BSc (Hons) Computing and Information Systems

CIS109

Introduction to Java and Object Oriented Programming (Volume 2)

Subject guide

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Contents

Chapter 1

Introduction

This is the second volume of an introductory programming course in Java. It is assumed that the reader has first studied Volume 1 [Dan07]. For a full explanation of how to study this course, the reader is reminded to refer to Chapter 1 of Volume 1.

1.1 What We Cover in this Subject Guide

In this volume, we cover more advanced, but essential topics in Object Oriented Programming. These include:

- Command-line arguments
- Recursion
- Packaging programs
- More about variables
- Bits, types, characters and type casting
- Files and streams
- Sorting arrays and searching
- Defining your own classes
- Inheritance
- Exception handling
- `Vectors`

1.1.1 Suggested Schedule for Volume 2

This schedule is an approximate indication of how much time to spend on each chapter. It assumes that all the material is to be covered in ten weeks. This is a minimum. If you have a longer period of study you can adjust this proportionally.

Week 1: Chapters 2 and 3

Week 2: Chapter 4

Week 3: Chapters 5 and 6

Week 4: Chapter 7

Week 5: Chapter 8

Week 6: Chapter 9

Week 7: Chapter 9

Week 8: Chapter 10

Week 9: Chapter 11

Week 10: Chapter 12

All the example programs given in the text, exercises and solutions, and other useful information will be provided on the accompanying CD and on the course website.

Details on how to access this website will be posted on

http://www.londonexternal.ac.uk/current_students/programme_resources/index.shtml

1.2 Books

I refer to a number of books throughout the text, specifically at the beginning of each chapter. Details of these books can be found in the bibliography in on the last page of this volume (page 117).

Chapter 2

Command-Line Arguments

2.1 Learning Objectives

Chapter 2 explains:

- the purpose of command-line arguments
- how to use command-line arguments.

2.2 Reading

- [CK06] pages 308-310

2.3 Introduction

Now, at last, you will learn the purpose of the line

```
public static void main(String [ ] args)
```

The name, `args`, is a formal parameter to the `main` method. The parameter `args` is of type array of `String`. The use of `args` is straightforward: if we run our program `fred.class` normally we type `java fred`, but if we like, we can write anything else we like after `java fred`, for example:

1. `java fred hello`

   or

2. `java fred 1 2 3 4`

   or

3. `java fred fred.java`

The `Strings` that we type after `java fred` are called *command line arguments*. The command line arguments are passed to the program in the `String` array parameter of the `main` method, namely, `args`. (We could have called `args` anything we liked. Let's stick to `args` though.)
In 1, above, there is one command line argument `args[0]` and its value is the `String "hello"`.
In 2, there are four command line arguments:

name	value
`args[0]`	”0”
`args[1]`	”1”
`args[2]`	”2”
`args[3]`	”3”

Note: `"0"`,`"1"`,`"2"`, and `"3"` are all of type `String`. If we want to add them up we first have to convert them to `int`s using the method `Integer.parseInt()`.
In 3, there is one command line argument `args[0]` and its value is the `String` `"fred.java"`.

2.4 The Number of Command Line Arguments

Since `args` is an array, the number of command line arguments is simply given by the expression `args.length`. (Recall that, if `a` is an array then `a.length` is the number of elements of `a`.)

2.5 Exercises on Chapter 2

2.5.1 Add One

Write a program which prints out one more than its command line argument. For example, `java AddOne 5` should output 6, etc.

2.5.2 Add

Write a program which adds its two command line arguments i.e. `java Add 5 6` should output 11.

2.5.3 Backwards

Write a program that allows you to enter as many words as you like as command line arguments and the program prints them out in reverse order.

2.5.4 Add All

Write a program that allows you to enter as many integers as you like as command line arguments and the program prints out their sum.

2.5.5 Add All Real

Write a program that allows you to enter as many real numbers as you like as command line arguments and the program prints out their sum.

2.5.6 Exercises (no solutions)

1. Write a program that prints out the average of all its command line arguments.
2. Write a program that prints out all the longest of all its command line arguments.
3. Write a program that prints all its command line arguments backwards. So `java back Fred Bloggs` should output `derf sggolB`

2.6 Summary

Having worked on Chapter 2 you will have:

- Understood the purpose of command-line arguments.
- Learned how to use command-line arguments.

Chapter 3

Recursion

3.1 Learning Objectives

Chapter 3 explains:

- recursion
- how to define and use recursive methods.

3.2 Reading

- [Dow03] Chapter 4

3.3 Definition of a Recursive Method

A recursive method is one that calls itself.

3.4 Examples of Recursive Methods

3.4.1 Factorial

[Lecture16/FactorialNew.java]

3.4.2 Greatest Common Divisor

The greatest common divisor of two integers is the largest integer that divides them both exactly. For example gcd(8,12)=4, gcd(7,13)=1 and gcd(16,96)=16.

An algorithm for finding the GCD of two positive integers n and m is as follows:

1. if $n = m$ then return n
2. if $n > m$ then subtract m from n and go to 1
3. if $m > n$ then subtract n from m and go to 1

[Lecture16/gcdNew.java]

3.5 Exercises on Chapter 3

3.5.1 Fibonacci Numbers

Write a program such that `java fibonacci n` prints out the nth Fibonacci number. The Fibonacci sequence goes 1,1,2,3,5,8,13,21,34,55,89,$\cdots$.

3.5.2 Multiplication

Multiplication of non-negative integers can be defined recursively in terms of addition:
mult(n,0) = 0
mult(n,$m+1$) = n+mult(n,m)
Write a class which has a method `mult` which implements such a function.

3.5.3 Exponentiation

Exponentiation of non-negative integers can be defined recursively in terms of Multiplication:
n^0 = 1
(n^{m+1}) = n*(n^m)

Write a class which has a method `power` which implements such a function.

3.5.4 Reversing Input

Without using `Vectors` or arrays write a program which reads in characters from the keyboard and prints them out in the opposite order to which they were typed in. The program should stop when the user presses the *enter* key.

3.5.5 The Syracuse Sequence

The *Syracuse Sequence* starting with 14 goes like this:
14 7 22 11 34 17 52 26 13 40 20 10 5 16 8 4 2 1
The rule is as follows: if n is even then the next number in the sequence is $n/2$ and if n is odd the next number is $3n+1$.
The sequence stops at 1.
Using recursion, write a program not containing the word "`while`", such that for all positive integers, n, `java syr n` prints out the Syracuse sequence starting with n.
(Try running `syr.class` to see how your program should behave.) An interesting fact about the Syracuse sequence is that nobody knows whether it always ends with 1 or not! No-one has proved it and no one has found an example that does not end in 1.

3.6 Summary

Having worked on Chapter 3 you will have:

- Understood recursion.
- Learned how to define and use recursive methods.

Chapter 4

Packaging Programs

4.1 Learning Objectives

Chapter 4 explains:

- the purpose of the `CLASSPATH` system variable
- the purpose of the `package` statement
- the purpose of the `import` statement
- how to run a Java program that is part of a package, from the command line.

4.2 Reading

- [CK06] Chapter 13
- [NK05] page 66
- [Kan97] page 33
- [Smi99] Chapter 17

4.3 Introduction

If you have some useful programs that you wish to use over and over again it is useful to package them up so you can refer to them from anywhere (i.e., make them public). There is a statement in Java that comes at the beginning of your program called a `Package Statement`. This is used in conjunction with a system variable called `CLASSPATH`[1] used by your Java System in conjunction with your operating system to tell Java where to look for `.class` files.

[1] See Volume 1 for instructions on setting the CLASSPATH.

Consider [`LecturePackages/egg.java`] Java will expect to find a directory called `food` at 'the top level' of a directory in `CLASSPATH`.

The directory `food` will contain a directory called `veg`. The directory `veg` will contain a file `radish.class` and `radish.class` will have a static method called `me()`.

```
                    <somewhere in CLASSPATH>
                            |
-----------------------------------------------------
|              |          |         |              |
               food
                |
-----------------------------------
```

```
|        |          |               |
                   veg
                    |
     ---------------------------
    |       |                   |
        radish.class
```

The java code for `radish.class` could be [`LecturePackages/food/veg/radish.java`] Notice the `package` statement.

4.4 `Public` Classes

We can also now explain the need for the `public` keyword for the method `me` of `radish`. If we remove it and recompile LecturePackages/egg.java we get

```
egg.java:6: No method matching me() found in class food.veg.radish.
       food.veg.radish.me();
                       ^
1 error
```

If you want to be able to call a method from outside the package where it is declared you must declare it as `public`.

4.5 File Names and Public Classes

If your `.java` file contains a public class `fred` then the file must be called `fred.java`. You can therefore see that each java file can only define one public class. It can however define as many non-public classes as you like.

