Java: Selection, Iteration, Inheritance, Composition

M250 Tutorial 04

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19 January 2025

Java: Selection, Iteration, Inheritance, Composition

M250 Tutorial Agenda

- Introductions
- Adobe Connect reminders
- *Adobe Connect* — if you or I get cut off, wait till we reconnect (or send you an email)
- Statements: Select, Iteration and others
- Composition
- JShell (optional)
- Some useful Web & other references
- Time: about 1 hour
- Do ask questions or raise points.
- Slides/Notes M250Tutorial20250119CompositionPrsntn2024J

Tutorial

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 LaTeX — all these slides and notes
  - Mac OS X
- *Learning style* — I read the manual before using the software

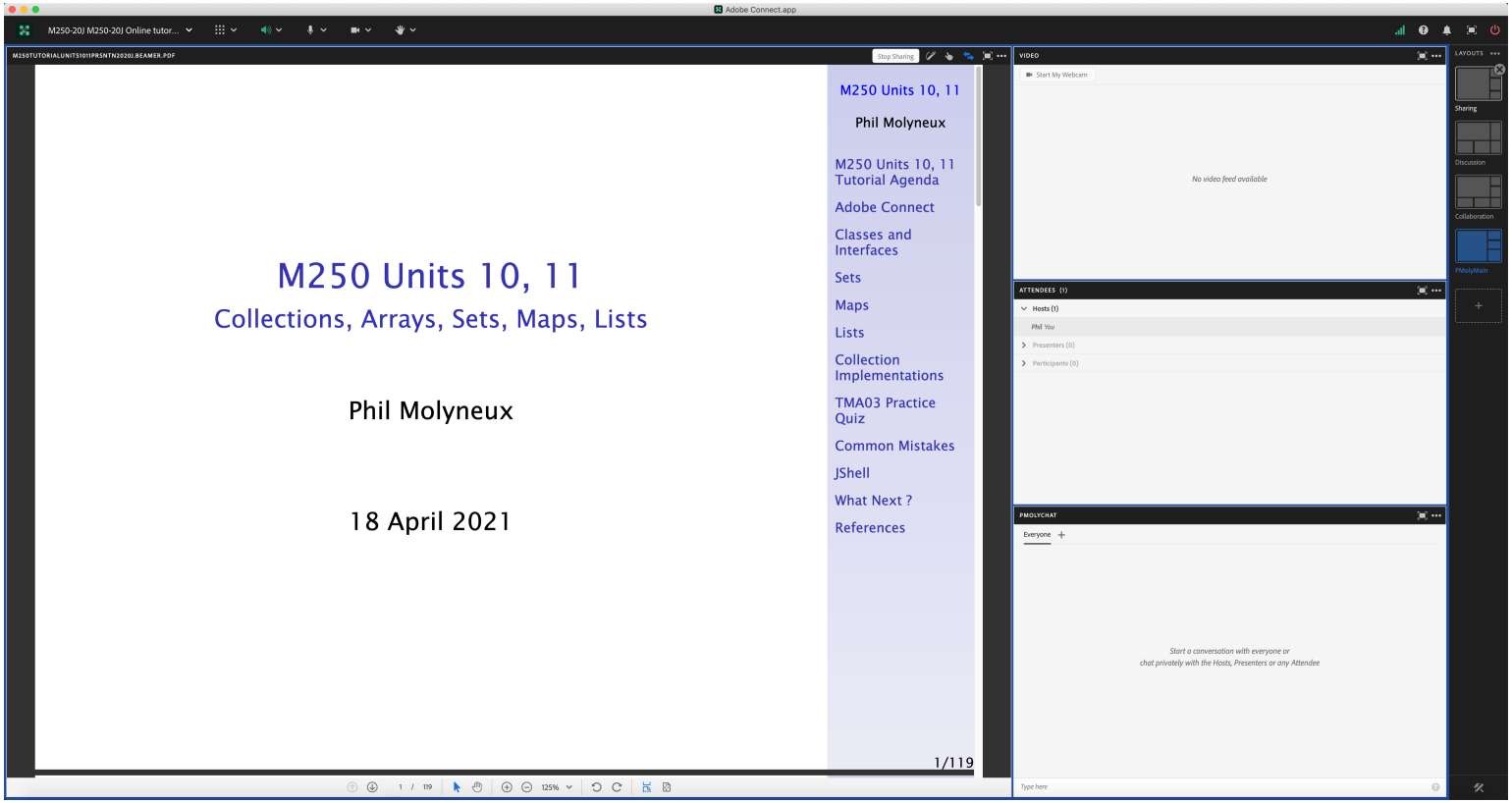
Tutorial

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 ?*

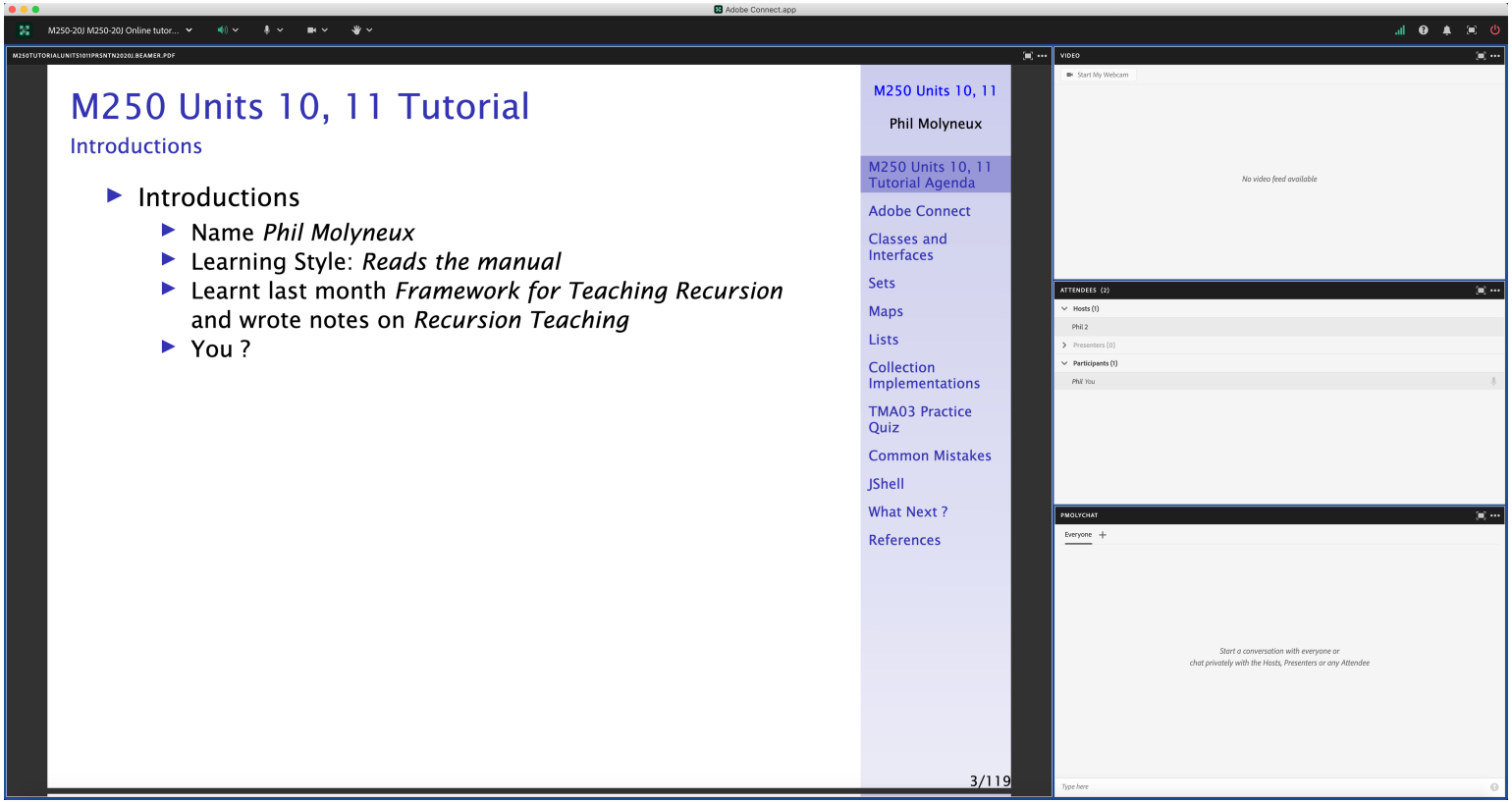
Adobe Connect

Interface — Host View



Adobe Connect

Interface — Participant View



Adobe Connect

Settings

- **Everybody** *Menu bar* › *Meeting* › Speaker & Microphone Setup
- *Menu bar* › *Microphone* › Allow Participants to Use Microphone ✔
- Check Participants see the entire slide **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** ⌘ + \

Adobe Connect Interface

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 blued 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

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** Meeting > Manage Meeting Information — can access a range of information in Web page.
- **Delete File Upload** Meeting > Manage Meeting Information > Uploaded Content tab select file(s) and click Delete
- **Attendance Report** see course Web site for joining room

Adobe Connect

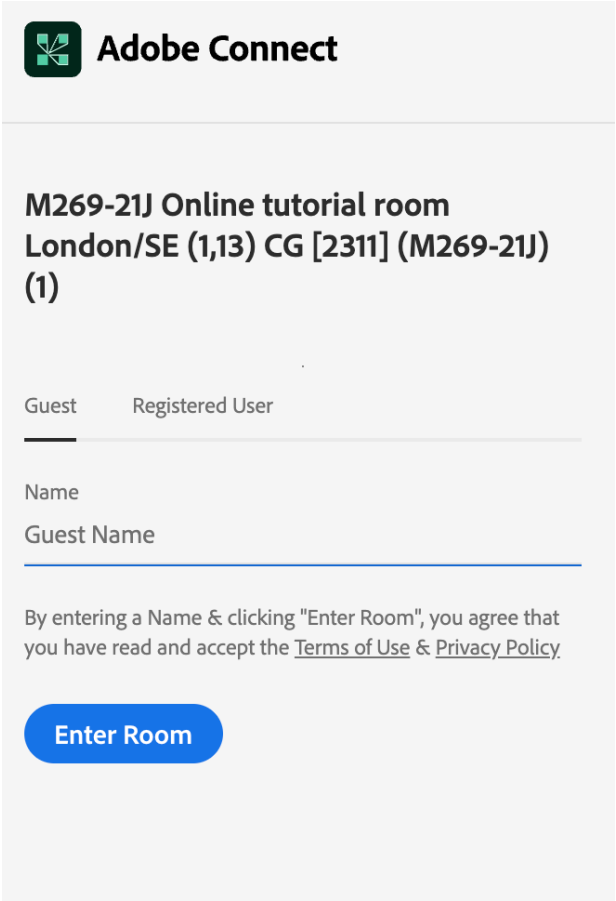
Invite Attendees

- **Provide Meeting URL** Menu › Meeting › Manage Access & Entry › Invite Participants...
- **Allow Access without Dialog** Menu › Meeting › Manage Meeting Information provides new browser window with *Meeting Information* Tab bar › Edit 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

Adobe Connect

Entering a Room as a Guest (1)

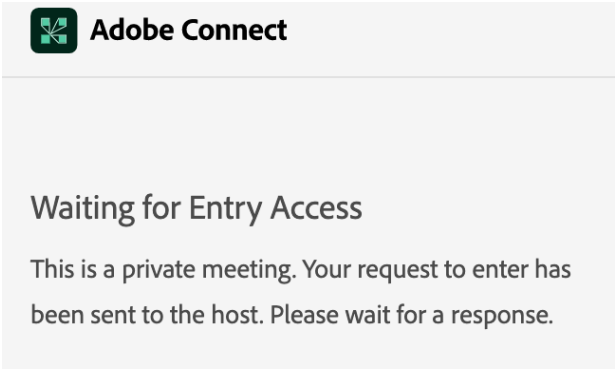
- Click on the link sent in email from the Host
- Get the following on a Web page
- As *Guest* enter your name and click on Enter Room



Adobe Connect

Entering a Room as a Guest (2)

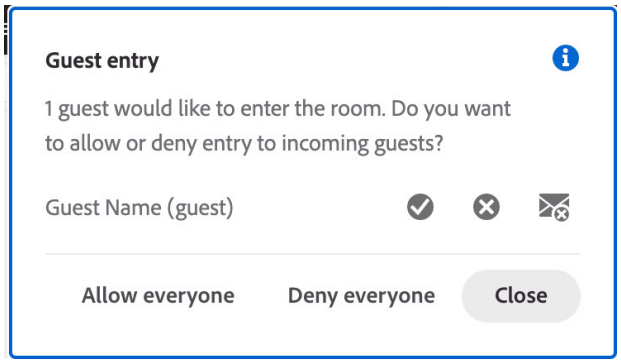
