COMPSCI4039: Programming

FileIO and Exceptions

What we’re working towards

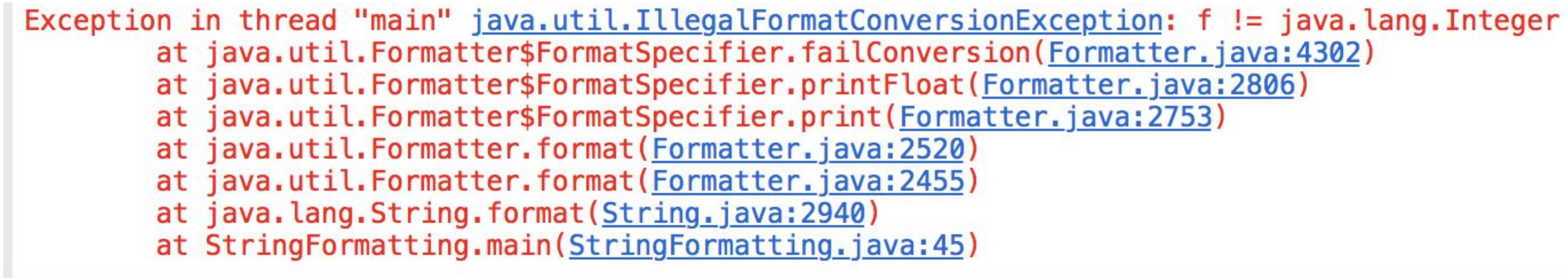
See LoadStudents.java…

- Loads a comma separated file holding student names and grades into an array of Student objects
- The file parsing bit is quite straightforward
- But the **exception handling** is a bit of a pain.

Exceptions

- How many of you have seen an Exception?

All of you...



```
Exception in thread "main" java.util.IllegalFormatConversionException: f != java.lang.Integer
	at java.util.Formatter$FormatSpecifier.failConversion(Formatter.java:4302)
	at java.util.Formatter$FormatSpecifier.printFloat(Formatter.java:2806)
	at java.util.Formatter$FormatSpecifier.print(Formatter.java:2753)
	at java.util.Formatter.format(Formatter.java:2520)
	at java.util.Formatter.format(Formatter.java:2455)
	at java.lang.String.format(String.java:2940)
	at StringFormatting.main(StringFormatting.java:45)
```

What are exceptions?

- Exceptions are **objects**
- Exceptions are made and **thrown** when something bad happens
- We can **catch** exceptions in our programs so that we can make the bad things better
- Some exceptions **have to be caught** (we have not seen any of these yet)
    - Known as **checked** exceptions
- Some don’t have to be caught (all the ones you’ve seen so far)
    - Known as **unchecked** exceptions
- Dealing with files requires us to be able to handle **checked** exceptions

Unchecked exceptions

- Unchecked exceptions are common e.g.:
  - You try and access an element of an array that doesn’t exist
  - You try and convert “Hello” into an integer
  - ….
- Normally, they cause some red text to appear, and your program to stop
- You can also make them happen on purpose using the **`throw`** command

```java
public class Throw {
    public static void main(String[] args) {
        System.out.println("About to throw an unchecked exception");
        throw new ArrayIndexOutOfBoundsException();
    }
}
```

Output:

```
About to throw an unchecked exception
Exception in thread "main" java.lang.ArrayIndexOutOfBoundsException
    at Throw.main(Throw.java:5)
```

Throw your own

- You can also make your own Exception (...exceptions are objects…)
- To make an unchecked exception, you **extend** the **`RuntimeException`** class

```
public class MyException extends RuntimeException {
}
```

```
public class Throw {
    public static void main(String[] args) {
        System.out.println("About to throw an unchecked exception");
        throw new MyException();
    }
}
```

Output:

```
About to throw an unchecked exception
Exception in thread "main" MyException
    at Throw.main(Throw.java:5)
```

Catching

- Exceptions become really useful once you know how to **catch** them
  - Remember: all exceptions **can** be caught. Some (checked ones) **have to be caught**.
- Catching an exception detects that it has happened and allows you to act accordingly.
- Achieved using `try / catch / finally` blocks

```
try {
    // code A
}catch(<ExceptionType> <name>) {
    // some code if code A causes an exception to be thrown
}finally {
    // some code done regardless of exception being thrown or not
}
```