We may wish to put the class `dog` in a package. Since `dog` is in a directory called `LecturePackages` we must call the package `LecturePackages` as well. [`LecturePackages/dog.java`]

4.5.1 Running Programs that are Part of Packages

To run our program we must type

```
java LecturePackages.dog
```

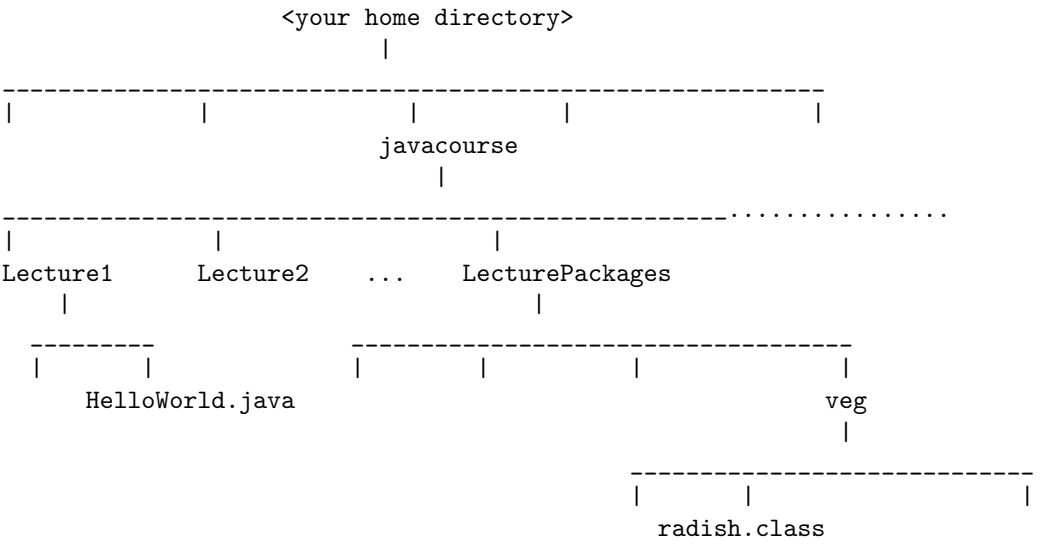
4.6 The `import` Statement

Now consider [`LecturePackages/pig.java`] Because of the import statement we do not have to refer to the method `me()` by its full name `food.veg.radish.me()` but simply as `radish.me()`.

We have been using the import statement throughout this course. Here is the simple Echo program without an import statement. [`Lecture2/EchoNoImportNew.java`] Notice that we have had to refer to `Scanner` by its full name since it is a class defined in the `java.util` package.

4.7 Laborious but Worthwhile Packaging Task

You may decide to have a new directory `javacourse` to put all the useful programs you have used on this course. Package them up nicely together. The simplest way to do this would be to keep the same directory structure as this course with the different Lectures.



and then add the full pathname `/home/you/javacourse` to your `CLASSPATH`. In Unix you would say

```
CLASSPATH=$HOME/javacourse:$CLASSPATH
export CLASSPATH
```

and add a package statement to every program like this [`Lecture1/HHH.java`] You can then run HHH.java wherever you are by typing

```
java Lecture1.HHH
```

provided your `CLASSPATH` is correctly set. If this seems an onerous task, then simply package up the useful array methods like this: Please see [Dan07], Chapter 1 for more information on the `CLASSPATH` system variable. [`LectureNonVoidMethods/ArraysNew.java`] We can now refer to these methods in other programs. Make a new directory and use `LectureNonVoidMethods/Arrays.java` to write a program which reads some numbers into an array and prints the average. [`LectureTest/Test1.java`] Or if we use an `import` statement: [`LectureTest/Test2.java`] For some reason, if you want to test a program that is part of a package and your test program is in the same subdirectory as the package, then you must include a package statement at the beginning of your test program as in [`LectureNonVoidMethods/Test2.java`] So you make the test program also part of the package. This is not a problem. Also notice that you do not need to import from the same package that you are currently in. So we do not need

```
import LectureNonVoidMethods.*
```

Java will automatically look in the current package for unresolved class and method names.

4.8 Exercises on Chapter 4

4.8.1 Add Comments

Add your own comments explaining each of the methods in the class `ArraysNew` defined in Section 4.7, page 13.

4.8.2 No Import

Consider the following Java program: `[Lecture2/EchoNew.java]` How would it have to be rewritten if there was no `import` statement in Java?

4.8.3 A Complete Application

See the class `ArraysNew` in Section 4.7, page 13. The methods in class `ArraysNew` can be referred to in other classes. Write a complete Java application (by calling some of the methods in the class `ArraysNew`) which asks the user how many numbers they are going to enter, reads in the numbers and prints their average.

4.8.4 Add your Own Method

Add your own method to the class `ArraysNew` in Section 4.7, page 13, which multiplies the elements of an array together. Write a complete application that uses this method to compute factorial.

4.9 Summary

Having worked on Chapter 4 you will have:

- Understood the purpose of the CLASSPATH system variable.
- Understood the purpose of the `package` statement.
- Learned the purpose of the `import` statement.
- Learned how to run a Java program that is part of a package, from the command line.

Chapter 5

More About Variables

5.1 Learning Objectives

Chapter 5 explains:

- about local variables and the scope of variables
- about simple variables
- about reference variables
- more about how the values of these variables are passed as parameters to methods.

5.2 Reading

- [Fla05] Page 150
- [NK05] Page 132
- [Hub04] 5.2
- [Kan97] Q1.10, Q2.12

5.3 Introduction

5.3.1 Local Variables

A local variable is one that is declared inside a method or inside another structure like a `for` loop. Consider the program [`LectureScope/p1.java`] What is its output? The `x` declared inside the method `f()` is called a *local variable*.

The program [`LectureScope/p3.java`] also prints 2 because the assignment in the method `f()` is to a local variable `x` and not the global one that gets printed in `main()`.

Now consider [`LectureScope/p2.java`] The output of this is 3 because both `main()` and `p` reference the same global variable `x`.

A common error is illustrated in [`LectureScope/ForLocal.java`] The compiler will complain with

```
ForLocal.java:8: cannot resolve symbol
symbol  : variable i
location: class ForLocal
      System.out.println(i);
                         ^
```

```
1 error
```

The variable `i` is only in scope inside the body of the loop.

5.4 What's Really in a Variable?

There are two kinds of variable in Java:

- Simple variables
- Reference variables

Simple variables are those whose type is simple, like `int` or `char` etc.

All other variables are reference variables (for example `String` variables or array variables).

When you make an assignment to a simple variable, the actual value is stored in the variable. For example, the assignment `int x=79;` puts the value 79 into the variable `x`.

When you make an assignment to a reference variable, what is assigned is the address of the object.

For example `String s= "cat"` will not put the value `"cat"` in the variable `s` but the `String "cat"` will be stored somewhere in memory and `s` will contain the address of where `"cat"` has been stored. So `String s ="fred";String t=s; System.out.println(t);` will print `fred` and `String s ="fred";String t=s; s="mary"; System.out.println(t);` will print `fred`. In the second example `String t=s;` makes variable `t` 'point at' the same as what variable `s` points at. The assignment, `s="mary"` makes `s` point at something different, but `t` still points at what `s` pointed at before.

Similarly the assignment `a [ ] = new in[50]` creates an array of 50 `int`s somewhere in RAM and the variable `a` will contain the address of this array.

5.5 Exercises

What is the output of [`LectureRefVars/test1.java`]

What is the output of [`LectureRefVars/test2.java`]

5.6 Parameters Passed by Value

When parameters are passed in a method call, it is as if the method has some local variables whose names are the same as the formal parameters of the method. Before executing the body of the method these local variables are assigned the values of the corresponding actual parameters.

Consider a [`Lecture9/intParams.java`] The output of this is 3. This is because when we call `p(n)` a copy of the value of n is made before we execute `p`. The variable `n` is not changed.

5.7 Exercises on Chapter 5

Consider the following programs and see if you can explain their behaviour.

5.7.1 Arrays (1)

[Lecture9/arrayParams.java]

5.7.2 Arrays (2)

[Lecture9/arrayParams2.java]

5.7.3 String**s**

[Lecture9/StringParams.java]

5.7.4 Test Array

[Lecture8/TestArray.java]

5.7.5 Test Int

[Lecture8/TestInt.java]

5.8 Summary

Having worked on Chapter 5 you will have:

- Learned about local variables and the scope of variables.
- Learned about simple variables.
- Learned about reference variables.
- Learned more about how the values of these variables are passed as parameters to methods.

Chapter 6

Bits, Types, Characters and Type Casting

6.1 Learning Outcomes

Chapter 6 explains:

- that variables of different types have different sizes
- about type casting
- about characters and Unicode
- why the `read` method returns an `int`.

6.2 Reading

- [LO02] Chapter 1
- [Fla05] pages 21-28
- [Kan97] Chapter 2
- [Smi99] Chapter 4

6.3 Introduction

The memory of a computer (Random Access Memory or RAM for short) is made up of a sequence of consecutive bytes. These days (2007) a typical personal computer has about 512 megabytes of RAM. This is roughly 512 million bytes, each consisting of 8 bits. A bit can have only two possible values: 0 or 1. Every time you declare a variable in your program it is temporarily using up some RAM. If you declare a large array it will take up lots of RAM. Try running [`LectureChar/BigMemory.java`]

On my laptop, I get the following error message:

```
Exception in thread "main" java.lang.OutOfMemoryError:
    at BigMemory.main(BigMemory.java:7)
```

6.3.1 Exercise: Maximum Array Size

Experiment to find out what the biggest `int` array you can have is. On my system it's at least 15,000,000.

6.4 Different Types Have Different Sizes

A variable consists of some bytes of RAM. When you declare a variable of a particular type, some bytes of RAM are allocated to hold that variable. Depending on what the type is, different amounts of RAM are allocated. A `boolean` variable, for example, needs only one bit since it has only two possible values: `true` and `false`.

6.5 Characters

Java allows two bytes (=16 bits) to store characters. This means that in Java we can represent 2^{16} different characters.

6.5.1 Exercise

Write a Java program to work out 2^{16}. So Java can represent 65536 different characters. This is because Java tries to be international, so you will be able to write programs to output characters in your own alphabet wherever you live (provided, of course, your operating system is correctly set up to do so).

Unfortunately, on my computer I can only print $256 = 2^8$ different characters. These are the ones whose Unicode value is between zero and 255. For any other Unicode values my computer simply prints out a question mark.