- See the *Waiting for Entry Access* for *Host* to give permission



Adobe Connect

Entering a Room as a Guest (3)

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



Adobe Connect

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

Adobe Connect

Layouts

- 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 *PMolyAux0n*
  - Create new Share pod
  - Use existing Chat pod
  - Use same Video and Attendance pods

Adobe Connect

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

Graphics Conversion

PDF to PNG/JPG

- 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 ⌘ + ⏎

Adobe Connect Recordings

Exporting 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

Statements

Overview

- A statement may change the computer's state: value of variables, fields, array elements, the contents of files and so on — the execution of a statement may:
- terminate normally (and execution continues with the next statement, if any) or
- terminate abruptly by throwing an exception or
- exit by executing a `return` statement (if inside a method or constructor) or
- exit a switch or loop by executing a `break` statement or
- exit the current iteration of a loop and start a new iteration by executing a `continue` stement or
- does not terminate at all (eg, `while (true) {}`)

Statements

Expression & Block Statements

- An expression statement is an expression followed by a ;

```
expression ;
```

- The only forms of expression that may be used here are assignments, increment and decrements, method call, and object creation
- A block statement is a sequence of variable declarations, class declarations and statements

```
{
  variableDeclarations
  classDeclarations
  statements
}
```

- An empty statement consists of ; only — it is equivalent to the block statement { }

Selection Statements

if Statement

- The `if` statement has the form

```
if (condition)
  trueBranch
```

- The `if-else` statement has the form

```
if (condition)
  trueBranch
else
  falseBranch
```

- The condition must have type `boolean` or `Boolean`
- trueBranch and falseBranch are statements

Selection Statements

Common if errors (a)

- What is wrong with the following

```
if (dataAvailable) ;
  processData() ;
```

```
if (dataAvailable)
  processData() ;
  reportResults() ;
```

```
if (dataAvailable)
  processData() ;
  reportResults() ;
else
  reportNoData() ;
```