Simple example

```
import java.util.Random;
public class ArrayException {
    public static void main(String[] args) {
        int[] x = new int[10];
        Random r = new Random();
        int pos = r.nextInt(20);
        System.out.println(x[pos]);
    }
}
```

- This code will (sometimes) cause `ArrayIndexOutOfBoundsException` to be thrown (when `pos` >= 10 (the length of the array))
- We can **catch** this exception...

```java
import java.util.Random;
public class ArrayExceptionCaught {
    public static void main(String[] args) {
        int[] x = new int[10];
        Random r = new Random();
        try {
            int pos = r.nextInt(20);
            System.out.println(x[pos]);
        }catch(ArrayIndexOutOfBoundsException e) {
            e.printStackTrace();
        }finally {
            System.out.println("This happens whatever");
        }
    }
}
```

- Now if pos >= 10 the Exception is caught (by the catch statement) and we do something (in this case, prints “Too big”)
- If pos < 10 we don’t enter the catch block
- Either way we enter the finally block

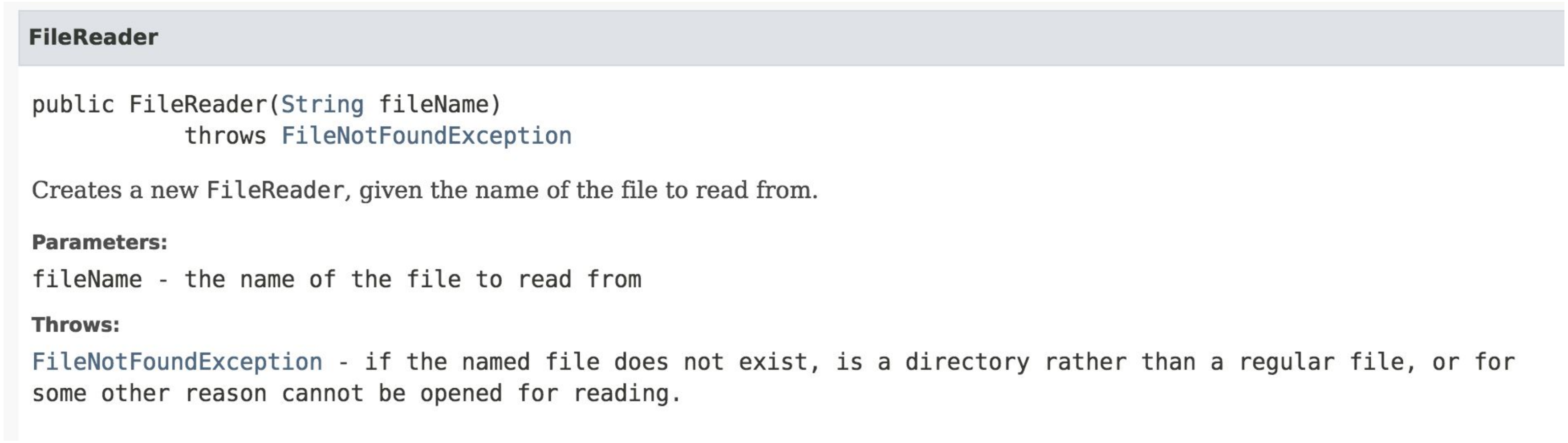
- In this case, we could do the same with if / else
- But in many cases try / catch is much neater (and compulsory!)

Aside - `Random`

- In the last example we used `Random`
- `Random` is a Java class that provides the capability for generating (pseudo)random numbers.
- We created an instance of the class:
    - `Random r = new Random();`
- And then called the `nextInt(int max)` method to generate random integers between `0` and `max-1`
- It has methods for generating other types (e.g. `doubles`)

A checked exception - `FileNotFoundException`

- `FileReader` is a Java class that allows you to read characters from a file
- Here's an excerpt from the Java API
- It tells us that the constructor throws `FileNotFoundException` and we therefore have to **catch** it



FileReader

```
public FileReader(String fileName)
           throws FileNotFoundException
```

Creates a new `FileReader`, given the name of the file to read from.

