meetings and sessions](#)
- Click on the link sent in email from the Host
- Get the following on a Web page
- As *Guest* enter your name and click on 


Adobe Connect

M269-21J Online tutorial room
London/SE (1,13) CG [2311] (M269-21J)
(1)

 Guest Registered User

 Name
 Guest Name

By entering a Name & clicking "Enter Room", you agree that you have read and accept the [Terms of Use](#) & [Privacy Policy](#).

Enter Room

- See the *Waiting for Entry Access* for *Host* to give permission


Adobe Connect

Waiting for Entry Access

 This is a private meeting. Your request to enter has been sent to the host. Please wait for a response.

- *Host* sees the following dialog in *Adobe Connect* and grants access

Guest entry


1 guest would like to enter the room. Do you want to allow or deny entry to incoming guests?

Guest Name (guest)   

Allow everyone Deny everyone **Close**

2.6 Layouts

- **Creating new layouts** example *Sharing* layout
- **Menu** > **Layouts** > **Create New Layout...** > **Create a New Layout dialog** > **Create a new blank layout** and name it *PMolyMain*
- New layout has no Pods but does have Layouts Bar open (see Layouts menu)
- **Pods**

- **Menu** > **Pods** > **Share** > **Add New Share** and resize/position — initial name is *Share n* — rename *PMolyShare*
- **Rename Pod** **Menu** > **Pods** > **Manage Pods...** > **Manage Pods** > **Select** > **Rename** or **Double-click & rename**
- Add Video pod and resize/reposition
- Add Attendance pod and resize/reposition
- Add Chat pod — rename it *PMolyChat* — and resize/reposition
- Dimensions of **Sharing** layout (on 27-inch iMac)
 - Width of Video, Attendees, Chat column 14 cm
 - Height of Video pod 9 cm
 - Height of Attendees pod 12 cm
 - Height of Chat pod 8 cm
- **Duplicating Layouts** does *not* give new instances of the Pods and is probably not a good idea (apart from local use to avoid delay in reloading Pods)
- **Auxiliary Layouts** name *PMolyAuxOn*
 - Create new Share pod
 - Use existing Chat pod
 - Use same Video and Attendance pods

2.7 Chat Pods

- **Format Chat text**
- **Chat Pod** > **menu icon** > **My Chat Color**
- Choices: Red, Orange, Green, Brown, Purple, Pink, Blue, Black
- Note: Color reverts to Black if you switch layouts
- **Chat Pod** > **menu icon** > **Show Timestamps**

2.8 Graphics Conversion for Web

- Conversion of the screen snaps for the installation of Anaconda on 1 May 2020
- Using GraphicConverter 11
- **File** > **Convert & Modify** > **Conversion** > **Convert**
- Select files to convert and destination folder
- Click on **Start selected Function** or  + 

2.9 Adobe Connect Recordings

- **Menu bar** > **Meeting** > **Preferences** > **Video**
- **Aspect ratio** > **Standard (4:3)** (not Wide screen (16:9) default)

- **Video quality** **Full HD** (1080p not High default 480p)
- **Recording** **Menu bar** **Meeting** **Record Session** ✓
- **Export Recording**
- **Menu bar** **Meeting** **Manage Meeting Information**
- **New window** **Recordings** **check Tutorial** **Access Type button**
- **check Public** **check Allow viewers to download**
- **Download Recording**
- **New window** **Recordings** **check Tutorial** **Actions** **Download File**

[ToC](#)

3 Composition

3.1 TMA02 Practice Quiz

- These questions below are similar to TMA02
- Create the complete solution in BlueJ first and ensure it compiles
- This exercise uses [CodeRunner](#) to check your answers — it has to compile for CodeRunner to work
- Note that if asked to produce a string it must be exactly as given
- The quiz can be attempted any number of times without penalty
- The exercise models a [Car](#) class that is composite since it has an [Engine](#) component
- Open BlueJ and create a new Project
- **Project** **New Project...**
- There may be a problem navigating folders — in that case use the text box
- Create new classes **Edit** **New Class...** **Engine** and **Car**
- The javadoc comments are omitted for space here

```
1 public class Engine {
```

```
53 }
```

```
55 public class Car {
```

```
95 }
```

3.1.1 Engine Class

- The **Engine** class requires a single **int** instance variable **revs** that represents the revolutions (revs) per minute of the engine. It also needs three **int** constants:
- **MAXREVS** which is set to 6000 (above that, the engine will blow up),
- **MINREVS** which is set to 1000 (below that, the engine will stall) and

- **REVSINC** which is set to 1000 (which, for the purpose of this question, is the amount by which **revs** can be increased or decreased).
- Declare the variables and write a public, zero-argument constructor for **Engine** that sets **revs** to 0.

```
2 private int revs ;
3 private final int MAXREVS = 6000 ;
4 private final int MINREVS = 1000 ;
5 private final int REVSINC = 1000 ;

7 public Engine() {
8     this.revs = 0 ;
9 }
```

- Note that constants are covered in Unit 7 Section 4.4 page 119
- **final** objects cannot be changed
- **immutable** contents of the object cannot be changed — so final and immutable are not the same thing
- See [Stack Overflow: Immutable and Final in Java](#)
- See [Stack Overflow: Properties of Immutable Objects](#)
- The **Engine** class requires a getter method **getRevs()** for **revs** which returns the value of **revs**.
- Write **getRevs()**.

```
11 public int getRevs() {
12     return this.revs ;
13 }
```