6.5.2 Exercise: Find All Characters

Write a program that prints out the character corresponding to every Unicode value between 0 and $2^{16} - 1$. On my computer, only the first 256 give anything. After that, I just get `'?'`. How is it on your computer?

6.6 Type Casting

To display the character whose Unicode value is 37 we do [`LectureChar/Unicode.java`] `(char)37` means the character whose Unicode value is 37. This is called *type casting* or simply *casting*. To do type casting you write a type in brackets followed by an expression. The reason you need type casting is that an expression on its own could be of many different types and Java will treat it differently depending on what type it is. Therefore we have to tell the Java system which type we want the expression to be treated as. Consider [`LectureChar/AplusB.java`] On my computer, this prints out
195
ã

The reason for this is as follows: `'a' + 'b'` is interpreted as the Unicode value of the character `'a'` + the Unicode value of the character `'b'`. These two are added together to give the `int` 195.

Which when we print gives 195. `(char)('a' + 'b')` will be interpreted as the character whose Unicode value is 195. Apparently, this character is ã.

6.6.1 Quick Question

The Unicode value of `'b'` is one more than that of `'a'`. What are the Unicode values of `a` and `b` respectively?

6.7 The Method `read()`

In this section we discuss the `read()` method. This method is used for inputting a single character. Consider[`LectureChar/Try.java`] Here we are inputting just a single character using `read()`, instead of the previous `readLine()` which reads a whole line. The method `read()` returns the Unicode value of the character that the user typed in. So if you want to print out the character the user typed in, the output of `read()` must be cast to `char` otherwise the Unicode value will be written out as in [`LectureChar/Try1.java`]

6.7.1 End of File

If you are using Unix, try running LectureChar/Try1.java and typing in CTRL `d` (hold the control key down and press `d` at the same time). This stands for end of file. The program prints:

```
You typed in -1
```

This means that `read()` returns -1 when end of file is reached. (If you didn't understand this bit, don't worry. It will become clear in the chapter on Files.) This is why `read()` returns an `int` rather than a `char`.

6.7.2 A Reason why `read()` Returns an `int`

A variable of type `int` occupies 32 bits. All the 2^{16} values of type `char` are reserved for storing real characters. No special value of type `char` is used to represent special things like representing end of file. We therefore need a bigger type to be the return type of `read()`.

6.8 More Type Casting

6.8.1 Question

Consider [`LectureChar/EOF.java`] What do you think is its output? Now consider [`LectureChar/Try3.java`] If you input integers between 0 and 65535 inclusive you get the same answer back. If you enter 65536 you get 0, if you enter 65537 you get 1, etc. This is because the only whole numbers that can be stored as type `char` lie between 0 and 65535. If we try to cast a number not in this range as a `char`, it will be 'squashed' into this range simply by

calculating its value mod 65536. This explains why entering -1 gives us back the value 65535, since -1 mod 65536 is 65535.

Another way to think of this is that four bytes are used to store an `int` and only two are used to store a char. When a `int` is cast to a `char` the two most significant bytes are discarded. So this means that the two least significant bytes in the `int` representation of -1 are both 11111111. In fact -1 is represented as the four bytes:
11111111 11111111 11111111 11111111. If you cast a value to a smaller type you may lose information.

6.9 Exercises on Chapter 6

6.9.1 Research

Read pages 23 band 24 of [Fla05] to find out how big each type is.

6.9.2 `Int` to `Boolean`

Write a program to check whether or not an `int` can be cast as a `boolean`.

6.9.3 `Boolean` to `Int`

Write a program to check whether or not a `boolean` can be cast as an `int`.

6.9.4 `Float` to `Int`

Write a program to check whether or not a `float` can be cast as an `int`.

6.9.5 `Int` to `Float`

Write a program to check whether or not an `int` can be cast as a `float`.

6.9.6 `Double` to `Float`

Write a program to check whether or not a `double` can be cast as a `float`.

6.9.7 `Float` to `Char`

Write a program to check whether or not a `float` can be cast as a `char`.

6.9.8 `Int` to `Short`

Write a program to check whether or not an `int` can be cast as a `short`.

6.9.9 Next Biggest

What is the next biggest `int`, n, after 0, such that `System.out.println(`n`)` gives 0.

6.9.10 What is the Output?

Why is the output of [`LectureChar/IntToShort1.java`]

```
0
0
0
0
0
0
0
0
0
0
```

See Question 6.9.9 for the answer.

6.9.11 Largest `Int`

What does the following program output? [`LectureChar/LargestInt.java`]

6.10 Summary

Having worked on Chapter 6 you will have:

- Learned that variables of different types have different sizes.
- Learned about type casting.
- Learned about characters and Unicode.
- Learned why the `read` method returns an `int`.

Chapter 7

Files and Streams

7.1 Learning Objectives

Chapter 7 explains:

- the purpose of a file
- how to read a file a character at a time
- how to read a file a line at a time
- how to write to a file
- how to write a simple spell-checking program, which checks that all words in a file have been spelled correctly.

7.2 Reading

- [CK06] Chapter 20
- [LO02] Chapter 14
- [DD07] Chapter 15

7.3 Introduction

A file is some data that is not in the memory of the computer. The most common place to find files is on a disc. The difference between data on a disc and data in memory is that disc data survives after you have finished executing the program. So if there is any information that needs to be kept as a result of running a program, you had better write it to a file. Similarly, many programs are required to manipulate data produced by other programs. This means that programs are required to read data from files stored on discs.

Java also treats user input as if the data input is coming from a file; similarly, user output is exactly the same as writing to a file.

7.4 Reading Files

Consider: [`Lecture11/cat1.java`] This program prints out the contents of a file called `fff.dat` on the screen. When I run it

```
my name
is sebastian.
I live in
London.
```

is displayed. This is because that is what is in the file called `fff.dat`.

Look up the class `FileReader` in
http://java.sun.com/j2se/1.5.0/docs/api/java/io/BufferedReader.html. and
http://java.sun.com/j2se/1.5.0/docs/api/java/io/FileReader.html respectively. Notice that we can use the `Scanner` with a FileReader as well as with `System.in`.

7.4.1 End Of File

If we are reading a file using `nextLine()` and we come to the end of the file, `hasNextLine()` will return the value `false`. Therefore the code:

```
while (in.hasNextLine())
     {
       System.out.println(in.nextLine());
     }
```

will repeatedly read a line from `in(fff.dat)` and write it out to the screen until the end of file is reached.

Notice the extra `throws Exception`. This will be explained in Chapter 11. See what happens if you leave it out.

7.5 Reading Files a Character at a Time

Consider [`Lecture11/cat79.java`] Here we are reading from file `fff.dat` a single character at a time. As explained in Section 6.7.1, the method `read()` returns an `int`: either the *Unicode* value of the character just read in, or -1 if we have reached the end of file. We must therefore cast the value just read in as a character in order to print it out properly.

7.5.1 Question

If we forget to cast to `char`, as in [`Lecture11/cat79u.java`] what happens?

7.5.2 The Newline Character

The end of a line in a file is achieved using a special character called newline, written `'\n'` in Java. so

```
println("hello");
```

is exactly the same as

```
print("hello");
print('\n');
```

7.6 Writing to Files

Once we have started off with

```
PrintStream out =new PrintStream(new FileOutputStream("hhh.dat"));
```

writing to the file `hhh.dat` is just like outputting to the screen. We can use the methods `out.print()` and `out.println()`.

7.6.1 Closing the File

There is one small difference between writing to a file and writing to the screen; when we have finished writing a file, we must close it with

```
out.close()
```

If you forget to do this it is quite possible that you will find that after you finish executing your program, your file will not have been written to. Here is a program to write to a file called "`hhh.dat`" [`Lecture11/cat83.java`] After we have run it we will find a new file in the current directory called `hhh.dat` with

```
this
file was written by
a Java program
```

written in it.

[`Lecture11/cat.java`] This program copies the contents of any file to standard output (i.e., it displays any file on the screen). This program uses **command line arguments**. To display a file called `fred`, type

```
java cat fred
```

[`Lecture11/copy.java`] This program copies the contents of any file to any other.

7.6.2 Swap all `a`s and `b`s

Write a program called `swapab.java` that is the same as cat.Java except all the 'a's and 'b's are swapped.

7.6.3 Example: Counting the Number of Lines in a File

To count the number of lines we can either simply read the file a line at a time, as in [`Lecture11/lineCount2.java`] or alternatively, read the file a character at a time and keep a count of the number of newline characters that we encountered, as in [`Lecture11/lineCount1.java`]

7.6.4 Example: Counting the Number of Words in a File

To count the number of words in a file, we first need to decide what a *word* is. Let us say that a word is any consecutive string of characters, not containing a newline character `'\n'`, a tab character `'\t'` or a space `' '`. We need to read the file a character at a time and add one to a counter every time we go from *not being in a word* to *in a word*.

- We start off *not in a word*.
- When *not in a word*, we stay *not in a word* if the next character we read is a newline, space or tab.
- When *not in a word*, we go *in a word* if the next character we read is a not a newline, space or tab.
- When *in a word*, we stay *in a word* if the next character we read is not a newline, space or tab.
- When *in a word*, we go *not in a word* if the next character we read is a newline, space or tab.

[`Lecture11/wordCount.java`]

7.7 Example: A Simple Spell Checker

There is a file `Lecture11/words` consisting of a big list of words in English (courtesy of Unix), one per line. We can use it to write a simple spell checker. We are using the method

`java.lang.String.startsWith()`.