Selection Statements

Common if errors (b)

```
if (dataAvailable) ;
  processData() ;
```

- The trueBranch is an empty statement (;)

```
if (dataAvailable)
  processData() ;
  reportResults() ;
```

- reportResults() ; will always be executed

```
if (dataAvailable)
  processData() ;
  reportResults() ;
else
  reportNoData() ;
```

- Will not compile
- **Moral** Always use block statements

Selection Statements

switch Statement

- A `switch` statement has the form

```
switch (expression) {
  case constant1: branch1
  case constant2: branch2
  ...
  default: branchN
}
```

- expression must be of type `int`, `short`, `char`, `byte` or a boxed version of these or `String` or an enum type
- Each constant must be a compile-time constant expression, consisting only of literals, `final` variables, `final` fields declared with explicit field initialisers or an unqualified enum value
- (not used in M250)

Iteration Statements

for Statement

- A `for` statement has the form

```
for (initialization ; condition ; step)
  body
```

- initialization is a variableDeclaration or an expression
- condition is an expression of type `boolean` or `Boolean`
- step is an expression
- body is a statement
- initialization and step may be comma-separated lists of expressions
- initialization, condition and step may be empty. An empty condition is equivalent to `true`

for Statement

Execution

- The `for` statement is executed as follows

1. The initialization is executed
2. The condition is evaluated. If it is `false`, the loop terminates.
3. If it is `true` then
   (a) the body is executed
   (b) the step is executed
   (c) execution continues at (2.)

for Statement

for Example 1(a)

- What does the following code do ?

```
for (int i = 1 ; i <= 4 ; i++) {
  for (int j = 1 ; j <= i ; j++) {
    System.out.print("*") ;
  }
  System.out.println() ;
}
```

for Statement

for Example 1(b)

```
jshell>   for (int i = 1 ; i <= 4 ; i++) {
   ...>     for (int j = 1 ; j <= i ; j++) {
   ...>       System.out.print("*") ;
   ...>     }
   ...>     System.out.println() ;
   ...>   }
   ...>
*
**
***
****
```

Iteration Statements

while Statement

- A `while` statement has the form

```
while (condition)
  body
```

- condition is an expression of type `boolean` or `Boolean` and body is a statement
- It is executed as follows:

1. The condition is evaluated. If it is `false`, the loop terminates
2. If it is `true`, then
   (a) The body is executed
   (b) Execution continues at (1.)

while Statement

while Example 1(a)

- Example linear search with `while` loop

```
String[] wdays =
  {"Monday","Tuesday","Wednesday"
  ,"Thursday","Friday","Saturday","Sunday"} ;

int wdayno(String wday) {
  int i = 0 ;
   while (i < wdays.length
          && ! wday.equals(wdays[i])) {
     i++ ;
   }
   if (i < wdays.length) {
     return i ;
   } else {
     return -1 ;
   }
} ;
```

while Statement

while Example 1(b)

```
String[] wdays =
  {"Monday","Tuesday","Wednesday"
  ,"Thursday","Friday","Saturday","Sunday"} ;

int wdayno(String wday) {
  int i = 0 ;
   while (i < wdays.length
          && ! wday.equals(wdays[i])) {
     i++ ;
   }
   if (i < wdays.length) {
     return i ;
   } else {
     return -1 ;
   }
} ;
```

```
jshell> int d1 = wdayno("Friday") ;
d1 ==> 4

jshell> int d2 = wdayno("Dimanche") ;
d2 ==> -1
```

while Statement

while Example 2(a)

- Write code using a `while` statement that is equivalent to a `for` loop statement

while Statement

while Example 2(b)

- Write code using a `while` statement that is equivalent to a `for` loop statement

```
initialization
while (condition) {
  body
  step
}
```

```
for (initialization ; condition ; step)
  body
```

- Note that this is different behaviour to the `for` statement in Python where assignments to variables in the suite of the loop does not change the assignments made in the target list
- See Python: for statement

Iteration Statements

foreach Statement

- A variant of the `for` statement to iterate over elements of a collection (or *iterable*)

```
for (ElementType x : expression)
  body
```

- `expression` must have type `Iterable<t>` where `t` is some subtype of `ElementType` or an array
- All collections are directly iterable since `Collection<t>` has superinterface `Iterable<t>`
- Entries of a map can be iterated over because interface `Map<K,V>` describes a method `entrySet` that returns a `Set<Map.Entry<K,V>>` which implements `Iterable(Map.Entry<K,V>>)`

Iteration Statements

Removing While Iterating

- Removing elements from a collection while iterating over it is fraught with problems
- Likely to generate errors (`ConcurrentModificationException`)
- Proper way is to use an `Iterator`
- Example from Barnes (2016, page 134) *Objects First with Java*

```
Iterator<Track> it = tracks.iterator() ;
while (it.hasNext()) {
  Track t = it.next() ;
  String artist = t.getArtist() ;
  if (artist.equals(artistToRemove)) {
    it.remove() ;
  }
}
```

Returns, Exits and Exceptions

return Statement

- A `return` statement with an expression argument has the form:

```
return expression ;
```

- This form of `return` must occur in the body of a method (not constructor) whose return type is a supertype or boxed or unboxed version of the type of expression
- The `return` statement is executed as follows:
- expression is evaluated to some value v
- It then exits the method and continues execution at the method call expression that called the method
- The value of that expression will be v, possible after application of a widening, boxing or unboxing conversion

return Statement

return Example 1

- wdayno using a for loop

```
int wdayno(String wday) {
  for (int i = 0 ; i < wdays.length ; i++) {
    if (wday.equals(wdays[i])) {
      return i ;
    }
  }
  return -1 ;
}
```

- Notice that the final return is after the for loop
- What is the effect of the code below?

```
int wdayno(String wday) {
  for (int i = 0 ; i < wdays.length ; i++) {
    if (wday.equals(wdays[i])) {
      return i ;
    }
  return -1 ;
  }
}
```

return Statement

return Example 1(b)

```
jshell> int wdayno(String wday) {
   ...>   for (int i = 0 ; i < wdays.length ; i++) {
   ...>     if (wday.equals(wdays[i])) {
   ...>       return i ;
   ...>     }
   ...>   return -1 ;
   ...>   }
   ...> }
   ...>
|  Error:
|  missing return statement
|    int wdayno(String wday) {
|                            ^
```

Returns, Exits and Exceptions

break, continue, label

- A `break` statement is legal only inside a loop or switch and has one of the forms

```
break ;
break labelName ;
```

- Executing `break` exits the innermost enclosing loop or switch and continues execution after that loop or switch
- A `continue` statement is legal only inside a loop and has one of the forms

```
continue ;
continue labelName ;
```

- Executing `continue` terminates the current iteration of the innermost enclosing loop and continues execution at the step in `for` loops or the condition in `while` and `do-while` loops

Returns, Exits and Exceptions

break, continue, label

- A `label` statement has the form

```
labelName : statement
```

- The scope of labelName is statement, where it can be used in `break` or `continue`
- Use of labels is evidence of poor program design
- Just don't

Returns, Exits and Exceptions

throw Statement

- A `throw` statement has the form:

```
throw expression ;
```

- The type of expression must be a subtype of class `Throwable`
- The `throw` statement is executed as follows:
- expression is evaluated to obtain an exception object `v`
- If it is `null` then a `NullPointerException` is thrown
- Otherwise the exception object `v` is thrown
- The enclosing block statement terminates abruptly
- The thrown exception may be caught by a dynamically enclosing `try-catch` statement
- If the exception is not caught then the entire program execution will be aborted