- The **Engine** class requires a method **isRunning()** which returns **true** if **revs** is positive (ie the engine is running) or **false** if not.
- Write **isRunning()**.

```
15 public boolean isRunning() {
16     return this.revs > 0 ;
17 }
```

- The **Engine** class requires a method **startEngine()** that returns a **boolean**. If the engine is already running, then this method returns **false**. If the engine is not already running and the value of **revs** is 0 then **revs** is set to the minimum rev value and the method returns **true**, otherwise the method returns **false**.
- Write **startEngine()**.

```
19 public boolean startEngine() {
20     if (this.isRunning()) {
21         return false ;
22     } else {
23         this.revs = MINREVS ;
24         return true ;
25     }
26 }
```

- The **Engine** class requires a method **incRevs()** that returns a **boolean**. If it is possible to increase **revs** by **REVSINC** without exceeding **MAXREVS** then that is done and **true** returned. If not, then **revs** is set to 0 and **false** returned (modelling the engine blowing up).

- Write `incRevs()`.

```

28 public boolean incRevs() {
29     if (this.getRevs() + REVSINC <= MAXREVS) {
30         this.revs = this.getRevs() + REVSINC ;
31         return true ;
32     } else {
33         this.revs = 0 ;
34         return false ;
35     }
36 }

```

- The `Engine` class requires a method `decRevs()` that returns a `boolean`. If it is possible to decrease `revs` by `REVSINC` without going below `MINREVS` then that is done and `true` returned. If not, then `revs` is set to 0 and `false` returned (modelling the engine stalling).

- Write `decRevs()`.

```

38 public boolean decRevs() {
39     if (this.getRevs() - REVSINC >= MINREVS) {
40         this.revs = this.getRevs() - REVSINC ;
41         return true ;
42     } else {
43         this.revs = 0 ;
44         return false ;
45     }
46 }

```

- The `Engine` class requires a method `reduceToIdling()` that reduces `revs` from whatever value it is now down to `MINREVS`, repeatedly reducing it by `REVSINC`, (modelling reducing the revs until the engine is idling). So for example if `revs` was 4000, then `reduceToIdling()` would change `revs` to 3000, then 2000, then 1000, and then not reduce it any more.
- Write `reduceToIdling()`. The method does not return a value.

```

48 public void reduceToIdling() {
49     while (this.getRevs() - REVSINC >= MINREVS) {
50         this.decRevs() ;
51     }
52 }

```

[ToC](#)

3.1.2 Car Class

- The `Car` class requires a single instance variable `eng` of type `Engine`.
- This is where composition occurs because a `Car` *has-an* `Engine`.
- Write a public constructor for `Car` that takes a single argument of type `Engine` and sets `eng` to that argument.
- Declare the instance variable and write the constructor.

```

56 private Engine eng ;
58 public Car(Engine eng) {
59     this.eng = eng ;
60 }

```

- The `Car` class requires a method `start()`. This method sends a message to `eng` to tell it to start, and if unsuccessful, reports this as a `String` output "Engine is already running".

- There is no return value.

```

62 public void start() {
63     if (!(this.eng.startEngine())) {
64         System.out.println("Engine_is_already_running") ;
65     }
66 }

```

- The **Car** class requires a method **getRevs()** that returns the **int** value of **revs** (from **eng**).
- This value has to be obtained by sending a message to **eng** (because an instance of class **Car** doesn't know the value itself).
- Write **getRevs()**.

```

68 public int getRevs() {
69     return this.eng.getRevs() ;
70 }

```

- The **Car** class requires a method **accelerate()**. This method first checks that the engine is running (sends a message to **eng**). If it is not running then this is reported as a **String** output "You've not started the engine yet". If it is running then it attempts to increase the revs (by sending another message to **eng**). If this increase is unsuccessful then this is reported as a **String** output "You blew up the engine!".
- Write **accelerate()**. The method does not return a value.

```

72 public void accelerate() {
73     if (!(this.eng.isRunning())) {
74         System.out.println("You've_not_started_the_engine_yet") ;
75     } else if (!(this.eng.incRevs())) {
76         System.out.println("You_blew_up_the_engine!") ;
77     }
78 }

```

- The **Car** class requires a method **decelerate()**. This method first checks that the engine is running (sends a message to **eng**). If it is not running then this is reported as a **String** output "You've not started the engine yet". If it is running then it attempts to decrease the revs (by sending another message to **eng**). If this decrease is unsuccessful then this is reported as a **String** output "Stalled".
- Write **decelerate()**. The method does not return a value.

```

80 public void decelerate() {
81     if (!(this.eng.isRunning())) {
82         System.out.println("You've_not_started_the_engine_yet") ;
83     } else if (!(this.eng.decRevs())) {
84         System.out.println("Stalled") ;
85     }
86 }

```

- The **Car** class requires a method **stop()**. This method first checks that the engine is running (sends a message to **eng**). If it is not running then this is reported as a **String** output "You've not started the engine yet". If it is running then it reduces the engine revs gradually to the idling revs — sends another message to **eng** to do this.
- Write **stop()**. The method does not return a value.

```

88 public void stop() {
89     if (!(this.eng.isRunning())) {
90         System.out.println("You've_not_started_the_engine_yet") ;

```

```

91     } else {
92         this.eng.reduceToIdling() ;
93     }
94 }

```

[ToC](#)

3.1.3 Example Problems

- Initially for the constants I had

```

final int MAXREVS = 6000 ;
final int MINREVS = 1000 ;
final int REVSINC = 1000 ;