The user simply types the beginning of the word he wants to check as a command line argument. For example,

```
java spell freq
```

will print out all English words starting with `freq`. These are:

```
frequencies
frequency
frequent
frequented
frequenter
frequenters
frequenting
frequently
frequents
```

The answer is [`Lecture11/spell.java`]

7.8 A Slightly Better Spell Checker

Rather than expecting the user to enter the word they are looking for on the command line, we can give the user a prompt > to enter a word. The program keeps giving the user another go. The

program stops if the user simply presses return. [Lecture11/spell1.java]

7.9 Example: A Program to Find Anagrams

Here is a program that might be useful for people who do crossword puzzles. The user types in a word and it finds all the anagrams of the word in the English dictionary. An anagram is simply a re-arrangement, for example `taste` is an anagram of `state`. The program is based very closely on the spell checker spell1.java. The only difference is that instead of checking whether each word in the dictionary *starts with* the word the user entered, we check whether the word is an anagram of the word in the dictionary.

We have written a method called `anagram` which returns true if `s` and `t` are anagrams of each other. We do this by converting `s` and `t` to arrays of characters, `as` and `at`. Then, for each element of `at`, we see if we can find it in `as`. If we do, we change the corresponding element of `as` to zero, so we never find it again. A zero is not a printable character. If at any stage we don't find a letter we are looking for, then it can't be an anagram. [Lecture11/anagrams.java]

7.10 Exercises on Chapter 7

7.10.1 Third Line

Write a program that prints out the third line of `fff.dat`.

7.10.2 Hundredth Line

Write a program that prints out the hundredth line of `ggg.dat`.

7.10.3 Odd Lines

Write a program to print out the odd lines of `ggg.dat`.

7.10.4 Even Lines

Write a program to print out the even lines of `ggg.dat`.

7.10.5 Cat Choose

Write a program that prints out the contents of a file of the user's choice.

7.10.6 Cat Command Line

Write a program that prints out the contents of the file whose name is typed on the command line.

7.10.7 Third Char

Write a program that prints out the third character of `fff.dat`.

7.10.8 Hundredth Char

Write a program that prints out the hundredth character of `ggg.dat`. The file `ggg.dat` contains all the integers from 1 to 100 in ascending order, one integer per line:

```
1
2
3
```

```
.
.
.
97
98
99
100
```

7.10.9 Odd Characters

Write a program to print out the ascii values of the odd chars of `ggg.dat`. The output is Make sure you understand the output of this program.

7.10.10 Even Characters

Write a program to print out the ascii values of the even characters of `ggg.dat`. The output is Make sure you understand the output of this program. Don't forget - the newline character counts as a character.

7.10.11 Swapchars

Write a program called `swapchars.java` using command line arguments that allows any two characters to be swapped. For example if the program was called `swapchars` then to swap all 'a's and 'b's in a file `fred` we would type `java swapchars fred ab`.

7.10.12 Manycat

Write a program called `manycat.java` that is the same as `cat.Java` except many files can be printed out one after the other. For example to print `fred1`, `fred2`, and `fred3` we would type `java manycat fred1 fred2 fred3`.

7.10.13 Swapcase

Write a program called `swapcase.java` that is the same as `cat.Java` except that all lower case letters are swapped for upper case and vice versa. (Hint: see Character class in [Fla05, Inc].)

7.10.14 ASCII

Write a program called `ascii.java` that is the same as `cat.Java` except that as well as printing out each character, it also prints its Unicode value. What is the Unicode value for the newline character?

7.10.15 Remnewline

Write a program called `remnewline.java` that is the same as `cat.java` except that it doesn't print out the newline characters in the file.

7.10.16 Tenperline

Write a program called `tenperline.java` that is the same as `remline.java` except that it prints 10 characters on each line.

7.10.17 List Words

Write a program that prints out every word in a file, one word per line.

7.10.18 Assignment – Spell Checker

Write a spell checker that goes through a file and prints out all the words it finds that aren't in the dictionary.

7.10.19 Hard Assignment – A Better Spell Checker

Write a spell checker that goes through a file and every time it finds a word not in the dictionary it prompts the user either to accept the word or enter a replacement.

7.11 Summary

Having worked on Chapter 7 you will have:

- Understood the purpose of a file.
- Learned how to read a file a character at a time.
- Learned how to read a file a line at a time.
- Learned how to write to a file.
- Written a simple spell-checking program, which checks that all words in a file have been spelled correctly.

Chapter 8

Sorting Arrays and Searching

8.1 Learning Objectives

Chapter 8 explains:

- how to sort elements as they get put into an array
- about one method of sorting an array
- both linear and binary searching
- about complexity analysis
- that sorting arrays of `int`s and sorting arrays of `String`s is essentially the same.

8.2 Reading

- [LO02] Chapter 10
- [DD07] Chapter 5
- [Wu06] Chapter 15 Sections 15.1 and 15.2
- [Bis01] Chapter 6.4

8.3 Introduction

The reason why it is good to sort things into some order is that it makes things easier to find. Imagine a telephone directory where the names were just in any old order – impossible! Before we sort any array of things, we need to decide what order to sort them in. For example if they are `int`s, we may want ascending or descending order. If the things we are sorting are names, then we may want to sort them in alphabetical order.

8.4 Ways of Sorting

8.4.1 Sorting as you Create

One way of making sure an array is sorted is to insert things in the correct place as we create the array. As you can probably imagine, this will involve a lot of shuffling things around. Imagine 'in our hand' we have a partially filled array consisting of the numbers we have so far read in and sorted, and a new number that we have just read in. We want to put this new number into the correct place in the array so that the array is still sorted. We need 3 methods:

1. A method to find where to put the new number in the array.
2. A method to shuffle to the right every element of the array from that point on.
3. And finally, a method that does all the work (by calling the other two methods), namely, finding where to put the new number, shuffling everything one to the right from that point on and updating the array with the new number to be inserted.

Each method has an extra parameter, which tells it where the next free element of the array is. This is very useful because it tells us how far we need to shuffle, etc.
[Lecture8/SortOnInput.java]

8.4.2 Exercise

Write a program that tests `Lecture8/SortOnInput.java`.

8.5 Sorting an Array

Suppose we have read n numbers into an array a. To sort a we do $n-1$ passes of the array. After i passes we are sure that the first $i+1$ elements of the array are in order. For the first pass we compare the zeroth element of the array with all the later elements of the array (i.e. with the first, second, ..., up to the last element of the array). If any of these elements is less than the zeroth, we swap them. At the end of doing this we are guaranteed to have the smallest element in the zeroth element of the array. We then move on to the first element of a and repeat the process on the later elements of the array, namely, comparing a[1] with a[2], a[3] etc. and swapping if necessary. At the end of this pass we have a[0] the smallest and a[1] the next smallest. After $n-1$ such passes the array will be completely sorted.

The code to do this is a loop within a loop and is shown in [`Lecture8/SortArray.java`] For the outer loop we have variable `i` going from 0 to `size-2`. The inner loop has variable `j` going from `i+1` to `size-2`. This ensures that `j` always stays ahead of `i` and that all comparisons are made. if we find that `a[i]>a[j]` we must swap `a[i]` and `a[j]`.

8.5.1 Swapping

Swapping two memory locations, `a[i]` and `a[j]`, for example, involves a temporary storage place.

```
{int temp=a[i]; a[i]=a[j]; a[j]=temp;}
```

If we simply wrote

```
a[i]=a[j];
a[j]=a[i];
```

the locations `a[i]` and a[j] would both end up with the same value. There are many other sorting algorithms not considered here. Please see other reference books for further information.

8.6 Searching

Having sorted our array we then want to check whether or not it contains certain items. What is an efficient way of doing this?

8.6.1 Linear Searching

How do we look for someone's name in a telephone directory? We do not just start at page 1, and then 2, etc. until we find it. That is what we would have to do if the telephone directory was not in order. The code to do this is: [`Lecture8/LinearSearch.java`] We are searching for the `int` called `thing` in array `a`. This method returns a boolean, `true` if we find it and `false` if we don't. This code is interesting as we have a `for` loop with an empty body. The way we know that we've found `thing` is that when we leave the `for` loop the last thing we found was `thing`. So we return true if this was the case and false otherwise.

8.6.2 Binary Searching

One way to look for a name is to open the directory in the middle and pick a name n, say. If, by some miracle, n is what we are looking for then we have finished! If the name we are looking for comes before n we can repeat the process, thinking of the first half of the directory as the whole directory (as we never have to look in the second half), or if the name we are looking for comes after n we can repeat the process on the second half. Each time round the loop we are, in effect, cutting the directory in half. This is a very quick way of finding what we want. For example, if the dictionary had 2^n entries, it would take at most n repetitions of the above process before we either found what we want or discovered that it was not there. How do we know if something isn't there? We end up looking in a dictionary containing only one word and it's not the one we are looking for. We implement binary searching by having two `int` variables `first` and `last` to tell us which part of the array to search in for the thing we are looking for. Initially we look in the whole array. As we proceed, `first` and `last` get closer to each other.
[`Lecture8/BinarySearch.java`] Don't forget, we are doing integer division.

8.6.3 Exercises on Binary Searching

1. Suppose the array `a` has 3 elements and `thing` is at $a[0]$, what are the successive values of `mid`?

2. Suppose the `a` has 4 elements and `thing` is at `a[1]`, what are the successive values of `mid`?

3. Suppose the `a` has 17 elements and `thing` is bigger than everything in `a`, what are the successive values of `mid`?

A more useful method would be to say where it found the thing rather than say true it's there or false it's not. We can use -1 to mean that it's not there. [`Lecture8/BinarySearchPos.java`]

8.7 Efficiency of Different Algorithms: Complexity Analysis

An important question is how fast different algorithms are for searching and sorting. The speed of an algorithm is measured not in number of seconds but rather in terms of the ratio of the number of elements being searched through or sorted and the time. The sensible kinds of question that can be asked are:

> If we doubled the number of elements how much longer would it take?

or

> If we trebled the number of elements how much longer would it take?