Returns, Exits and Exceptions

try-catch-finally Statement

- A `try-catch` statement is used to catch particular exceptions thrown by a code block
- It has the following form:

```
try
  body
catch (E1 x1) catchBody1
catch (E21 | E22 | ... | E2k x2) catchBody2
...
finally finallyBody
```

- All the various bodies are block statements
- There can be zero or more `catch` clauses and the `finally` clause may be absent, but there must be at least one `catch` or `finally` clause

throw Statement

throw Example 1(a)

```
class WeekdayException extends Exception {
  public WeekdayException(String wday) {
    super("Illegal weekday: " + wday) ;
  }
}

int wdayno(String wday) throws WeekdayException {
  for (int i = 0; i < wdays.length; i++) {
    if (wday.equals(wdays[i])) {
      return i ;
    }
  }
  throw new WeekdayException(wday) ;
}
```

throw Statement

throw Example 1(b)

```
jshell> class WeekdayException extends Exception {
   ...>   public WeekdayException(String wday) {
   ...>     super("Illegal weekday: " + wday) ;
   ...>   }
   ...> }
   ...>

jshell> int wdayno(String wday) throws WeekdayException {
   ...>   for (int i = 0; i < wdays.length; i++) {
   ...>     if (wday.equals(wdays[i])) {
   ...>       return i ;
   ...>     }
   ...>   }
   ...>   throw new WeekdayException(wday) ;
   ...> }
   ...>

jshell> int d4 = wdayno("Dimanche")
|  Exception REPL.dJShelld31dWeekdayException:
         Illegal weekday: Dimanche
|        at wdayno (#25:7)
|        at (#27:1)
```

assert Statement

Description

- The `assert` statement has one of the following forms:

```
assert booleanExpression ;
assert booleanExpression : expression ;
```

- booleanExpression must have type `boolean` or `Boolean`
- expression must be of type `boolean`, `char`, `double`, `float`, `int`, `long`, a boxed version of these or `Object`
- When assertions are enabled at run-time, every execution of the `assert` command will evaluate booleanExpression
- If the result is `true`, program execution contines normally
- If the result is `false`, the assertion fails, and an `AssertionError` will be thrown
- In the second form, expression will be evaluated, and its value passed to the appropriate `AssertionError` constructor

assert Statement

assert Example 1(a)

- See Unit 8 section 7

```
assert x > 2 : "x was " + x ;
```

Composition

Unit 4 Composition Supplement

- Unit 4 Section 8 and the Composition Supplement discuss *composition* and compare it to *inheritance*
- *Composition* is preferred where there is a `has-a` or `is-part-of` relation

Lollipop Class

Initialising a Lollipop Object (1)

- **Lollipop Example 1** (a)
- Initialise the component objects
- Use them to initialise the composite object

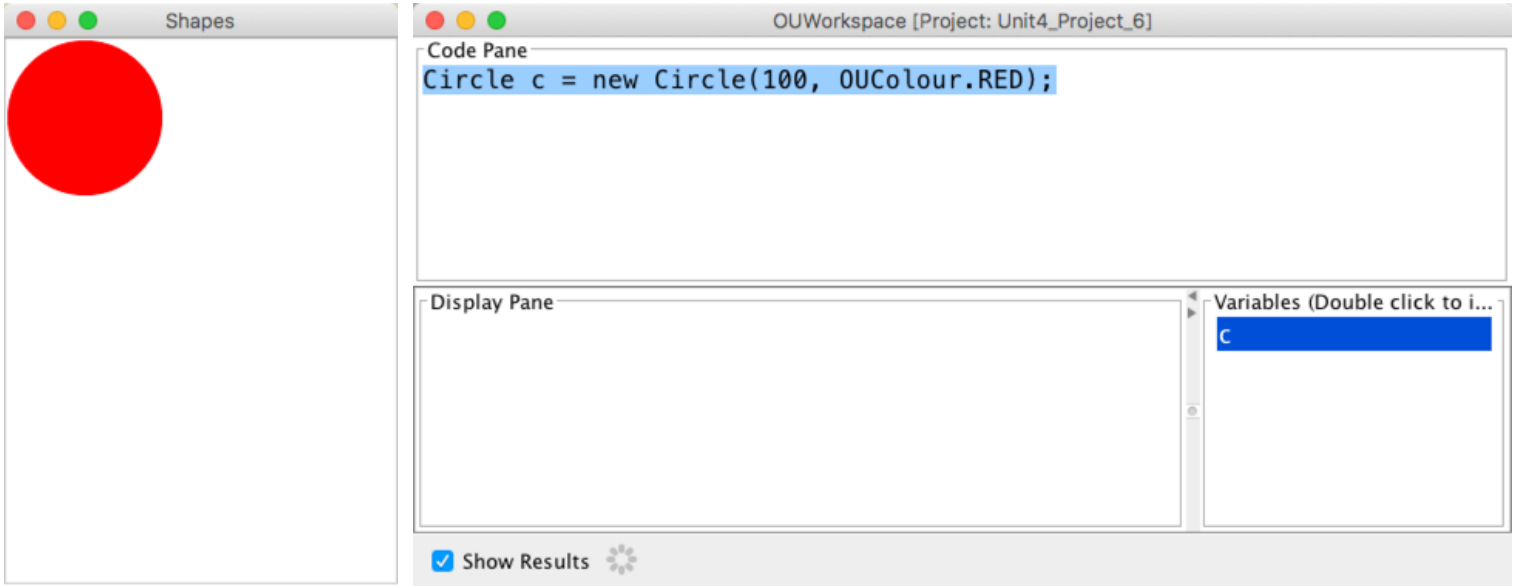
```
Circle c = new Circle(100, OUColour.RED);
Rectangle r = new Rectangle(10, 100, OUColour.PINK);
Lollipop lo = new Lollipop(c, r);
```

Lollipop Class

Initialising a Lollipop Object (2)

- **Lollipop Example 1** (b)
- Initialise the sweet in OUWorkspace
- Graphical Display > Open

```
Circle c = new Circle(100, OUColour.RED);
```