```

- For each field, I had the *Specification* (not *Compilation*) error:
- The field **XXX** is missing modifier **private**
- Reading Unit 7 Section 4.4, I thought the constants should be class (static) fields, so tried:

```

private static final int MAXREVS = 6000 ;
private static final int MINREVS = 1000 ;
private static final int REVSINC = 1000 ;

```

- For each field, I had the *Specification* (not *Compilation*) error:
- The field **XXX** should not have modifier **static**
- My next version compiled and met the specification but generated a large number of error messages
- The first error test had

```

// This tests startEngine() returns true when revs is 0
Engine e = new Engine();
System.out.println(e.getRevs());
System.out.println(e.startEngine());

```

- This should have reported 0, **true** but reported 0, **false** (scroll right in the window to see **Expected** and **Got**)
- Decided to try the file in JShell (see below)
- Using JShell with the file containing the two classes but generated a large number of error messages

```

jshell> /open M250TMA02PracticeQuiz.java
jshell> /list

```

```

jshell> Engine en = new Engine()
en ==> Engine@68de145

jshell> System.out.println(en.getRevs())
0

jshell> System.out.println(en.startEngine())
false

jshell> System.out.println(en.getRevs())
0

```

- Looks like **startEngine()** is a problem

- What is wrong with the following definition of `startEngine()`?

```

19 public boolean startEngine() {
20     if (!(this.isRunning())) {
21         return false ;
22     } else {
23         this.revs = MINREVS ;
24         return true ;
25     }
26 }

```

- Other error messages involved `startEngine()` so fix this first and see what happens
- `if` condition round the wrong way — a common error

```

19 public boolean startEngine() {
20     if (this.isRunning()) {
21         return false ;
22     } else {
23         this.revs = MINREVS ;
24         return true ;
25     }
26 }

```

- Re-compiled and passed all the tests

[ToC](#)

4 Inheritance

4.1 Classes

- A **class** represents a concept, a template for creating instances (objects)
- An **object** is an instance of a concept (a class)
- A classDeclaration of `class C` has the form

```

classModifiers class C extendsClause implementsClause
classBody

```

- `extendsClause` and `implementsClause` refer to superclasses and interface (see later in M250)
- For a top-level class `classModifiers` may be a list of `public` and at most one of `abstract` or `final`
- The `classBody` contains declarations of fields, constructors, methods, nested classes, nested interfaces, and initialiser blocks (M250 mainly uses the first three)
- The declarations *may* appear in any order but you should use the order suggested in *M250 Code Conventions*

```

{
    fieldDeclarations
    /* class (static) variables */
    /* instance variables */
    constructorDeclarations
    methodDeclarations
}

```

- A source file may begin with `package` (not used in M250) and `import` declarations (to be covered later)

```

class Point {
    int x, y ;

    Point(int x, int y) {
        this.x = x ;
        this.y = y ;
    }

    void move(int dx, int dy) {
        x = x + dx ;
        y = y + dy ;
    }

    public String toString() {
        return "(" + x + "," + y + ")";
    }
}

```

Accessible to	Member Visibility			
	Public	Protected	Default	Private
Defining class	Yes	Yes	Yes	Yes
Class in same package	Yes	Yes	Yes	No
Subclass in different package	Yes	Yes	No	No
Nonsubclass different package	Yes	No	No	No

Table from [Evans and Flanagan \(2014, p 126\)](#)

	Superclass instance method	Superclass class method
Subclass instance method	Overrides super	Compile fail
Subclass class method	Compile fail	Hides sub

```

1  class Foo {
2      public static void method() {
3          System.out.println("in_Foo");
4      }
5  }

7  class Bar extends Foo {
8      public static void method() {
9          System.out.println("in_Bar");
10     }
11 }

```

- Example of a static (class) method *hiding* another static method
- Example from [CodeRanch: Overriding vs Hiding](#)
- What is the difference between *overriding* and *hiding*?

```

17 /**
18  * Class Foo defines
19  * class method classMethod()
20  * instance method instanceMethod()
21  */
22 class Foo {
23     public static void classMethod() {
24         System.out.println("classMethod()_in_Foo");
25     }

27     public void instanceMethod() {
28         System.out.println("instanceMethod()_in_Foo");
29     }

```

```
30 }
```

- Now declare **Bar** as a subclass of **Foo**

```
32 /**
33  * Class Bar is a subclass of Foo also defining
34  * class method classMethod()
35  * instance method instanceMethod()
36  */
37 class Bar extends Foo {
38     public static void classMethod() {
39         System.out.println("classMethod()_in_Bar");
40     }
41
42     public void instanceMethod() {
43         System.out.println("instanceMethod()_in_Bar");
44     }
45 }
```

- Now run a test job with these declarations

```
9 class OverrideHideEG {
10     public static void main(String[] args) {
11         Foo f = new Bar();
12         f.instanceMethod();
13         f.classMethod();
14     }
15 }
```

- The output is:

```
instanceMethod() in Bar
classMethod() in Foo
```

- The instance method *overrides* the instance method from **Foo**
- The class method of the instance is **hidden** since **f** is declared of type **Foo**
- The above code was in the file **OverrideHideEG.java**

```
<Java><139> ls
OverrideHideEG.java
<Java><140> javac OverrideHideEG
error: Class names, 'OverrideHideEG',
are only accepted
if annotation processing is explicitly requested
1 error
<Java><141> javac OverrideHideEG.java
<Java><142> java OverrideHideEG.java
error: can't find main(String[]) method in class: Foo
<Java><143> java OverrideHideEG
instanceMethod() in Bar
classMethod() in Foo
```