8.7.1 Linear Searching

In linear searching, we just start at the beginning and go through from 'left to right' until we find what we are looking for. If we have say, 100 items, it will take on average 100/2=50 comparisons before we find what we are looking for. If, on the other hand, we have a million items, it will take on average 500,000 comparisons. The average number of comparisons is clearly proportional to the number of elements that we start with. If we double the number of elements we will double the average number of comparisons before we find the element we are looking for. If we treble the number of elements we (roughly) treble the amount of time taken to find the element we are looking for. Such an algorithm is said to be of order n, written $O(n)$.

8.7.2 Binary Searching

In binary searching, on the other hand, after each comparison, we halve the search space. If we start off with 32 elements it will take at most five comparisons to find what we are looking for ($32 = 2^5$, alternatively we can say $\log_2 64 = 6$), if we have 64 elements it will take at most 6 comparisons ($64 = 2^6$, alternatively we can say $\log_2 32 = 5$), if we have 4096 elements it will take at most 12 comparisons, if we have 16 million elements it will take at most 24 comparisons! (Since $2^{24} > 16000000$). Clearly this is much more efficient than linear searching. $\log_2(n)$ is the number that 2 must be raised to the power of to give n. The number of comparisons in binary searching is proportional to $\log_2(n)$. We say that binary searching is $O(\log_2(n))$. See [LO02] pages 358-374 for a discussion of complexity analysis.

8.8 Exercises on Chapter 8

8.8.1 A Class for Searching and Sorting Arrays

Consider the class [`Lecture8/ArraysOfIntsNew.java`]

8.8.2 Test the Class

Write a program for testing your program.

8.8.3 Sorting Arrays of `String`s

Write a similar class which works on arrays of `String`s.

8.8.4 Test your Class

Test your program by asking the user to enter some `String`s and your program should sort them and print a different message depending whether or not it can find the `String` `"telephone"`.

Notice the only differences between the two are superficial – purely how we compare `String`s as opposed to `int`s.

8.8.5 Exercises (No Solutions)

1. Write a program that sorts its command line arguments into alphabetical order.

8.9 Example Assignment

Here is an extract from a course handbook:
For calculating the degree classifications
Each student does:

- n1 first year half-units
- n2 second year half-units
- n3 third year half-units

The candidate's overall mark is calculated as $\frac{ux+vy+wz}{ub+wc+vd}$ where

- x is the total marks of the best b first year half units.
- z is the total marks of the best c third year half units.
- y is the total marks of the remaining best d second and third year half units.
- u, v and w are constants which vary from degree to degree. The Values you should use are:

```
static int n1=8;
static int n2=8;
static int n3=8;
static int b=6; /*Number of 1st year marks that count*/
static int c=6; /*number of 3rd year marks that count*/
static int d=8; /*number of remaining 2nd and 3rd year units that count */
static int u=1;
static int v=3;
static int w=5;
```

The degree classification is as follows:

Below 35 is a Fail

35– is a Pass Degree

40– is a Third Class Honours Degree

50– is a Lower Second Class Honours Degree

60– is an Upper Second Class Honours Degree

70– is a First Class Honours Degree

Write a Java program which inputs n1 first year half-unit marks, n2 second year half-unit marks, n3 third year half-unit marks, and then outputs the degree classification.

8.10 Summary

Having worked on Chapter 8 you will have:

- Learned how to sort elements as they get put into an array.
- Learned one method of sorting an array.
- Understood both linear and binary searching.
- Had a brief introduction to complexity analysis.
- Learned that sorting arrays of `int`s and sorting arrays of `String`s is essentially the same.

Chapter 9

Defining Classes

9.1 Learning Objectives

Chapter 9 explains:

- how to define your own classes
- how to use constructors
- about instance variables
- about instance methods
- how to defined classes in terms of other user-defined classes.

9.2 Reading

- [LO02] Chapter 9
- [Smi99] Chapter 5
- [CK06] Chapters 6 and 7
- [Hub04] Chapter 6
- [Fla05] Chapter 3
- [Kan97] Chapter 1

9.3 Introduction

We have already used objects often in this course. For example, when we wrote

```
DrawingWindow d = new DrawingWindow(500,500);
```

we were declaring a variable of type `DrawingWindow` and assigning it the value `new DrawingWindow(500,500)`.

How are things like `DrawingWindow` actually defined? They are defined as a `class`. The name of the class will be `DrawingWindow`. The `DrawingWindow` class has a *constructor* with two parameters. We can see this because of the expression `new DrawingWindow(500,500)`.

9.4 An Example of Defining your own Class

We now give some examples of how to define and use classes.

9.4.1 WARNING!

For these examples to work, make sure you have got the directory (folder) which contains all the Lecture directories in your CLASSPATH.

To run your programs in a sensible operating system like Unix you would type

```
java LectureSimpleObjects.printHouse
```

at the command line.

9.4.2 A `Date` Class

A Date consists of three fields: a day, a month and a year, all of which are `int`s: [LectureSimpleObjects/Date.java]

The class `Date` has three fields: `day`, `month`, and `year` all of type `int`. We create an object of type `Date` by giving values to fields using `new`. For example `Date d = new Date(30,12,2009)` or `Date e = new Date(17,1,2010)`. We are calling a *constructor* of the `Date` class. Inside our `Date` class we have:

```
public Date(int d, int m, int y)
{
  day=d;
  month=m;
  year=y;
}
```

This is a constructor. A constructor looks exactly like a method except that it does not have a return type and **its name is the same as the class.** In Java, fields are often referred to as *instance variables*.

9.5 Using a Class that you have Defined

9.5.1 Using the `Date` Class

[LectureSimpleObjects/printDate.java] Here we define a date `d`, assign it a value, and print out its fields (instance variables).

Objects and Instances

We say variable `d` references (or points to) an object of type `Date`. We have created an *instance* of the class `Date`. It is an instance of `Date` where the values of the fields are 1, 12 and 2003 respectively. When we call a constructor `Date` by saying `new Date(1,12,2003)` we are creating an object and assigning values to its fields.

We can reassign to `d` in exactly the same way that we reassign to any other variable. For example if we said `Date d = new Date(17,1,2010)`, then a new instance of `Date` would be created and

this would now be 'pointed to' by variable d.

9.5.2 Dot Notation

To access the fields of an object, *dot notation* is used. In d.day corresponds to the day field of d so has the value 1, d.month corresponds to the month field of d so has the value 12 and d.year corresponds to the year field of d so has the value 2003.

9.6 Using Classes in other Classes

9.6.1 A Person Class

A person has a first name, a middle name and a family name, which are all Objects of type String; a date of birth which is an Object of type Date (as defined in Section 9.4.2); and a sex which is of type boolean.
[LectureSimpleObjects/Person.java] For a person there are two possible values for sex. We have arbitrarily decided that true means female and false means male. For person, we have defined two constructors. We can have as many constructors as we like provided that they all have a different signature. In the second constructor however, we pass a String to give the sex. If the String starts with an 'f' or an 'F' then it means female, otherwise male.

Using the Person Class

[LectureSimpleObjects/printPerson.java] Here we are creating a Date d and a Person p whose date of birth is d. Notice how we get at the year that d was born using dot notation : p.dob.year . We could have defined p without declaring d as follows:

```
Person p  = new Person("John","Smith",new Date(1,12,2003),false);
```

9.6.2 A House Class

A house has a number, an array of persons and a number of rooms.
[LectureSimpleObjects/House.java] Here we have illustrated the use of the special keyword this. Because we couldn't think of different names, we have given the first two parameters, the same names as the fields. To distinguish the formal parameter from the field name we say this.number. This is the field of *this* Object called number.

9.6.3 A Street Class

A street has a name and an array of houses. [LectureSimpleObjects/Street.java]

9.7 An Aside: Expressions for Arrays

We can assign an array explicitly, without giving it a name, as in [LectureSimpleObjects/ArrayTest.java] The elements of the array are written as a list of expressions between curly brackets and separated by commas. Using this we could define a class Houses. [LectureSimpleObjects/Houses.java]

9.8 Define your House in a Single Expression

Your house can be defined 'in one go' as follows: [LectureSimpleObjects/MyHouse.java] LectureSimpleObjects.MyHouse.it is now a constant object standing for my house. It can now be used anywhere.

9.9 A More Complex Example with Instance Methods

Suppose you want to write a method sumandav that returns both the sum and average of an array of ints. Clearly sumandav would take one int array parameter, but what would be the return type of such a method? It has to return something that has two values:

1. An int to hold the sum
2. and a double to hold the average.

We cannot use an array in any obvious way as the return type, because all the elements of an array must be of the same type and here we want two elements of different type: an int and a double. To get round this problem we have to define our own class as follows: [LectureSimpleObjects/IntAndDouble.java] As we will see, defining a class is like defining a new type. Having defined a class we can then declare variables of that type in exactly the same way that we declare variables of existing types. These variables can be assigned values corresponding to Objects of the type.

9.9.1 The Package Statement

We have already studied the package statement in Chapter 4. The package statement at the beginning tells us that IntAndDouble is part of a package called LectureSimpleObjects. Because we have done this we will be able to refer to a type that we have just invented, called LectureSimpleObjects.IntAndDouble. We will be able to use this type wherever we want. The type LectureSimpleObjects.IntAndDouble has, in essence, become part of the Java programming language for us. If we do not have this package statement we will not be able to use this type anywhere apart from the directory that contains it.