Parameters:

`fileName` - the name of the file to read from

Throws:

`FileNotFoundException` - if the named file does not exist, is a directory rather than a regular file, or for some other reason cannot be opened for reading.

FileReader

```
import java.io.FileNotFoundException;
import java.io.FileReader;
public class FR {
    public static void main(String[] args) {
        try {
            String fN = "/Users/simon/Desktop/students.csv";
            FileReader fr = new FileReader(fN);
        }catch(FileNotFoundException e) {
            e.printStackTrace();
        }
    }
}
```

FileReader object is created in the try.
Catch catches the Exception (FileNotFoundException) that the FileReader constructor might throw

`printStackTrace()` is a useful method that Exceptions have for debugging

- It is the constructor that **throws** the exception
- So we have to put the code that makes the FileReader (`new FileReader(filename)` etc) into a **try** block

Closing the `FileReader`

- FileReader objects need to be **closed** when we're finished with them
- It is good practice to do this in a **finally** block: it gets closed whatever happens.
- The API tells us that the close method of `FileReader` can throw an `IOException` which we will need to catch
- We do this in a separate `try catch` block within the `finally` of the first `try catch` block
- ...and we need to create the `FileReader` reference outside the first `try catch` block so that it is in scope

```java
import java.io.FileNotFoundException;
import java.io.FileReader;
import java.io.IOException;
public class FR2 {
    public static void main(String[] args) {
        FileReader fr = null;
        try {
            String fN = "/Users/simon/Desktop/students.csv";
            fr = new FileReader(fN);
        }catch(FileNotFoundException e) {
            e.printStackTrace();
        }finally {
            try {
                fr.close();
            }catch(IOException e) {
                e.printStackTrace();
            }
        }
    }
}
```

Make the reference here so it is visible in `finally`

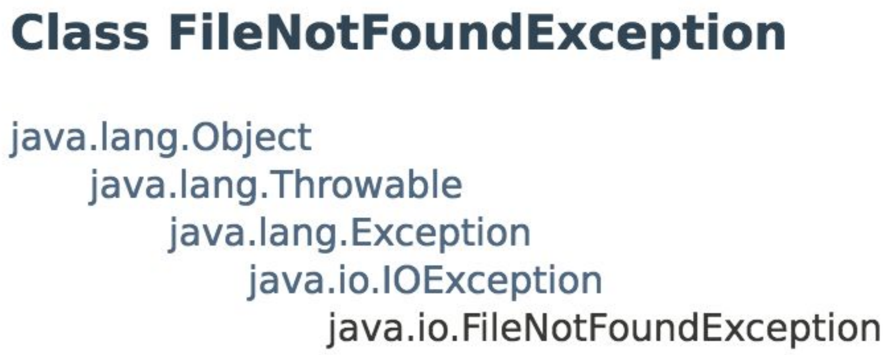
Try and close the `FileReader`, catching the `IOException` that might be thrown.

FileReader

- We can now do the actual file reading
- But first, a couple more useful things about `Exceptions...`

Catching ‘higher’ exceptions

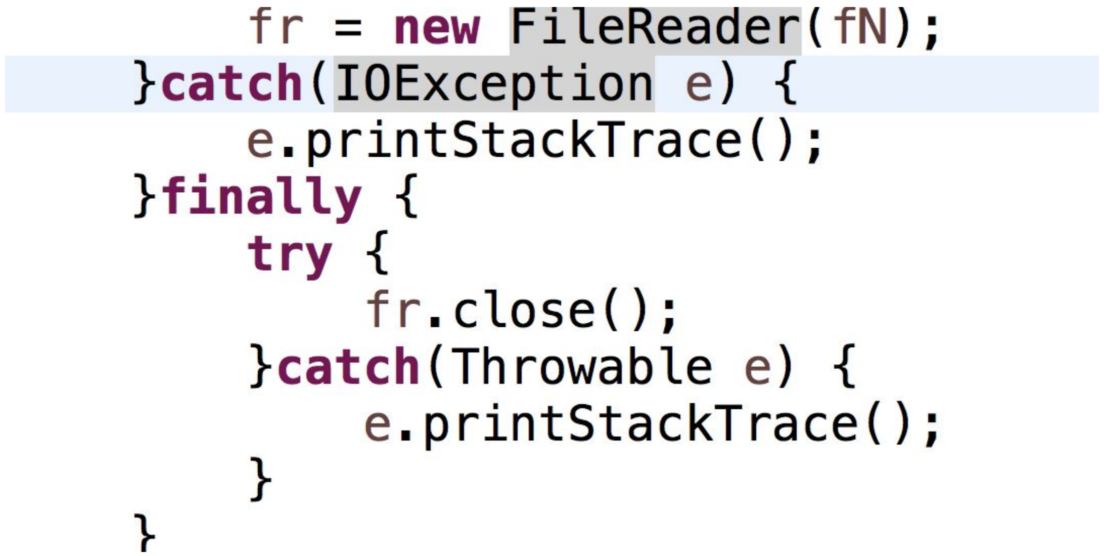
- `FileNotFoundException` inherits from `IOException` which inherits from `Exception`, which also inherits from `Throwable`
- Anywhere where we need to catch `FileNotFoundException`, we could catch any of these types instead, and it would be caught (this is an example of **polymorphism**)