- Why didn't the error message say *File not found*?
- See [StackOverflow: javac error](#)
- Using **OverrideHideEG.java** in JShell

```
jshe11> /open OverrideHideEG.java
jshe11> /list
1 : class OverrideHideEG {
    public static void main(String[] args) {
        // stuff removed
    }
}
// further stuff removed
```

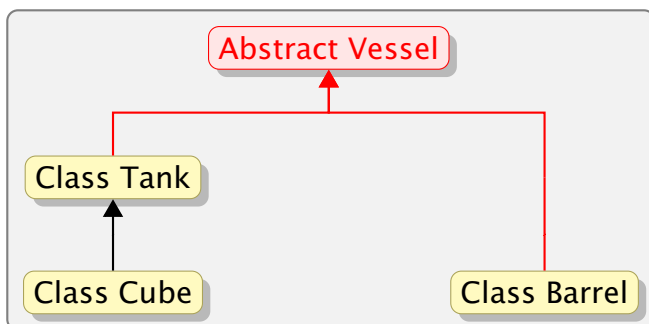


```
jshell1> OverrideHideEG.main(new String[0])
instanceMethod() in Bar
classMethod() in Foo
```

- [How to run a whole Java file added as a snippet in JShell?](#) (15 July 2019)
- The class method is *overloaded* and the choice of which method to invoke is made at compile time
- The correct version of an overridden method is chosen at run time based on the run time type of the object on which the method is invoked
- See [Bloch \(2017, page 239, Item 52\)](#)

4.2 Abstract Classes, Subclasses and Overriding

- The abstract class `Vessel` models the notion of a vessel for liquids
- It has a field `contents` representing its actual contents
- An abstract method `capacity()` for computing its maximal capacity and a method for filling in more, but only up to its capacity (the excess will be lost)
- The abstract class has subclasses `Tank` (a `Rectangular cuboid` vessel), `Cube` (a cubic vessel, subclass of `Tank`), and `Barrel` (a cylindrical vessel)
- The subclasses implement the `capacity()` method, they inherit the `contents` field and the `fill()` method from the superclass, and they override the `toString()` method inherited (inherited from class `Object`) to print each vessel object appropriately



- The red rectangles denote abstract classes (which may implement various interfaces)
- Yellow rectangles denote concrete classes extending abstract classes and (possibly) implementing interfaces
- Note UML style diagrams have more detail — see [UML Class and Object Diagrams Overview](#)

```

43 abstract class Vessel {
44     double contents ;
45
46     public Vessel() {
47         contents = 0 ;
48     }
49
50     abstract double capacity() ;
51
52     public void fill(double amount) {
53         contents
54         = Math.min(contents + amount, capacity()) ;
  
```

```
55 }
56 }
```

- **Abstract** classes cannot be instantiated but can be extended
- Intended to be a superclass of several classes that have common features

```
58 class Tank extends Vessel {
59     double depth, width, height ;

61     public Tank(double depth
62                 , double width, double height) {
63         super() ;
64         this.depth = depth ;
65         this.width = width ;
66         this.height = height ;
67     }

69     @Override
70     double capacity() {
71         return depth * width * height ;
72     }

74     @Override
75     public String toString() {
76         return ("tank_(" + depth + ","
77                + width + "," + height + ")") ;
78     }
79 }
```

```
81 class Cube extends Tank {

83     public Cube(double side) {
84         super(side, side, side) ;
85     }

87     @Override
88     public String toString() {
89         return ("cube_(" + depth + ")") ;
90     }
91 }
```

```
93 class Barrel extends Vessel {
94     double radius, height ;

96     Barrel(double radius, double height) {
97         super() ;
98         this.radius = radius ;
99         this.height = height ;
100    }

102    @Override
103    double capacity() {
104        return (height * Math.PI * radius * radius) ;
105    }

107    @Override
108    public String toString() {
109        return ("barrel_(" + radius + "," + height + ")") ;
110    }
111 }
```

```
9 class VesselEG {
10     public static void main(String[] args) {
11         Vessel v1 = new Barrel(3, 10) ;
12         Vessel v2 = new Tank(10, 20, 12) ;
13         Vessel v3 = new Cube(4) ;

15         Vessel[] vs = { v1, v2, v3 } ;

17         v1.fill(90) ;
18         v1.fill(10) ;
19         v2.fill(100) ;
20         v3.fill(80) ;
```

```

40 }
41 }

22 double totalCap = 0 ;
23 for (int i = 0; i < vs.length; i++) {
24     totalCap = totalCap + vs[i].capacity() ;
25 }
26 System.out.println("Total_capacity_is_"
27                     + totalCap) ;

29 double totalConts = 0 ;
30 for (int i = 0; i < vs.length; i++) {
31     totalConts = totalConts + vs[i].contents ;
32 }
33 System.out.println("Total_contents_is_"
34                     + totalConts) ;

36 for (int i = 0; i < vs.length; i++) {
37     System.out.println("vessel_number_" + i
38                       + ":" + vs[i]) ;
39 }

```

```

jsHELL> /open VesselEG.java

jsHELL> VesselEG.main(new String[0])
Total capacity is 2746.743338823081
Total contents is 264.0
vessel number 0: barrel (3.0, 10.0)
vessel number 1: tank (10.0,20.0,12.0)
vessel number 2: cube (4.0)

jsHELL>