9.9.2 Instance Variables

LectureSimpleObjects.IntAndDouble contains two variable declarations:

```
public int i;
public double d;
```

These declare two instance variables called `i` and `d`. These are the components (also called *attributes*) of an Object of type `LectureSimpleObjects.IntAndDouble`. The reason they are public is that, having created an Object of type `LectureSimpleObjects.IntAndDouble`, we want to be able to refer to its two components separately. The components are often called *fields* or *members*.

9.9.3 A Constructor

```
public IntAndDouble(int x,double y)
   {
     i=x;
     d=y;
   }
```

Whenever we define a new type like `LectureSimpleObjects.IntAndDouble` we will also want to define a method which, when called, creates objects of this type. This is called a *constructor*. A constructor always has the same name as the class containing it. In this case, all the constructor does is assign values to the instance variables of the class. The values of the actual parameters in a call to this constructor determine the values of the instance variables in any given instance of the class. This is a very typical use of a constructor in Java.

9.9.4 Creating Objects with `new`

An expression like `new LectureSimpleObjects.IntAndDouble(5,1.0)` creates an instance of an object of type `LectureSimpleObjects.IntAndDouble` with its `i` field set to 5 and its `r` field set to 1.0. Here we are calling the constructor of `LectureSimpleObjects.IntAndDouble` with actual parameters 5 and 1.0. Later we will see that a class can have arbitrarily many constructors.

Here is the code containing our method `sumandav` that we initially required.
`[LectureSimpleObjects/SumAndAv1.java]`

We work out the sum and average of the `int`s in our array parameter `a` and then create an instance of an object of type `LectureSimpleObjects.IntAndDouble` with `sum` and `av` as the values of its two fields, and then return this object as the result of our method `sumandav`.

We don't really need the variable `i`. We can simply return the `new` expression itself, as in
`[LectureSimpleObjects/SumAndAv4.java]`

Again, if we want to make `sumandav` usable everywhere we had better include a package statement at the beginning:

`[LectureSimpleObjects/SumAndAv3.java]`

Here is a program that can use `SumAndAv3`: `[LectureSimpleObjects/UseSumAndAv.java]` We are using the method `LectureNonVoidMethods.Arrays.readintarray()` to read some tt ints into an array and then calling `LectureSimpleObjects.SumAndAv3.SumAndAv()` to return the sum and average. `x.i` is the `int` field of the `IntAndDouble x` where we store the sum, and `x.d` is the `double` field where we store the average. To run this program you must type:

```
java LectureSimpleObjects.UseSumAndAv
```

9.9.5 Instance Methods

Our class `IntAndDouble` has another method called `toString`. This is an example of an *instance* method. We can tell that it is an instance method because

- It does not have the word `static` at the beginning of its definition.
- Its name is not the same as the name of the class. This means that it is not a constructor.

To see how an instance method is called, consider [LectureSimpleObjects/UseSumAndAv2.java] The call to `toString` is achieved using 'dot' notation. `x.toString()` is the `toString()` method of the Object `x`. Every time an object is created, new copies of of the instance variables and instance methods are created. A class can have many instance methods. The purpose of the `toString()` method is to convert `IntAndDouble`s into `String`s so that they can be printed out. We have chosen to print `IntAndDouble`s in between parentheses and separated by a comma, first the `int` and then the `double`. This was completely our choice.

9.9.6 Leaving out `toString()`

If we include an Object in a `System.out.print()` statement we can leave out the calls to `toString()`. If `x` is an Object with its own `toString()` method then `System.out.print(x)` and `System.out.print(x.toString())` will behave in exactly the same way.

9.10 Exercises on Chapter 9

9.10.1 Exercise on `IntAndDouble`

Rewrite `IntAndDouble.java` (call it `IntAndDouble1.java`) so that it prints an `IntAndDouble` object like this:

```
Double: 2.4367
Int: 6
```

Here is a program to test your answer. [LectureSimpleObjects/TestIntAndDouble1.java] The output should be:

```
Double 4.5
Int 3

Double 6.15
Int 2
```

9.10.2 Expressions For Objects

Write a program that contains

1. An assignment to variable `x1` of a value of type Date, representing 2 March 2001.
2. An assignment to variable `x2` of a value of type Person, representing the man Joseph Boteju born on 2 March 2001.
3. An assignment to variable `x3` of a value type Person, representing the man Pushpa Kumar born on 17 May 1942.
4. An assignment to variable `x4` a value of type Person, representing the woman Ola Olatunde born on 27 August 1983.

Notice that for `x2` and `x3` we have chosen to use the different constructors for `Person`. We could equally well have written:

```
Person x3 = new Person("Pushpa","Kumar",new Date(17,2,1942),false)
```

9.10.3 `toString()` Methods

Add `toString()` methods to each of the classes, `Date`, `House` and `Street`.

9.10.4 Exercises (no solutions)

1. Write `toString()` instance methods for the classes:
   (a) `Person`
   (b) `House`
   (c) `Street`
2. Write a program for testing out your methods.

9.11 Summary

Having worked on Chapter 9 you will have:

- Learned how to define your own classes.
- Learned how to use constructors.
- Learned about instance variables.
- Learned about instance methods.
- Defined classes in terms of other user-defined classes.

Chapter 10

Inheritance

10.1 Learning Outcomes

Chapter 10 explains:

- how to extend a class
- the use of the keyword `super`
- more about instance methods
- about method overriding

10.2 Reading

- [LO02] Chapter 11
- [Smi99] Chapter 12
- [CK06] Chapter 8
- [Hub04] Chapter 7
- [Fla05] Chapter 3
- [Kan97] Chapter 1
- [NK05] Chapter 6
- [DD07] Chapter 7
- [Bis01] Chapter 9

10.3 Introduction

In the class `LectureSimpleObjects.Person`, a person has a first name and a surname. Suppose we decided that we also wanted to include a person's middle name as well as all the other information like date of birth and sex. We could rewrite the whole class `LectureInheritance.person` as in [`LectureInheritance/Person1.java`] Notice that, as well as adding the extra field `middlename`, we have had to change the constructors by giving them an extra parameter to accommodate this extra field. If we hadn't done this, then we would not have been able to give a person a middle name when creating him or her using `new`. We have kept the import statement so that we can refer to the class `LectureSimpleObjects.Date` simply as `Date`. A simpler way of achieving exactly the same goal is using *inheritance*: [`LectureInheritance/Person2.java`]

10.4 The `extends` keyword

By saying `Person extends LectureSimpleObjects.Person` we are saying that the new class

```
LectureInheritance.person
```

automatically possesses all the fields (but not the constructors) of the class

```
LectureSimpleObjects.person
```

10.5 The `super` Keyword

In the new constructors for our new class `LectureInheritance.person` we refer to a method called `super`. This simply refers to the corresponding constructor of the class that we are extending. Java will know which one we mean by the types of the parameters we pass it. This one call to `super` will assign values to all the fields except `middlename` which we then update separately. Here is a test program to check that the compiler understands our new class

`LectureInheritance.person`

[`LectureInheritance/Test1.java`] Because we have a package statement at the beginning, Java assumes that any references to the class `Person` refer to the one in `LectureInheritance` and not the one in `LectureSimpleObjects`. Don't forget, to run it we must type

```
java LectureInheritance.Test1
```

We can still refer to the **old** type of person by giving the full name of the class, as in [`LectureInheritance/Test2.java`]

10.6 More about Instance Methods

In Chapter 9 we introduced instance methods. Further examples are now given. Suppose we wanted to work out a person's age. To calculate a person's age we define a method called `age` in the class `person`. This method takes today's date as a parameter. In order to work out someone's age we need today's date (the parameter we are passing) and the person's date of birth, `this.dob`.
[`LectureInheritance/Person.java`] The method `age` does not have the word `static` in front of it. This is how we know that it is an instance method. We can only use this method in conjunction with an instance of the class `person` that has been created with `new`. Here we test out our new instance method:
[`LectureInheritance/Test3.java`] We pass the `age` method of variable `a`, a date. This date is 30 August 2001. The program prints 10, since that is Fred's age on 30 August 2001.

10.7 Shapes Revisited

Here is a class for drawing a horizontal line of stars:

[LectureInheritance/HorizLine.java] Here is a program to test it:
[LectureInheritance/Test4.java] The output is:

```
***************
*******
```

10.7.1 Extending `HorizLine` (Method Overriding)

We may want to be able to draw horizontal lines with different characters apart from stars. In fact we want to be able to specify different characters to occur at the ends of the line from the middle. So we can draw lines like

```
&......&
&............&
```

which have an `&` at either end and dots in the middle, or like

```
*          *
*   *
```

which have asterisks at either end and spaces in the middle.
Consider [LectureInheritance/BetterLine.java] Since `BetterLine` extends `HorizLine` it already has a `length` field and two instance methods `draw()` and `drawln()`. We add two new fields of type `char` for specifying the end and middle characters of the lines we want to draw. However, we do not want to use the `draw` and `drawln` methods of `HorizLine` since they only draw asterisks. We want to draw `endchars` at either end and `middlechars` in the middle. So we *override* the `draw` method of `HorizLine`. That is, we define a method which has exactly the same name and signature in the new class as in the class we are extending. Interestingly, we do not need to explicitly override `Drawln` (though we can if we want) since that calls `Draw` which has been overridden. To test it we can use
[LectureInheritance/Test5.java] The output is

```
-::::::::::::
*     *
*     *
```

For drawing our hollow rectangles and triangles we can use a `HollowLine`. This can be defined by extending `LectureInheritence.BetterLine` as follows:
[LectureInheritance/HollowLine.java] A `Hollowline` of length n is a `BetterLine` of length n with the end character being a `'*'` and the middle characters a `' '`. Here, the call to `super` is a call to `BetterLine`.