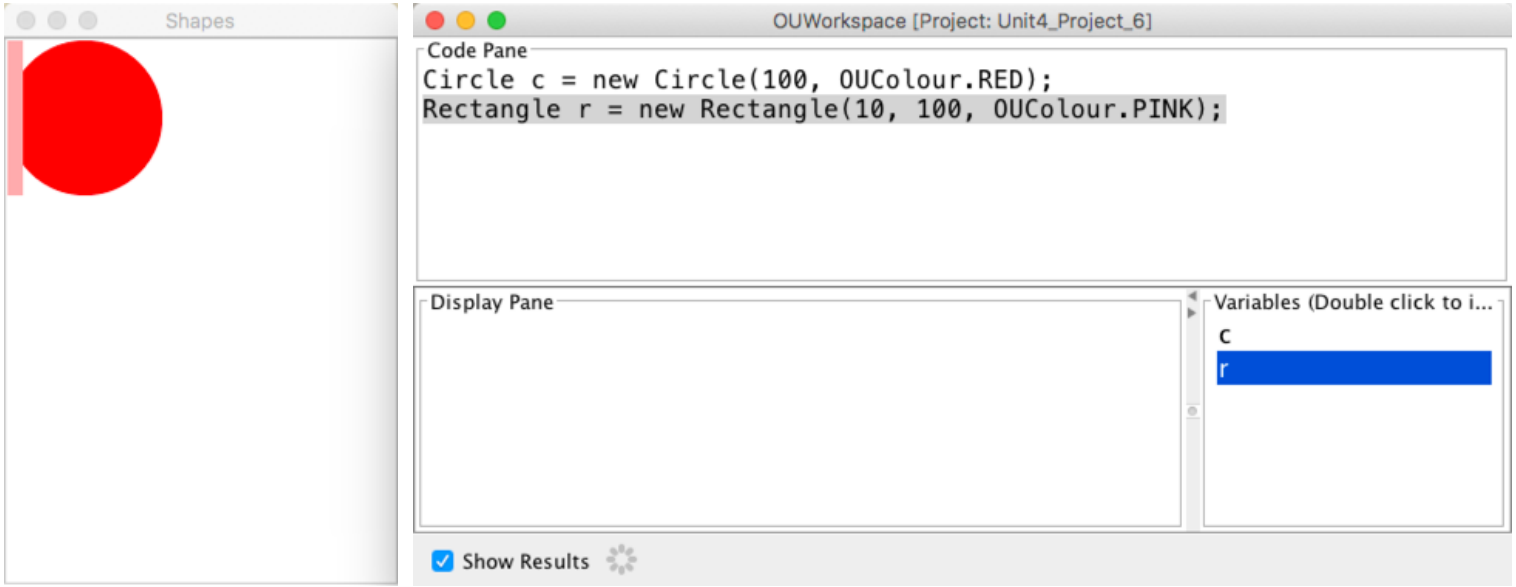


Lollipop Class

Initialising a Lollipop Object (3)

- **Lollipop Example 1** (c)
- Initialise the `stick` in `OUWorkspace`
- Graphical Display > Open

```
Rectangle r = new Rectangle(10, 100, OUColour.PINK);
```

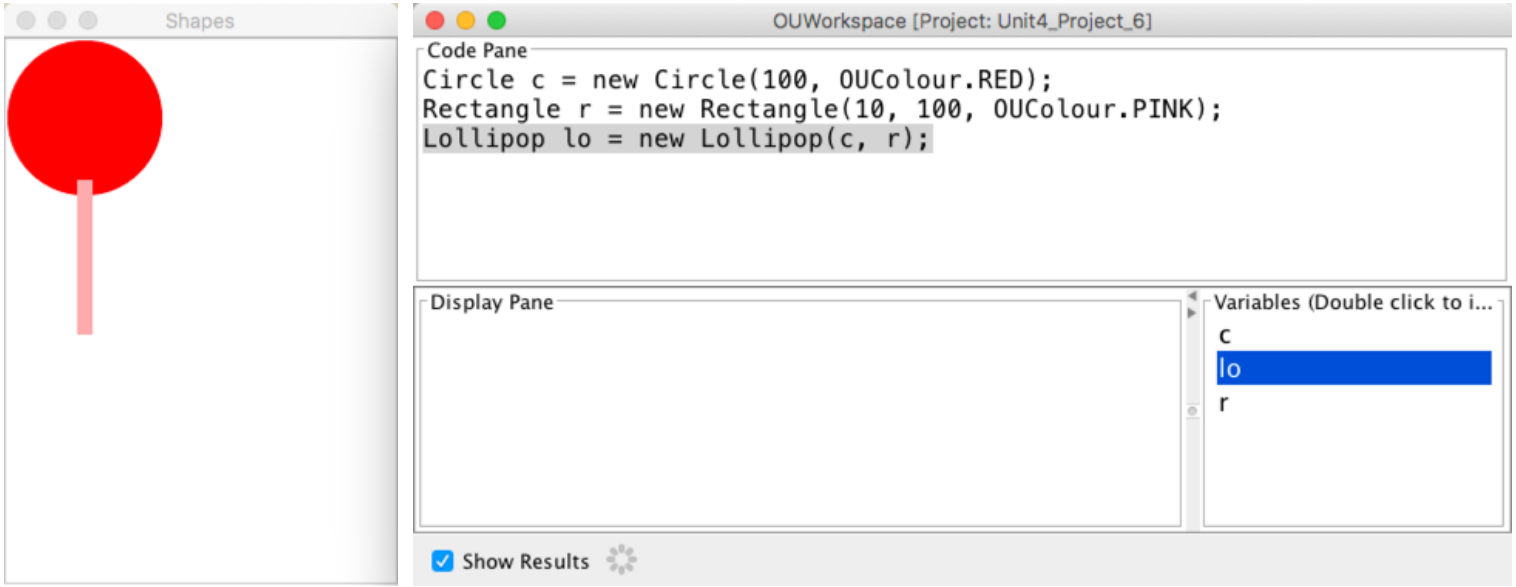


Lollipop Class

Initialising a Lollipop Object (4)

- **Lollipop Example 1** (d)
- Initialise the `Lollipop` in `OUWorkspace`
- Graphical Display > Open

```
Lollipop lo = new Lollipop(c, r);
```



Lollipop Class

Initialising a Lollipop Object (5)

- **Lollipop Example 2** (a)
- Pass in anonymous objects as actual arguments
- To make the `Lollipop` visible we have to create references to the components in `OUWorkspace`

```
Lollipop lo
  = new Lollipop(new Circle(100, OUColour.RED),
                 new Rectangle(10, 100, OUColour.PINK));
// lo created but not visible
Circle c = lo.getSweet();
Rectangle r = lo.getStick();
```

Lollipop Class

Initialising a Lollipop Object (6)

- **Lollipop Example 3** (a)
- The component object is initialised by the composite object
- To make the Lollipop visible we have to create references to the components in OUWorkspace

```
Lollipop lo = new Lollipop();
// lo created but with default values
// but not yet visible
Circle c = lo.getSweet();
Rectangle r = lo.getStick();
```

Circle and Rectangle Classes

Circle Class (1)

```
import ou.*;

public class Circle extends OUAnimatedObject {
  /* Instance variables */
  private OUColour colour ;
  private int xPos ;
  private int yPos ;
  private int diameter ;
```

Circle and Rectangle Classes

Circle Class (2)

```
public Circle() {
  super() ;
  this.colour = OUColour.BLUE ;
  this.xPos = 0 ;
  this.yPos = 0 ;
  this.diameter = 30 ;
}

public Circle(int aDiameter, OUColour aColour) {
  super() ;
  this.diameter = aDiameter ;
  this.colour = aColour ;
  this.xPos = 0 ;
  this.yPos = 0 ;
}
```

Circle and Rectangle Classes

Circle Class (3)

```
/* Instance methods */

public void setDiameter(int aDiameter) {
  this.diameter = aDiameter ;
  this.update() ;
}

public int getDiameter() {
  return this.diameter ;
}

public void setColour (OUColour aColour) {
  this.colour = aColour ;
  this.update() ;
}

public OUColour getColour () {
  return this.colour ;
}
```

Circle and Rectangle Classes

Circle Class (4)

```
public void setXPos(int x) {
  this.xPos = x ;
  this.update() ;
}

public int getXPos() {
  return this.xPos ;
}

public void setYPos(int y) {
  this.yPos = y ;
  this.update() ;
}

public int getYPos() {
  return this.yPos ;
}
```

Circle and Rectangle Classes

Circle Class (5)

```
  public String toString() {
    return ("An␣instance␣of␣class␣"
            + this.getClass().getName()
            + ":␣position␣("
            + this.getXPos() + ",␣" + this.getYPos()
            + "),␣diameter␣" + this.getDiameter()
            + ",␣colour␣" + this.getColour()) ;
  }
}
```