```

ToC

5 Interfaces

5.1 Interface Declarations

- An **interface** describes fields and methods but does not implement them
- It defines a *type* by specifying the behaviour of objects (whereas classes specify types by how objects are constructed)

```

interfaceModifiers interface extendsClause
    fieldDescriptions
    methodDescriptions
    methodDeclarations // Java 8 not used in M250
    classDeclarations // not used in M250
    interfaceDeclarations // not used in M250

```

- Notes and examples based on [Sestoft \(2016, section 13\) Java Precisely](#)
- An interface may be declared at top level (or inside a class or interface — not M250)
- *interfaceModifiers* may be **public** or absent
- The *extendsClause* may be absent or **extends** *I1,I2,...* where the *I1,I2,...* are super-interfaces
- A *fieldDescription* declares a named constant

```

fieldDescModifiers type f = initializer ;

```

- *fieldDescModifiers* is implicitly a list of **public**, **final**, **static**

- *methodDescription* for method `m` has the form

```
methodDescModifiers returnType m(formalList)
                        throwsClause ;
```

- *methodDescModifiers* is implicitly `abstract, public`

[ToC](#)

5.2 Interfaces — Example

```
import java.awt.Color ;
import java.awt.Graphics ;

interface Colored {
    Color getColor() ;
}

interface Drawable {
    void draw(Graphics g) ;
}

interface ColoredDrawable extends Colored, Drawable {
    // empty body but inherits from Colored and Drawable
}
```

- The `Colored` interface describes method `getColor()`
- Interface `Drawable` method `draw`
- `ColoredDrawable` describes both
- The methods are implicitly `public`

```
class ColoredPoint extends Point implements Colored {
    Color c;

    ColoredPoint(int x, int y, Color c) {
        super(x, y) ;
        this.c = c;
    }

    @Override
    public Color getColor() {
        return c ;
    }
}
```

- The methods `getColor()` and `draw` must be public as described in the interface declarations

```
class ColoredDrawablePoint extends ColoredPoint
    implements ColoredDrawable {

    ColoredDrawablePoint(int x, int y, Color c) {
        super(x, y, c) ;
    }

    @Override
    public void draw(Graphics g) {
        g.fillRect(x, y, 1, 1) ;
    }
}
```

- The method `fillRect()` is from package `java.awt.Graphics` in the module `java.desktop`
- `fillRect(int x,int y,int width,int height)`

```

class ColoredRectangle implements ColoredDrawable {
    int x1, x2, y1, y2;
    // (x1, y1) upper left, (x2, y2) lower right corner
    Color c;

    ColoredRectangle(int x1, int y1, int x2, int y2
                     , Color c) {
        this.x1 = x1 ; this.y1 = y1 ;
        this.x2 = x2 ; this.y2 = y2 ;
        this.c = c ;
    }

    @Override
    public Color getColor() {
        return c ;
    }

    @Override
    public void draw(Graphics g) {
        g.drawRect(x1, y1, x2-x1, y2-y1) ;
    }
}

```

[ToC](#)

6 String Formatting

Introduction

- A common task is to control the layout justification and alignment formats for numeric, strings and date/time data
- Here is an example of a simple interest calculation (using [JShell](#))

```

jshell> double intrst = 343.17 * 2.4 / 100
intrst ==> 8.236080000000001

jshell> System.out.println("Interest is_" + intrst + "_units")
Interest is 8.236080000000001 units

```

- We *could* write code to round the result to 2 decimal places but Java provides several ways of formatting strings by providing a *format string* (or *template string*) with embedded *format specifiers*
- Using `printf`

```

jshell> System.out.printf("Interest is_%.2f_units\n", intrst)
Interest is 8.24 units

```

- Using `String.format`

```

jshell> String intrstOut = (
...> String.format("Interest is_%.2f_units\n", intrst) )
intrstOut ==> "Interest is_8.24_units\n"

jshell> System.out.print(intrstOut)
Interest is 8.24 units

```

- `%.2f` and `%n` are *format specifiers*
- Notice the interest is rounded to 2 decimal places
- The `%n` results in a *line separator*

6.1 String Formatting Methods

- `String.format(fmt,v1,...,vn)` returns a String produced from `fmt` by replacing format specifiers with the strings resulting from formatting the values `V1,...,vn`
- `strm.printf(fmt,v1,...,vn)` where `strm` is a `PrintWriter` or `PrintStream`, constructs a string as above, outputs it to `strm`, and returns `strm`.
- `strm.format(fmt,v1,...,vn)` behaves as `strm.printf(fmt,v1,...,vn)`
- If a value `vi` is the wrong type for a given format specifier (or the format specifier is ill-formed) then an error is generated

[ToC](#)

6.2 Formatting Data Types

Formatting Specifiers

- A formatting specifier for numeric, character, and general types has the form:

```
%[index][flags][width][.precision]conversion
```

- The *index* is an integer 1,2,... indicating the value `vindex` to format.
- The *conversion* indicates what operation is used to format the value.
- The *width* indicates the minimum number of characters used to format the value.
- The *flags* indicate how the width should be used
- *precision* limits the output, such as number of fractional digits
- The brackets `[]` are meta-characters indicating optional parts
- The only mandatory parts are the percent sign (%) and the *conversion*

Conversions

- Table of *conversions* on numbers, characters (C) and general types (G)
- I integers, F floats, IF both.
- Uppercase conversion such as `X` produces uppercase