10.7.2 Rectangles of Stars

We can use `LectureInheritence.HorizLine` to make a class `LectureInheritence.Rectangle` as follows: [LectureInheritance/Rectangle.java] This has two `int` fields, `height` and `width`. In its `Draw` method, first we create an instance `m` of `HorizLine` of length equal to the width of the rectangle. Then we have a loop which draws this horizontal line `height` times. Clearly, this will produce a solid rectangle of stars. A program to test our rectangle class is:
[LectureInheritance/Test6.java] The output is:

```
*******
```

```
*******
*******
****
****
****
****
****
****
****
```

10.7.3 Better Rectangles

A better rectangle is one made up of `BetterLines`.
[`LectureInheritance/BetterRectangle.java`] We have deliberately made a *better rectangle* a generalisation of a *hollow rectangle*. For the first and last (top and bottom) lines, we draw a *betterline* with the end and middle characters both set to `ends`. For the middle lines we draw a `BetterLine` with the end character set to `ends` and the middle character set to `middle`:
[`LectureInheritance/Test7.java`] The output is:

```
!!!!!!!
!.....!
!.....!
!.....!
!!!!!!!
****
*  *
*  *
*  *
*  *
*  *
****
====
=88=
=88=
=88=
=88=
=88=
====
```

10.7.4 Hollow Rectangles

We can extend the class `BetterRectangle` to produce Hollow Rectangles as follows:
[`LectureInheritance/HollowRectangle.java`]

10.8 Exercises on Chapter 10

10.8.1 Test `HollowRectangle`

Write a program using HollowRectangle whose output is

```
******************
*                *
*                *
*                *
*                *
******************
*******
*     *
*     *
*     *
*     *
*     *
*     *
*     *
*     *
*     *
*     *
*******
```

10.8.2 Extend `Rectangle` to `Square`

Extend `Rectangle` to produce a class `Square`

10.8.3 Extend `BetterRectangle` to `BetterSquare`

Extend the class `BetterRectangle` to produce a class `BetterSquare`.

10.8.4 Left Bottom Triangles

1. Use a `BetterLine` etc. to define a class `HollowLeftBottomTriangle`.
   (Do it in a similar way by extending a class called `BetterLeftBottomTriangle`.)

2. Similarly define a class called `SolidLeftBottomTriangle` which is entirely made up of stars.

3. Write a program to test your classes.

10.9 Exercises (no solutions)

10.9.1 Left Top Triangles

Repeat exercise 10.8.4 for left top triangles.

10.9.2 Right Triangles

Repeat exercise 10.8.4 for Right top and right bottom triangles.

10.10 Summary

Having worked on Chapter 10 you will have:

- Learned how to extend a class.
- Learned the use of the keyword `super`.
- Learned more about instance methods.
- Learned about method overriding.

Chapter 11

Exception Handling

11.1 Learning Objectives

Chapter 11 explains:

- how to handle exceptions using `try` and `catch`
- what it means to throw an exception.

11.2 Reading

- [CK06] Chapter 15
- [Smi99] Chapter 13
- [Hub04] page 230
- [Fla05] pages 56-60
- [NK05] pages 103-115
- [Kan97] Q2.22-Q2.26
- [DD07] Chapter 12

11.3 Introduction

An exception is a signal that an error has occurred. To *throw* an exception means to signal an error. To *catch* an exception means to `handle` the error, i.e. to take action to recover from the error.
Consider the program [`LectureExceptions/test1.java`] This program compiles correctly but when we run it we get:

```
Exception in thread "main" java.lang.NumberFormatException: dl;fkas;lkf
at java.lang.Integer.parseInt(Integer.java:405)
at java.lang.Integer.parseInt(Integer.java:454)
at LectureExceptions.test1.main(test1.java:7)
```

A `java.lang.NumberFormatException` has been thrown because we are trying to parse the `String dl;fkas;lkf` as an `int`.

Now consider the program [`LectureExceptions/test2.java`] This program gives the compilation error:

```
test2.java:7: unreported exception java.io.IOException; must be caught or declared to be thrown
   int s =System.in.read();
                        ^
1 error
```

A cure is to add `throws IOException` as in [`LectureExceptions/test3.java`] An alternative is to catch the `IOException` as in [`LectureExceptions/test4.java`] Here we use `try` and `catch`. Now consider [`Lecture2/Add1ForceOkLoop.java`] In this program we have a `try` clause containing `int x=Integer.parseInt(s);` if the `String s` does not parse correctly to an integer (i.e. it contains characters which are not digits), then an *exception* will be thrown. The exception is caught by the `catch` clause which displays a message telling the user that they have made a mistake. We could write a method with one input parameter of type `String` which returns `true` if the `String` represents an `int` and `false` otherwise:
[`LectureExceptions/IntException.java`] We can use this method to produce the same behaviour as in `Lecture2/Add1ForceOkLoop.java`. See [`LectureExceptions/test5.java`] This code is slightly inefficient because we are parsing the `String` **twice** when it is correct. Explain this!

11.4 'File Not Found' Exceptions

Consider the program:
[`LectureExceptions/fileNotFound.java`] Because the file `silly.dat` does not exist, when we run this program, it says:

```
Exception in thread "main" java.io.FileNotFoundException: silly.dat (No such file or directory)
at java.io.FileInputStream.open(Native Method)
at java.io.FileInputStream.<init>(FileInputStream.java:64)
at java.io.FileReader.<init>(FileReader.java:31)
at LectureExceptions.propag1.main(propag1.java:9)
```

Now consider the program [`LectureExceptions/catchFileNotFound.java`] Now the program, when it runs, prints out

```
File not found
```

because we are catching the `FileNotFoundException`. Now we rewrite the program so that it asks the user to enter the file name.
[`LectureExceptions/catchUserFileName.java`] Now the program asks the user to enter the file name. If the user enters a non-existent file name then the error is *caught* with a message saying that the file doesn't exist. We now rewrite the program to force the user to enter an existing file name. [`LectureExceptions/forceUserFileName.java`] Here we stay in a loop until an existing file name is entered.

11.5 Throwing Exceptions

We can handle conditions by throwing exceptions when conditions are encountered, and catching them. Consider [`LectureExceptions/catchEOF.java`] This handles the 'End of file' condition.

11.6 Exercises on Chapter 11

11.6.1 'File Not Found' Exceptions

Re-do each exercise in Chapter 7, but this time catch the 'file not found' exceptions; where the file name is input by the user, force the user to re-enter a file name until it is found otherwise print a suitable error message.

11.7 Summary

Having worked on Chapter 11 you will have:

- Learned how to handle exceptions using `try` and `catch`.
- Learned what it means to throw an exception.

Chapter 12

Vectors

12.1 Learning Objectives

Chapter 12 explains:

- the similarities and differences between a `Vector` and an array
- how `Vectors` are used for storing arbitrarily large amounts of data.
- how to sort `Vectors`
- how to manipulate the contents of files by storing them in a `Vector` and then manipulating the `Vector`
- a way of writing a complete system for processing student marks.

12.2 Reading

- [Smi99] Chapter 21 and Chapter 7
- [Hub04] Chapter 8
- [Fla05] Page 160-178, 824
- [Kan97] Q2.13-Q2.19
- [DD07] Chapter 18
- [NK05] Chapter 8

12.3 Introduction

A `Vector` (see `java.util.Vector`) is a structure a bit like an array for storing many Objects. The main differences between `Vectors` and arrays are:

1. `Vectors` are *dynamic*: they can grow and shrink in size (number of elements) while the program is running.
2. All elements of a `Vector` are of type `Object`. Arrays can have elements of type `int`, `char` etc. `Vectors` cannot.

`Vectors` can be used whenever you would have used an array but do not know in advance how many elements you need to store. The most useful instance methods of class `Vector` are:

1. `void addElement()` Adds an Object to the end of a `Vector`
2. `Object elementAt(int i)` Returns the ith element
3. `int Size()` Returns the number of elements

4. `void removeElementAt(int i)` Removes the ith element
5. `void setElementAt(Object x, int i)` Changes the ith element to x.

12.4 Autoboxing, Unboxing and Generics

Before Java 1.5, handling `Vectors` and other similar types was much more difficult than it is now. With Autoboxing, Unboxing and Generics, things have become much easier.

Consider [`Lecture9/LargestInVec2.java`] This program allows us to store arbitrary amounts of data into the `Vector`. We can go on entering integers for as long as we like. The input terminates when the user types a non-integer value. The program then prints out the largest value entered. It is exactly the same algorithm that we used for finding the largest number in an array.

Here we are declaring `v` to be a `Vector` that only holds `ints`. Autoboxing and unboxing allow us to think of the type `Integer` as `int`. Really `Vectors` can only hold Objects but with autoboxing and unboxing we can *pretend* that they can hold simple types like `int` and `char`.

If we try and put a non-integer value in a `Vector <Integer>` we get a compilation error: [`Lecture9/errorVec.java`]

```
errorVec.java:8: addElement(java.lang.Integer) in java.util.Vector<java.lang.Integer>
cannot be applied to (java.lang.String) v.addElement("www");
```

12.5 Untyped `Vectors`

Consider [`Lecture9/Vector1.java`] Here, since we have not specified the type of the elements that we can put in the `Vector` we can use it to store all types of Object. Here we are adding five `Integers`, a `Character` and two `Strings`.

12.5.1 Exercise

Work out the output of `Lecture9/Vector1.java` above.