Class FileNotFoundException

```
java.lang.Object
    java.lang.Throwable
        java.lang.Exception
            java.io.IOException
                java.io.FileNotFoundException
```

example...



```
        fr = new FileReader(fN);
    }catch(IOException e) {
        e.printStackTrace();
    }finally {
        try {
            fr.close();
        }catch(Throwable e) {
            e.printStackTrace();
        }
    }
```

- This is from the end of our last program. We've swapped:
    - FileNotFoundException for its super class, IOException
    - `IOException` (second catch statement) for it's super-super class `Throwable`
- Note that both of the exceptions we need to catch could be caught as `IOException` (`FileNotFoundException` is a sub-class of `IOException`)

```java
import java.io.FileReader;
import java.io.IOException;
public class FR3 {
     public static void main(String[] args) {
          FileReader fr = null;
          try {
               String fN = "/Users/simon/Desktop/students.csv";
               fr = new FileReader(fN);
               // read file
               fr.close();
          }catch(IOException e) {
               e.printStackTrace();
          }
     }
}
```

This will catch Exceptions thrown by either the `FileReader` constructor **or** the `close()` method.

- This solution is not as neat - it's good practice to catch exceptions individually

Delegating catches

- If you don’t want to deal with the exception, you can delegate it up to whatever called your method.
- This is achieved by adding **throws <Exception1>, <Exception 2>, ...** into the method declaration:

```
public void myMethod(String a) throws IOException, ArrayIndexOutOfBoundsException {
```

- This means you can get rid of all the exception handling in our FileReader by defining our main to throw the exceptions...

```java
import java.io.FileNotFoundException;
import java.io.FileReader;
import java.io.IOException;
public class FR4 {
    public static void main(String[] args) throws FileNotFoundException, IOException{
        String fN = "/Users/simon/Desktop/students.csv";
        FileReader fr = new FileReader(fN);
        // some reading
        fr.close();
    }
}
```

- Defining methods that throw exceptions can be useful
- In this case, it’s just a bit lazy! (useful for quick prototyping)
- Q: the code above is a bit redundant - what could we remove?

Delegating catches 2

Because myMethod can throw a MyException, it has to be in a try catch block.

A `MyException` can be thrown in this method. It doesn't want to deal with it, so throws it up to the calling method (`main`).

```
public class Delegation {
    public static void main(String[] args) {
        try {
            myMethod();
        }catch(MyException e) {
            e.printStackTrace();
        }
    }
    public static void myMethod() throws MyException {
        // some code
        if(new Random().nextInt(10)<=7) {
            throw new MyException();
        }
    }
}
```

Order is important

- Because of polymorphism, multiple catch statements could potentially catch the same Exception:
- In such cases, which one will catch it?
- E.g. Where will the FnF exception be caught?

Exceptions are caught by the first (top to bottom) catch statement that they can be caught by

In this case, Java will not compile because all FnF exceptions will be caught buy the IOException making the line that prints FnF **unreachable**

```java
public class ClassQ {
    public static void main(String[] args) {
        try {
            throw new FileNotFoundException();
        }catch(IOException e) {
            System.out.println("IO");
        }catch(FileNotFoundException e) {
            System.out.println("FnF");
        }
    }
}
```

Time for some questions...