Format	conversion	flags	precision	Type
Decimal	d	−+ 0, (		I
Octal	o	−#0		I
Hexadecimal	x, X	−#0		I
Hex significand, exponent	a, A	−#+ 0		F
General: scientific, fractional	g, G	−#+ 0, (	Max. sig, digits	IF
Fixed-point number	f	−#+ 0, (	Fractional digits	IF
Scientific notation	e, E	−#+ 0, (	Fractional digits	IF
Unicode character [1]	c, C	−		C
Boolean: <code>false</code> , <code>true</code>	b, B	−		Boolean
Hex hashcode or <code>null</code>	h, H	−		G
Determined by <code>formatTo</code> method	s, S	−		G
A percent symbol (%)	%	(none)		
Platform specific newline	n	(none)		

Flags

Flag	Result
−	Left-justified
#	Conversion-dependent alternate form
+	Always include a sign
␣	Includes leading space for positive values
0	Zero-padded
,	Locale-specific grouping separators
(	Enclose negative numbers in parentheses

String Formatting — Documentation

- See [java.util.Formatter](#) for the full details
- See also the [man](#) entry for `printf` in Unix and [Text.Printf](#) in Haskell
- See also [Python: printf-style String Formatting](#) and:
 - [Python: Language Reference: Section 2.4.3 Formatted string literals](#) and [PEP 498 — Literal String Interpolation](#)
 - [Python: str.format\(\)](#) and [Python: Format String Syntax](#)
 - [Python: Template strings](#) and [PEP 292 — Simpler String Substitutions](#)
- Note that *printf* is an approach to string formatting rather than an absolute standard — there are many variations.
- See [Wikipedia: printf format string](#)

[ToC](#)

6.3 String Formatting Exercises

6.3.1 Java Formatting 2022 Exercises Q 1

- Given an array of integers, none with more than three digits, some negative and some positive

print them one per line in a right justified column with some sample text before and after the column

- For example, given the array

```
{-123, 123, 23, -23}
```

could print the array index, `idx` and values in a column as

```
idx 0 value is -123 units
idx 1 value is  123 units
idx 2 value is   23 units
idx 3 value is  -23 units
```

[Go to Soln 1](#)

[ToC](#)

6.3.2 Java Formatting 2022 Exs Soln 1

- Sample answer in `FormattingTest01.java`

```
10 public static int[] egArrayInt01 = {-123, 123, 23, -23 } ;
12 public static void testSpace() {
13     System.out.println("Array_egArrayInt01_="
14         + Arrays.toString(egArrayInt01)) ;
15     int aryLen = egArrayInt01.length ;
16     for (int idx = 0; idx < aryLen; idx++) {
17         int num = egArrayInt01[idx] ;
18         System.out.format("idx_%d_value_is_%4d_units%n",idx,num) ;
19     }
20 }
```

- Using static method `testSpace()` in class `FormattingTest01` in `jshe11`

```
jshe11> FormattingTest01.testSpace()
Array egArrayInt01 = [-123, 123, 23, -23]
idx 0 value is -123 units
idx 1 value is  123 units
idx 2 value is   23 units
idx 3 value is  -23 units
```

[Go to Q 1](#)

[ToC](#)

6.3.3 Java Formatting 2022 Exercises Q 2

- Given the following array

format the values as in the previous question but with `+` in front of positive numbers

```
57 public static int[] egArrayInt03 = {-123, 123, +23, -23 } ;
```

- Notice that one value already has `+` in front.

[Go to Soln 2](#)

[ToC](#)

6.3.4 Java Formatting 2022 Exs Soln 2

- Here is the test output — the code is in the following answer
- Note that the default printing of the array removes the provided + sign

```
jshe11> FormattingTest01.testFmtStr1()
Array = [-123, 123, 23, -23]

idx 0 value is -123 units
idx 1 value is +123 units
idx 2 value is  +23 units
idx 3 value is  -23 units
```

[Go to Q 2](#)

ToC

6.3.5 Java Formatting 2022 Exercises Q 3

- Given the following array
format the values as in the previous question but with () around negative numbers

```
57 public static int[] egArrayInt03 = {-123, 123, +23, -23 } ;
```

[Go to Soln 3](#)

ToC

6.3.6 Java Formatting 2022 Exs Soln 3

- The first solution has a width of 4 — notice the layout of the first number

```
jshe11> FormattingTest01.testFmtStr2()
Array = [-123, 123, 23, -23]

idx 0 value is (123) units
idx 1 value is  123 units
idx 2 value is   23 units
idx 3 value is (23) units
```

- The second version changes the width to 5

```
jshe11> FormattingTest01.testFmtStr2a()
Array = [-123, 123, 23, -23]

idx 0 value is (123) units
idx 1 value is  123 units
idx 2 value is   23 units
idx 3 value is (23) units
```

- The code

```
57 public static int[] egArrayInt03 = {-123, 123, +23, -23 } ;
58 public static String fmtStr1 = "idx_%d_value_is_+%4d_units%n" ;
59 public static String fmtStr2 = "idx_%d_value_is_%(4d_units%n" ;
60 public static String fmtStr2a = "idx_%d_value_is_%(5d_units%n" ;

62 public static void testFmtStr(String fmtStr, int[] ary) {
63     System.out.printf("Array_=%s%n",
64                       Arrays.toString(ary)) ;
65     int aryLen = ary.length ;
66     for (int idx = 0; idx < aryLen; idx++) {
67         int num = ary[idx] ;
68         System.out.format(fmtStr,idx,num) ;
69     }
70 }
```