Circle and Rectangle Classes

Rectangle Class (1)

```
import ou.*;

public class Rectangle extends OUAnimatedObject {
  /* Instance variables */

  private OUColour colour ;
  private int xPos ;
  private int yPos ;
  private int width ;
  private int height ;
```

Circle and Rectangle Classes

Rectangle Class (2)

```
public Rectangle() {
  super() ;
  this.colour = OUColour.PURPLE ;
  this.xPos = 0 ;
  this.yPos = 0 ;
  this.width = 40 ;
  this.height = 20 ;
}

public Rectangle(int aWidth, int aHeight,
                 OUColour aColour) {
  super() ;
  this.width = aWidth ;
  this.height = aHeight ;
  this.colour = aColour ;
  this.xPos = 0 ;
  this.yPos = 0 ;
}
```

Circle and Rectangle Classes

Rectangle Class (3)

```
/* Instance methods */

public void setWidth(int aWidth) {
  this.width = aWidth ;
  this.update() ;
}

public void setHeight(int aHeight) {
  this.height = aHeight ;
  this.update() ;
}

public int getWidth() {
  return this.width ;
}

public int getHeight() {
  return this.height ;
}
```

Circle and Rectangle Classes

Rectangle Class (4)

```
public void setColour (OUColour aColour) {
  this.colour = aColour ;
  this.update() ;
}

public OUColour getColour () {
  return this.colour ;
}
```

Circle and Rectangle Classes

Rectangle Class (5)

```
public void setXPos(int x) {
  this.xPos = x ;
  this.update() ;
}

public int getXPos() {
  return this.xPos ;
}

public void setYPos(int y) {
  this.yPos = y ;
  this.update() ;
}

public int getYPos() {
  return this.yPos ;
}
```

Circle and Rectangle Classes

Rectangle Class (6)

```
  public String toString() {
     return ("An␣instance␣of␣class␣"
             + this.getClass().getName()
             + ":␣position␣("
             + this.getXPos() + ",␣" + this.getYPos()
             + "),␣width␣" + this.getWidth()
             + ",␣height␣" + this.getHeight()
             + ",␣colour␣" + this.getColour()) ;
  }

}
```

Composition

Lollipop Class (1)

- **Lollipop Class** in `Lollipop.java`
- Instance and Class variables

```
import ou.*;

public class Lollipop {
  private Circle sweet ;
  private Rectangle stick ;
  private int licks ;

  private static final OUColour SWEET_COLOUR
                       = OUColour.RED ;
  private static final OUColour STICK_COLOUR
                       = new OUColour(200,200,200) ;
  private static final int SIZE = 100 ;
    //sweet diameter and stick height
  private static final int STICK_WIDTH = 10 ;
```

Composition

Lollipop Class (2) Constructors

item **Lollipop Constructor** with defaults

```
public Lollipop() {

  Circle c = new Circle(SIZE, SWEET_COLOUR) ;

  c.setXPos(75) ;
  c.setYPos(75) ;

  this.sweet = c ;

  this.stick
    = new Rectangle(STICK_WIDTH
                    , SIZE
                    , STICK_COLOUR) ;

  this.attachStick() ;

  this.licks = 0 ;
}
```

Composition

Lollipop Class (3) Constructors

- **Lollipop Constructor** with two arguments

```
public Lollipop(Circle aSweet, Rectangle aStick) {
  this.sweet = aSweet ;
  this.stick = aStick ;

  this.attachStick() ;

  this.licks = 0 ;
}
```

Composition

Lollipop Class (4) attachStick()

- **Lollipop attachStick()**

```
/**
 * Attach a stick to an existing sweet.
 * The sweet must have been initialised already.
 */

private void attachStick() {
  int radius = this.sweet.getDiameter() / 2 ;

  //move stick to the right to reach sweet centre
  this.stick.setXPos(this.sweet.getXPos()
                     + radius
                     - this.stick.getWidth() / 2) ;

  //move stick down near the bottom of the sweet
  this.stick.setYPos(this.sweet.getYPos()
                     + this.sweet.getDiameter()
                     - STICK_WIDTH) ;
}
```

Composition

Lollipop Class (5) Horizontal, Vertical Movement

- **Lollipop Horizontal, Vertical Movement**

```
/**
* Method to move a lollipop horizontally.
* The direction depends on the sign of the argument.
*/
public void horiz(int xinc) {
  this.sweet.setXPos(this.sweet.getXPos() + xinc) ;
  this.stick.setXPos(this.stick.getXPos() + xinc) ;
}

/**
* Method to move a lollipop vertically.
* The direction depends on the sign of the argument.
*/
public void vert(int yinc) {
  this.sweet.setYPos(this.sweet.getYPos() + yinc) ;
  this.stick.setYPos(this.stick.getYPos() + yinc) ;
}
```

Composition

Lollipop Class (6) Eat Sweet

- **Lollipop Eat Sweet**

```
/**
 * When you lick a lollipop, its sweet shrinks and
 * its stick changes colour
 * to get closer to the sweet's colour.
 */
public void lick() {
  if (this.sweet.getDiameter() > 1) {
    this.licks = this.licks + 1 ;

    this.sweet.setDiameter(this.sweet.getDiameter()
                           - 2) ;

    //Move the sweet so it stays on the stick
    //If we used attachStick,
    //the lollipop would move when licked.
    //This is because the circle is drawn relative
    //to the top-left corner of its bounding box.

    this.sweet.setXPos(this.sweet.getXPos() + 1) ;
    this.sweet.setYPos(this.sweet.getYPos() + 2) ;
```

Composition

Lollipop Class (7) Eat Sweet (contd)

- **Lollipop Eat Sweet** (contd)

```
//Transfer some colour to the stick.

OUColour stickCol = this.stick.getColour();
int str = stickCol.getRed() ;
int stg = stickCol.getGreen() ;
int stb = stickCol.getBlue() ;

OUColour sweetCol = this.sweet.getColour();
int swr = sweetCol.getRed() ;
int swg = sweetCol.getGreen() ;
int swb = sweetCol.getBlue() ;
```

Composition

Lollipop Class (8) Eat Sweet (contd)

- **Lollipop Eat Sweet** (contd)

```
      //Now add some colour
      //from the sweet to the stick!
      //Fudge factor:
      //1/50th of the difference between
      //the colours of the sweet and the stick
      //is added to the stick colour
      OUColour newCol
        = new OUColour(str + (swr - str) / 50,
                       stg + (swg - stg) / 50,
                       stb + (swb - stb) / 50) ;

      this.stick.setColour(newCol) ;
    } else {
      OUDialog.alert("It's all gone!") ;
    }

}
```