Reading from a file

- Now we’ve sorted out `Exception` handling (it’s not just a file thing…) we can read from the file.
- `FileReader` allows us to read individual characters
- This is tedious - we use a `Scanner` to read in complete lines
- We pass the FileReader to the Scanner when we make it...

```
// make a filereader object
fr = new
FileReader("/Users/simon/Desktop/students.csv");
// make a scanner around the filereader
Scanner s = new Scanner(fr);
```

Files and paths

- When we create a FileReader we will pass it the name of the file.
- This needs to include the complete **path** to the file
- In my case, the file is on my desktop: /Users/simon/Desktop/fileName
- On the lab machines (Windows) it might be something like this:
    - `H:\aDirectory\anotherDirectory`
- And remember that \ is a special character so to get a \ you need to use 2!
    - `String fileName = “H:\\aDirectory\\anotherDirectory\\etc”;`

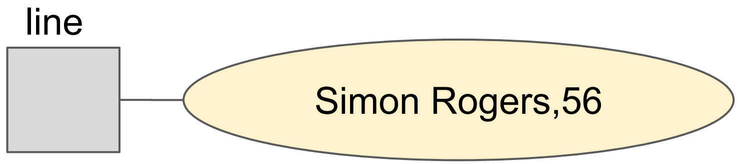
Reading from a file

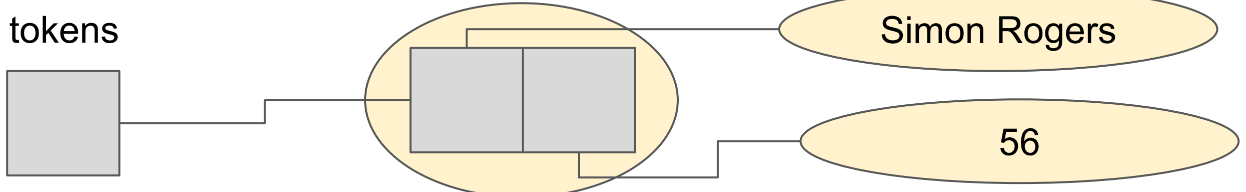
- We then loop while there are more lines to be read:

```
// Loop until no lines left
while(s.hasNextLine()) {
    // get the next line
    String line = s.nextLine();
```

Reading from a file

- Each line has the following format:
  - <name>,<grade>
- ...a name followed by a grade, separated by a comma
- We will use the `String.split` method which splits a String into an array of smaller strings
- If we ask it to split using a comma, it will give an array of all of the comma separated elements
- E.g.
  - `String line = “Simon Rogers,56”;`
  - `String[] tokens = line.split(“,”);`





Reading from a file

- Finally, we need to turn the grade into an `int` (it's currently a `String`)
- The **static** `parseInt()` method from the `Integer` class will do this:
  - `int grade = Integer.parseInt(tokens[1]);`
- We can now make a new Student object from the name and grade:
  - `new Student(tokens[0],grade);`
- And store it into the array (also increasing the number of students)
  - `students[nStudents++] = new Student(tokens[0],grade);`

Putting it all together

- See `LoadStudents.java`

Overview:

- To read from the file we need a `FileReader` object
- We give this to a `Scanner` to get the contents line by line
- We then process each line (I used `String.split`, you could also use another Scanner)
- Around this process we need all of the exception handling things.
- We needn't have done things line by line - could use any Scanner methods...e.g. `next(), nextInt()`, etc

Time for some questions...