- Test harness code

```

72 public static void testFmtStr1() {
73     testFmtStr(fmtStr1, egArrayInt03) ;
74 }

76 public static void testFmtStr2() {
77     testFmtStr(fmtStr2, egArrayInt03) ;
78 }

80 public static void testFmtStr2a() {
81     testFmtStr(fmtStr2a, egArrayInt03) ;
82 }

```

[Go to Q 3](#)
[ToC](#)

6.3.7 Java Formatting 2022 Exercises Q 4

- Write a format specifier to format 1123456 as 1,123,456

[Go to Soln 4](#)
[ToC](#)

6.3.8 Java Formatting 2022 Exs Soln 4

- Sample answer

```

jshell> String str1 = String.format("%,d%n",1123456)
str1 ==> "1,123,456\n"

jshell> PrintStream strm1 = System.out.format("%,d%n",1123456)
1,123,456
strm1 ==> java.io.PrintStream@61064425

```

[Go to Q 4](#)
[ToC](#)

6.3.9 Java Formatting 2022 Exercises Q 5

- Write a format specifier that will take a single argument 1234.1234 and format it both right and left justified in a width of 20

for example

```

|          1234.1234|
|1234.1234          |

```

[Go to Soln 5](#)
[ToC](#)

6.3.10 Java Formatting 2022 Exs Soln 5

- This uses the (-) and an index specifier

```

jshell> String.format("|%1$20.4f|%n|%1$-20.4f|%n",1234.1234)
$39 ==> "|          1234.1234|\n|1234.1234          |\n"

jshell> System.out.format("|%1$20.4f|%n|%1$-20.4f|%n",1234.1234)
|          1234.1234|

```

```
|1234.1234 |
$41 ==> java.io.PrintStream@61064425
```

- Notice how the same argument is used more than once

[Go to Q 5](#)

[ToC](#)

6.3.11 Java Formatting 2022 Exercises Q 6

- Given an array with at least 11 integers, format a character bar chart similar to the followin

```
Array = [0, 3, 5, 6, 9, 11, 13, 10, 8, 7, 5, 3]
```

- Output

```
0 (0)
1 ### (3)
2 ##### (5)
3 ##### (6)
4 ##### (9)
5 ##### (11)
6 ##### (13)
7 ##### (10)
8 ##### (8)
9 ##### (7)
10 ##### (5)
11 ### (3)
```

[Go to Soln 6](#)

[ToC](#)

6.3.12 Java Formatting 2022 Exs Soln 6

- We write the code in two parts
- The first part generates a string with the number of display characters
- The second part outputs the character bar chart
- The first version of `genNumChars()` uses an ordinary `for` loop

```
28 public static String genNumChars(int n, char ch) {
29     String str = "";
30     for (int idx = 0; idx < n; idx++) {
31         str = str + ch ;
32     }
33     return str ;
34 }
```

- The second version, `genNumChars01()` uses a library method from `java.lang.String`

```
36 public static String genNumChars01(int n, char ch) {
37     String str1 = String.valueOf(ch) ;
38     String str2 = str1.repeat(n) ;
39     return str2 ;
40 }
```

- The second part, `printTableFromArray()` outputs the character bar chart

```

42 public static int[] egArrayInt02
43     = {0,3,5,6,9,11,13,10,8,7,5,3} ;
44 public static char dsplyCh = '#' ;

46 public static void printTableFromArray(int[] ary) {
47     System.out.printf("Array_=%s%n",
48         Arrays.toString(ary)) ;
49     int aryLen = ary.length ;
50     for (int idx = 0; idx < aryLen; idx++) {
51         int num = ary[idx] ;
52         String str = genNumChars01(num,dsplyCh) ;
53         System.out.format("%2d_ %s_(%d)%n",idx,str,num) ;
54     }
55 }

```

[Go to Q 6](#)
[ToC](#)

7 JShell

- [JShell](#) is a Java *read-eval-print loop (REPL)* introduced in 2017 with JDK 9
- [Java Shell User's Guide](#) (Release 12, March 2019)
- [Tools Reference: jshell](#)
- [JShell Tutorial](#) (30 June 2019)
- [How to run a whole Java file added as a snippet in JShell?](#) (15 July 2019)

[ToC](#)

8 What Next ?

Programming, Debugging, Psychology

Although programming techniques have improved immensely since the early days, the process of finding and correcting errors in programming — known graphically if inelegantly as *debugging* — still remains a most difficult, confused and unsatisfactory operation. The chief impact of this state of affairs is psychological. Although we are happy to pay lip-service to the adage that to err is human, most of us like to make a small private reservation about our own performance on special occasions when we really try. It is somewhat deflating to be shown publicly and incontrovertibly by a machine that even when we do try, we in fact make just as many mistakes as other people. If your pride cannot recover from this blow, you will never make a programmer.