Composition

Lollipop Class (9) getStick, getSweet, getLicks

- **Lollipop getStick, getSweet, getLicks**

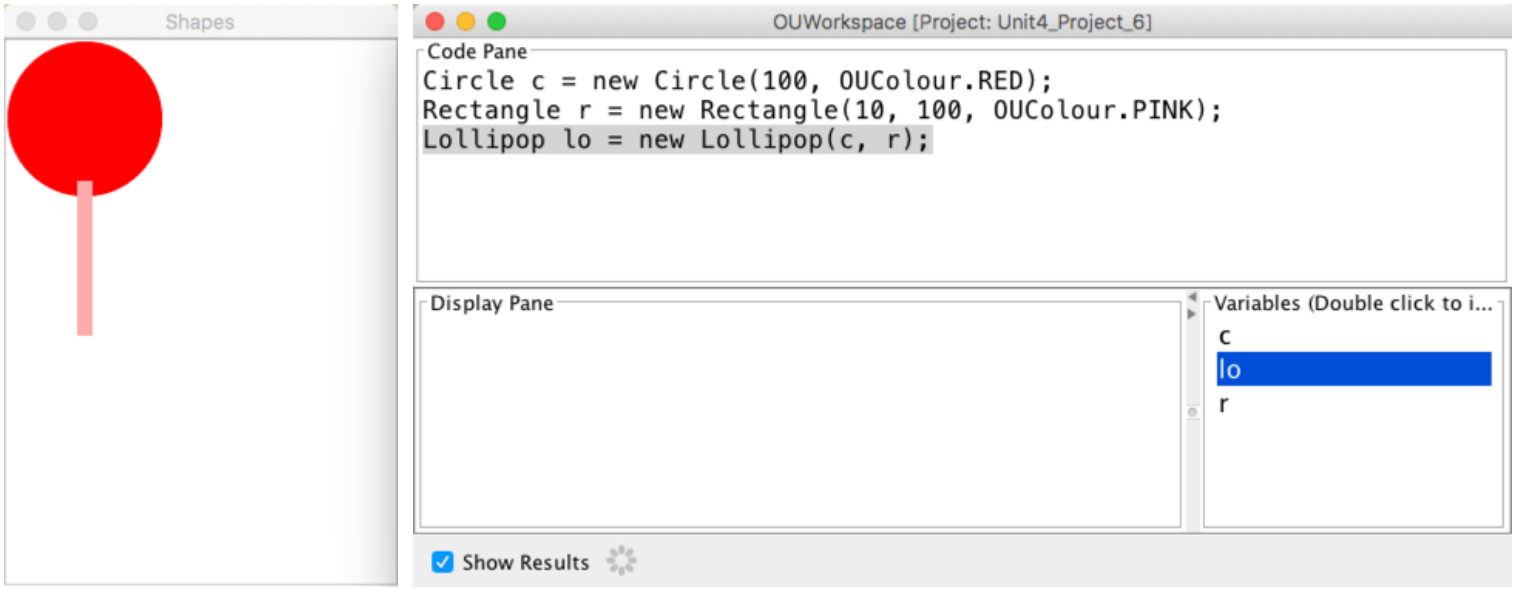
```
  /**
   * Enable workspace to see the stick part
   */
  public Rectangle getStick() {
    return this.stick ;
  }

  /**
   * Enable workspace to see the sweet part
   */
  public Circle getSweet() {
    return this.sweet ;
  }

  public int getLicks() {
    return this.licks ;
  }
}
```

Composition

Lollipop Interaction (1)

- **Lollipop Example 1** (a) (contd)

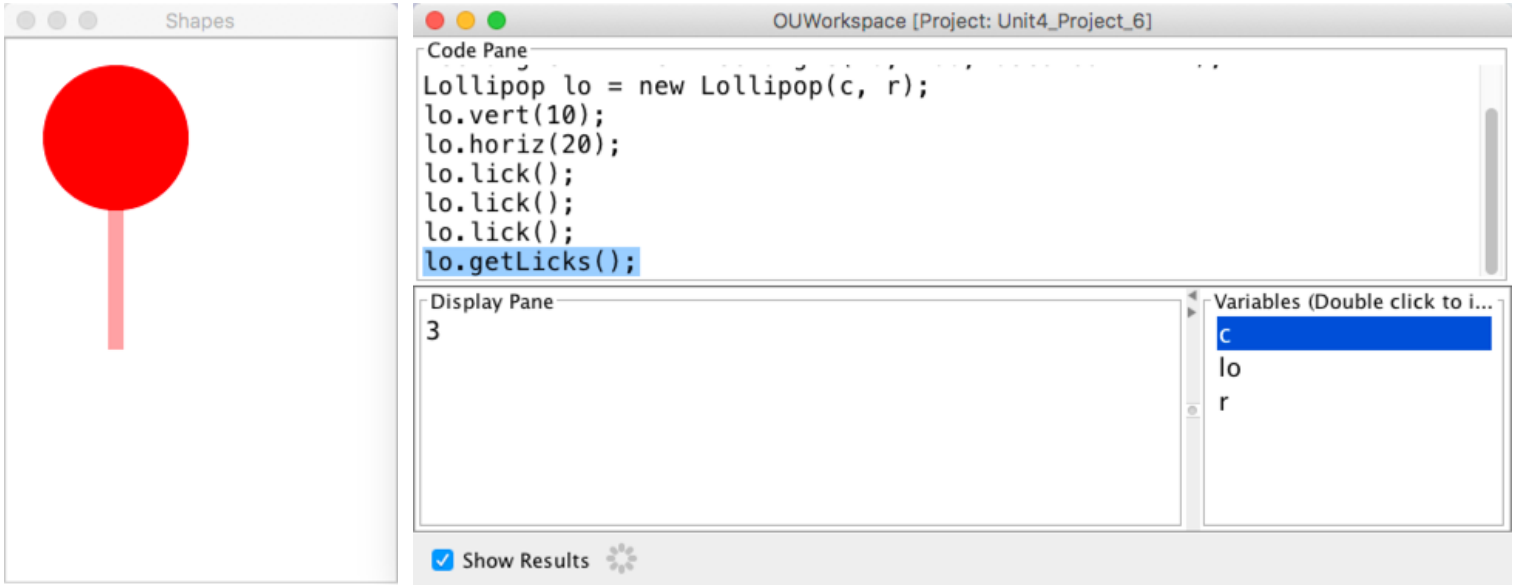
```
lo.vert(10);
lo.horiz(20);
lo.lick();
lo.lick();
lo.lick();
lo.getLicks();
```



Composition

Lollipop Interaction (2)

- **Lollipop Example 1** (a) (contd)
- After the above code is executed



Composition

Lollipop Interaction (3)

- **Lollipop Example 1** (a) (contd)

```
lo.vert(10);
lo.horiz(20);
lo.lick();
lo.lick();
lo.lick();
lo.getLicks();
```

- We can see the instance of the `Lollipop` has moved down, right
- The `sweet` has shrunk and the `stick` has changed colour (slightly)
- Notice that the `sweet` is now displayed overlapping the `stick` — what code should we have had to avoid this ?

Composition

Summary

- Composition is a relationship between classes in which component objects form part of composite objects.
- Composite object classes have instance variables that are of their component object class types.
- When initialising a composite object, its component parts also need to be suitably initialised.
- Anonymous objects can be used to avoid storing unnecessary references to objects that might break encapsulation.
- Favour composition over inheritance — see Bloch (2017, Item 18, page 87)
- Composition `has-a` relationship
- Inheritance `is-a` relationship

Java Shell, JShell

References

- 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)

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

What Next ?

To err is human ?

- 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)

What Next ?