Writing to a file

- Say we now want to sort the students and write them (sorted) to a new file
- Our `Student` object has a compareTo method (`Comparable` interface) so we can use `Arrays.sort`
- To write to a file we use a `FileWriter` object…
- The same Exception handling is required
- Once we've done that, we can write any `String` to the file using the `FileWriter's` `write()` method.
- See StudentLoader2.java
    - [had to add a getName() method to Student]

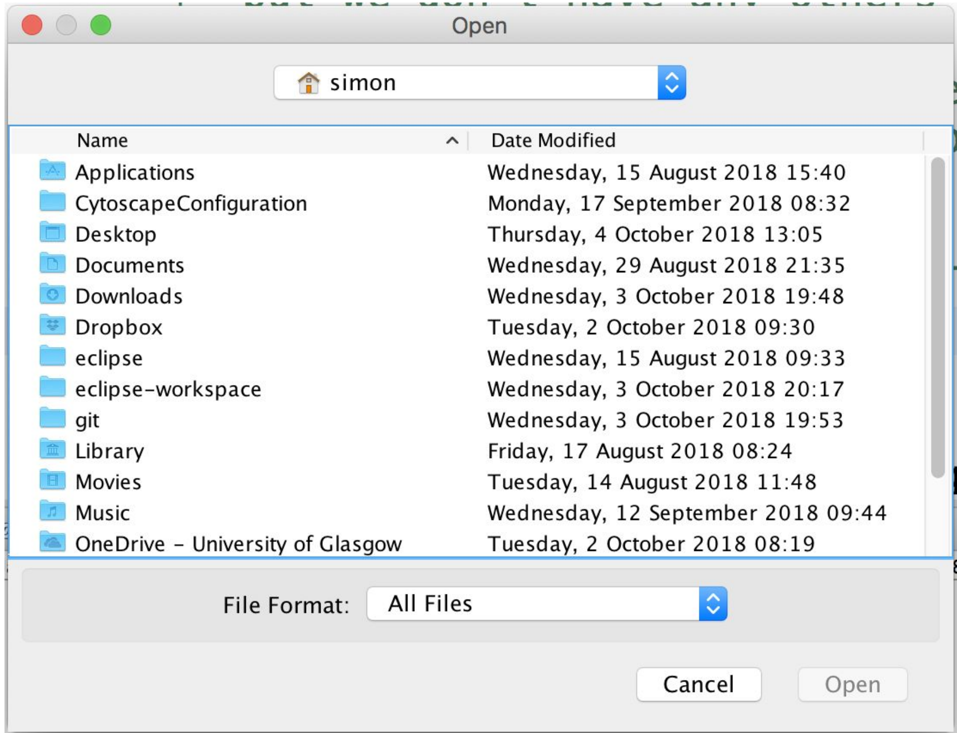
BufferedWriter

- You might see examples that use a BufferedWriter to write to the file
- Writing to a file is quite a slow process
- It can be beneficial to put things in a buffer (temporary storage) and only write to the file once there is enough there (nothing you will do on this course will need it)
- This is what `BufferedWriter` does.
- You can force it to write by **flushing** the buffer (`bw.flush()`)
- Data also written when:
  - Buffer is full
  - BufferedWriter is closed

```
fw = new FileWriter(outName);
BufferedWriter bw = new
BufferedWriter(fw);
// maybe a loop or something
bw.write(newLine);
```

JFileChooser

- What if we want to allow the user to specify the file?
- We could ask them to type in the filename
- Or we could use a JFileChooser...



Name	Date Modified
Applications	Wednesday, 15 August 2018 15:40
CytoscapeConfiguration	Monday, 17 September 2018 08:32
Desktop	Thursday, 4 October 2018 13:05
Documents	Wednesday, 29 August 2018 21:35
Downloads	Wednesday, 3 October 2018 19:48
Dropbox	Tuesday, 2 October 2018 09:30
eclipse	Wednesday, 15 August 2018 09:33
eclipse-workspace	Wednesday, 3 October 2018 20:17
git	Wednesday, 3 October 2018 19:53
Library	Friday, 17 August 2018 08:24
Movies	Tuesday, 14 August 2018 11:48
Music	Wednesday, 12 September 2018 09:44
OneDrive – University of Glasgow	Tuesday, 2 October 2018 08:19

File Format: All Files

JFileChooser

- `JFileChooser` is part of the Java Swing GUI library.
- It includes both open and save windows
- Very easy to use:
  - `JFileChooser fc = new JFileChooser();`
  - `int returnVal = fc.showOpenDialog(new JFrame());`
- This will pop up a `JFileChooser` dialog box
- `returnVal` tells you if a file was chosen or not (0 = yes)
- Access the `File` object using `fc.getSelectedFile();`
- **See `ChoosingFiles.java`**