Christopher Strachey, Scientific American 1966 vol 215 (3) September pp112-124

- To err is human, to really foul things up requires a computer.
- Attributed to [Paul R. Ehrlich](#) in [101 Great Programming Quotes](#)
- Attributed to [Bill Vaughn](#) in [Quote Investigator](#)
- Derived from [Alexander Pope](#) (1711, [An Essay on Criticism](#))
- *To Err is Humane; to Forgive, Divine*
- This also contains

*A little learning is a dangerous thing;
 Drink deep, or taste not the [Pierian Spring](#)*

- In programming, this means you have to *read the fabulous manual* (RTFM)

Weeks 11–520, TMA02

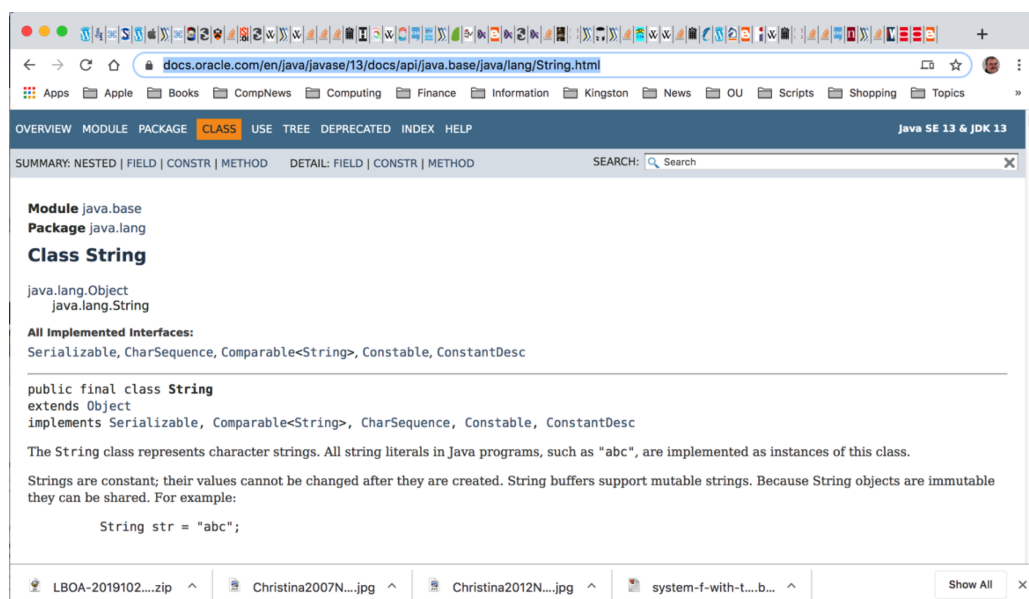
- TMA02 Thursday 6 March 2025
- Tutorial: Collections and file I/O: Online 10:00 Sunday 16 March 2025
- TMA03 Thursday 8 May 2025
- Tutorial: Exam revision: Online 10:00 Sunday 11 May 2025

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9 Web Links & References

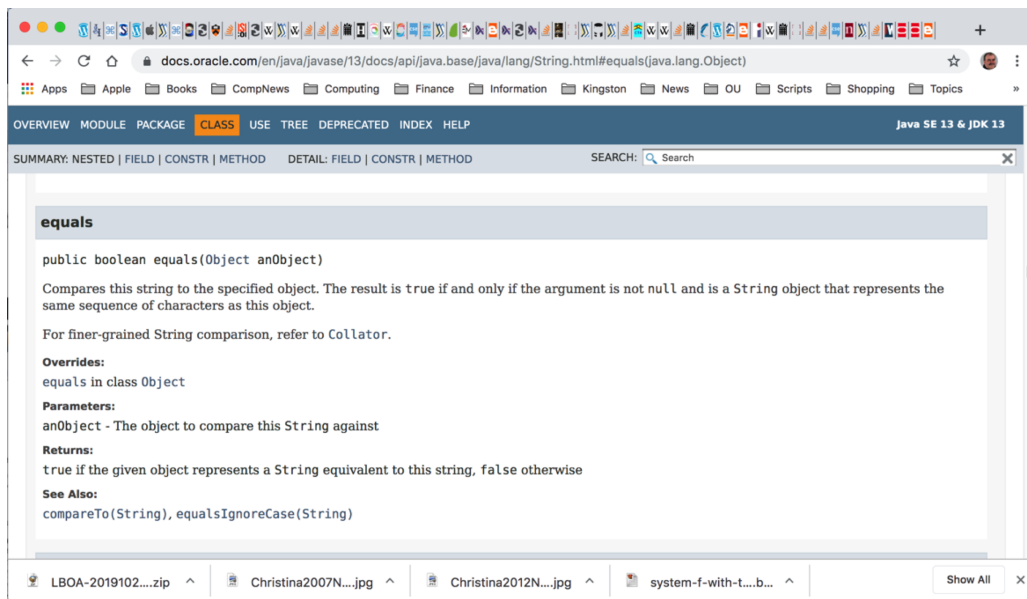
9.1 Java Documentation

- [Java Documentation](#) — BlueJ has JDK 7 embedded, JDK 13 is current (2019)
- [JDK 13 Documentation](#)
- [Java Platform API Specification](#)
- [Java Language Specification](#)
- [JDK Documentation](#) [API Documentation](#) [java.base](#)
 - [java.lang](#) — fundamental classes for the Java programming language
 - [java.util](#) — Collections framework



- [Strings](#) are *immutable* objects
- See [java.lang.StringBuilder](#) for *mutable* strings

- In a *functional programming approach* everything is immutable — it makes life simpler (but at a cost)



- Remember `(==)` tests for *identity* — what does this mean ?

[ToC](#)

9.2 Books Phil Likes

- M250 is self contained — you do not need further books — but you might like to know about some:
- [Sestoft \(2016\)](#) *Java Precisely* — the best short reference
- [Evans and Flanagan \(2018\)](#) — the best longer reference *Java in a Nutshell*
[Evans et al. \(2023\)](#) *Java in a Nutshell*
- [Barnes and Kölling \(2016\)](#) *Object First with Java* — the BlueJ book — see www.bluej.org for documentation and tutorial
- [Bloch \(2017\)](#) *Effective Java* — guide to best practice

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