TMA02, TMA03, Exam

- Tutorial Online 10:00 Sunday 16 February 2025 Inheritance and Interfaces
- TMA02 Thursday 6 March 2025
- Tutorial Online 10:00 Sunday 16 March 2025 Collections
- TMA03 Thursday 8 May 2025
- Tutorial Online Sunday 11 May 2025 Exam revision

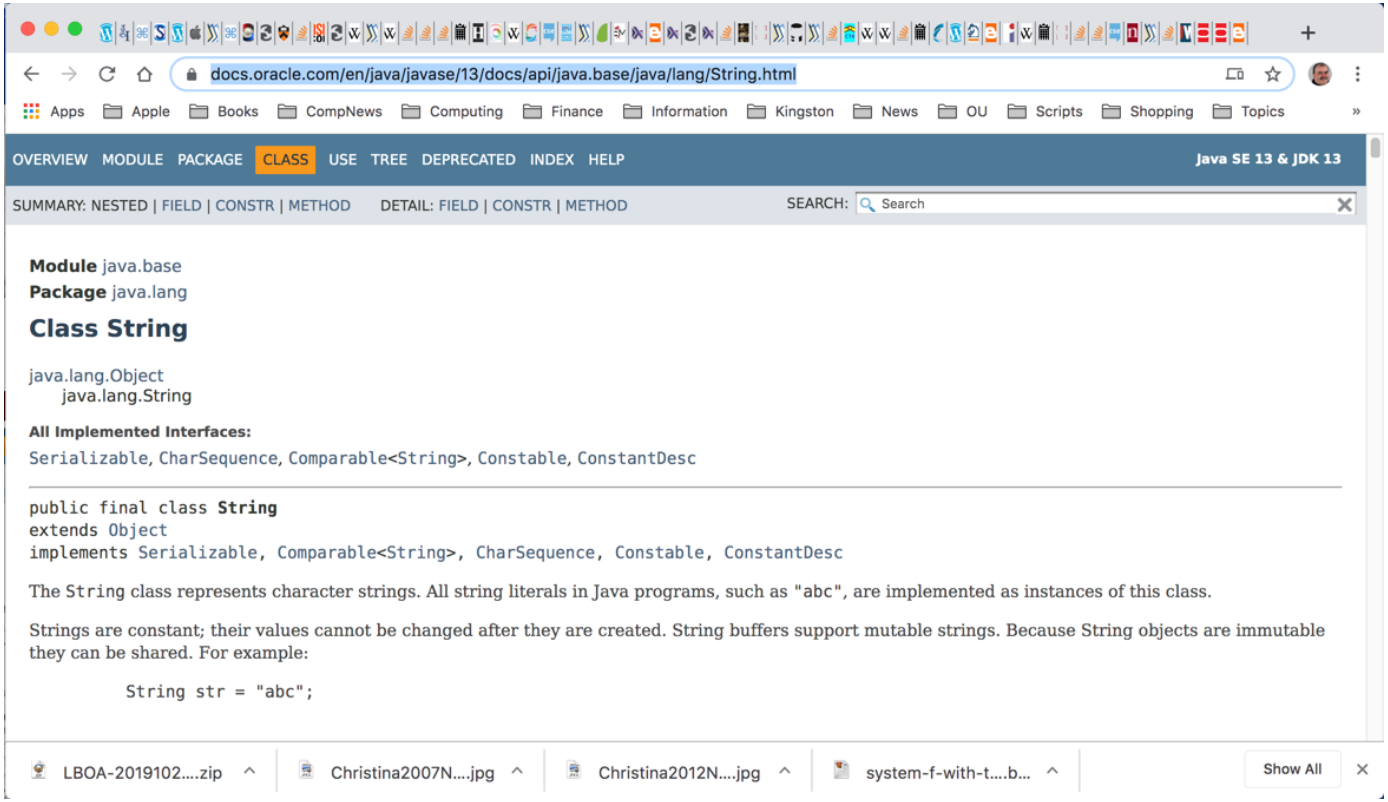
M250

Web Links

- 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

Java

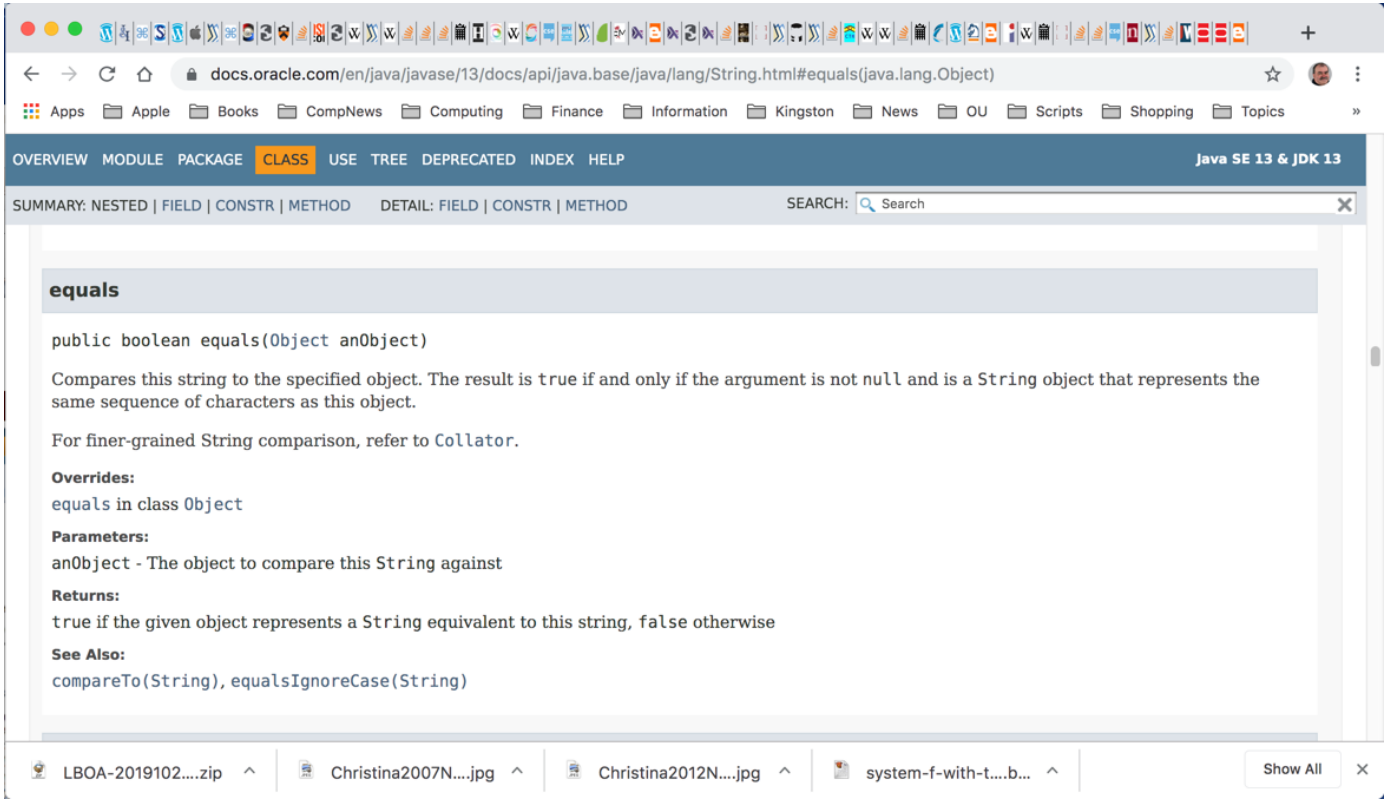
API Documentation (1)



- `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)

Java

API Documentation (2)



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

M250

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, Flanagan (2018) Java in a Nutshell — the best longer reference
- Barnes, Kölling (2016) Objects First with Java — the BlueJ book — see www.bluej.org for documentation and tutorial
- Bloch (2017) Effective Java — guide to best practice