12.6 Sorting `Vectors`

In the program `SortVector` below, the algorithm we use for sorting `Vectors` is exactly the same as the one we used for arrays. The sort method, `sort(v)` returns a `Vector` which has the same elements as `v` but is sorted in ascending order. The parameter to `sort` is of course not changed by `sort`. The first thing that the method `sort` does is make a copy of `v` using its `clone` method, `w= v.clone()`. Note the use of the method `Vector.setElementAt`. [`Lecture9/SortVector.java`] What does the following program do? [`Lecture9/RefParams.java`]

12.6.1 Exercises on Chapter 12

Write a program that reads some numbers (terminated by a non-integer), stores them in a `Vector` and prints out:

1. the smallest
2. the sum
3. the average.

12.6.2 Exercises (no solutions)

1. Write a program that asks the user to enter some numbers (terminated by a non-integer) and then prints them out in the opposite order to which they were entered. For example, if the user types `1 4 3 5` the output should be `5 3 4 1`.
2. Write a program that asks the user to enter some numbers and then prints them out in the opposite order to which they were entered, and then prints them out in the same order they were entered. For example, if the user types `1 4 3 5` the output should be `5 3 4 1 1 4 3 5`.
3. Write a program where first the user enters some numbers and then the program asks the user to pick a number. The program tells the user how many of these numbers the user entered. For example, if the user entered `7 4 4 3 1 7` and then the number chosen was `7`, then the program would output `2` because the user entered two sevens. If the number chosen by the user was `8`, then the program would output `0`.
4. Write a program where the user types in a number of `Strings` stored in a `Vector` of `Strings` and then the program prints out the longest `String`.
5. Write a method `readSort` which is like `Input3.readInVectorOfIntegers` but it sorts them into ascending order as it puts them into the `Vector`.
6. Write a method that sorts `Vectors` in descending order.
7. Write a method that does a binary search for an `Integer` in a `Vector`. It must return the position of the `Integer` in the `Vector` and -1 if it is not there. Assume the `Vector` is sorted in ascending order.
8. Write a method for removing all duplicates from a `Vector` of Objects.

12.7 Manipulating Files Using `Vectors`

We now show how problems involving file manipulation can be tackled by storing the contents of the file in a `Vector`, then manipulating the `Vector` and finally outputting the resulting `Vector` back to the file.

12.7.1 Character by Character

Consider [`Lecture12/fileToVector.java`] Here, the method `fileToVector.fileToVector(s)` reads from the file, `s`, a character at a time and returns the `Vector` consisting of the same sequence of `Characters` that were in the file `s`. Note the Vector contains `Characters` not `chars`.

12.7.2 Line by Line

Now consider [`Lecture12/lines.java`] Here we are reading the file a line at a time. Each element of the resulting `Vector` will be a `String`. So there will be as many elements of the resulting `Vector` as there are lines in the original file. When we print out the contents of the `Vector` we must therefore use `System.out.println` if we are to preserve the lines of the original file. If the original file contained no end of line characters then the whole file would end up being stored in the zeroth element of the `Vector`.

12.7.3 Exercises

12.7.4 Longest Line in a File

Write a program that reads a file into a `Vector` of `String`s, one element per line and then finds the longest line.

Longest Word in the English Language

Use the program above to find the longest word in the English language.

12.7.5 Occurrences of Printable Characters in a File

Write a program `occ1.java` which prints out the number of occurrences of each printable character in a file. Assume the printable characters are those whose Unicode values lie between 30 and 126 inclusive. For example, `java Lecture12.occ1.java longestline.java` should produce:

12.7.6 Longest Word in the English Language

Use `Lecture11/words` and `Lecture12/longestline.java` to find the longest word in the English language.

12.7.7 Occurrences, Most Popular First

Using a `Vector`, write another program like `Lecture12/occ1.java` which prints out the occurrences of each character in a file but this time prints them in order of popularity. Order the output so that the most frequently occurring character comes first etc.

12.7.8 Do the Same Without a `Vector`

Write a program that does the same as `Lecture12/occ2.java` but this time store the information from the file directly into the array `occs`.

12.7.9 Frequency

Write a program `freq.java` which you can use to find the frequency as a percentage of each character in a piece of text.

12.7.10 Finding Words in Dictionary

Write a program `find.java` so that `java find ../Lecture11/words fred` will say 'yes' if fred is an English word (i.e. if it finds it in the dictionary) and 'no' if it isn't.

12.7.11 Exercise (no solution)

Write a program `firstlast.java` that can be used to print out all English words that start and end with the same letter. The choice of letter should be a command line argument. So, for example, `java firstlast /usr/dict/words w` should print all English words that start and end with the letter 'w'.

12.8 A System for Processing Student Marks

We now develop a user-defined class for holding information about students on the Java course. For each student we hold the following information:

- name
- exam mark
- coursework mark
- total mark
- grade.

The student's grade and total mark is worked out from the exam mark and the coursework mark. The total mark is 60% of the exam mark plus 40% of the coursework mark.

The grades are calculated in using the total mark as follows:

A: total $\geq$ 70%

B: 60% $\leq$ total $<$ 70%

C: 50% $\leq$ total $<$ 60%

D: 40% $\leq$ total $<$ 50%

E: 35% $\leq$ total $<$ 40% and both exam and coursework are not less than 35

F: 0% $\leq$ total $<$ 35% or either exam or coursework less than 35

12.9 The Class `Student`

We define a class called `Student` which has five fields, one constructor, `Student`, and two static methods, called `grade` and `total` which work out the grade and total for a student. These two static methods are called by the constructor `Student`. The constructor`Student` has three parameters: the name, coursework mark and exam mark of the student. `Student` also has an instance method called `toString()` which converts a `Student` to a `String`. Its output is a `String` consisting of the five fields of a `Student`. Here is the class [`Lecture13/Student.java`]

12.9.1 Printing Objects

If we try to print an Object, first Java tries to apply the Object's `toString()` method to convert it to a `String` for printing. Try `System.out.println(new Student("fred",60,45));`

12.9.2 The Raw Data File `marks`

The result of each student has been stored in a text file called `marks` which is a file containing the following information about a student:

1. name
2. exam mark
3. coursework mark.

Each of these fields is on a separate line.
Here is a program called `Results`. It is a program which I used to process the `marks` file. It prints out each student's name, exam mark, coursework mark, total and grade.
[`Lecture13/Results.java`] Each time round the loop we read three `String`s from the file:

1. The student's name
2. The student's exam mark
3. The student's coursework mark

We then create a `Student` out of these using `new Student(name,exam,cwk)` and print this out.

12.10 Exercises

12.10.1 Students in `Vector`

Write a class `studentsinVector` which has one field called `Students` of type `Vector` (each element of which is a `Student`) and a constructor which reads from a file and then stores all the `Students` in the `Vector`, `Students`.

12.10.2 Print Students in `Vector`

Write a program `printstudentsinvector.java` which stores all the students in a `Vector` and prints out the results in the `Vector`.

12.10.3 Print Sorted Students in `Vector`

Write a program `printsorrtedstudentsinvector.java` which stores all the students in a `Vector` and prints out the results in the `Vector` but this time sorted in descending order of total mark.

12.11 Exercises (no Solutions)

12.11.1 Finding Students whose Name Starts with a Particular Prefix

Write a program `findstudent.java` so that `java findstudent marks Jones` will print out the information for all the students whose name starts with Jones. The file `marks` is where the raw data is kept.

12.11.2 Sorting as you Input

Rewrite `studentsinVector` so that it sorts by ascending order of mark by putting students in the right place in the `Vector` as they are read from the file.

12.12 Summary

Having worked on Chapter 12 you will have:

- Learned the similarities and differences between a `Vector` and an array.
- Seen how `Vectors` are used for storing arbitrarily large amounts of data.
- Learned how to sort `Vectors`.
- Learned how to manipulate the contents of files by storing them in a `Vector` and then manipulating the `Vector`.
- Written a complete system for processing student marks.

Chapter 13

Conclusion

You have now come to the end of the both volumes of the Java Subject Guide. By now you should be familiar with many Java programming concepts.

13.1 Topics

The first volume of the Java Subject Guide considered many of the basic concepts of programming. These included:

- Arithmetic and Boolean Expressions
- Variables and Types, Declarations and Assignments
- Input and Output
- Conditional Statements
- Loops: Simple and Nested
- Useful Built-in Methods
- Arrays
- Defining and Using Methods

and the second volume of the Java Subject Guide introduced:

- Command-line rguments
- Recursion
- Packaging Programs
- More about Variables
- Bits, Types, Characters and Type Casting
- Files and Streams
- Sorting Arrays and Searching
- Defining Your Own Classes
- Inheritance
- Exception Handling
- Vectors

13.2 Complete All the Challenging Problems!

In order to make sure that you are prepared for second year programming, make sure you attempt and complete **all** the challenging problems on page 75 before you start year two of the programme. This is the best way to prepare!

Part II

Appendices

Appendix A

Challenging Problems

We learn to program, not only by reading books or subject guides, but mainly by trying to solve programming problems. This is why I have provided you with some challenging problems. For each problem I will give you some hints as to how I would go about solving it. I hope you find these hints useful, but feel free to solve the problems your own way!

Each challenging problem has two numbers, for example [1,5] associated with it. This means that you need to have studied as far as Volume 1 Chapter 5 before you attempt this problem.

A.1 Try out a Program [1,2]

Here is a program that produces pretty colours: [`LectureElements/pretty.java`] Type it in and then compile and run it on you computer. Make sure you set the `CLASSPATH` correctly!

A.2 Rolling a Die [1,5] (dice.class)

Write a program which emulates rolling a die. Every time the program is run, it outputs a random number between 1 and 6.

A.2.1 Hint

This program will have just a simple main method that prints out a random number between 1 and 6. You need to find out how to generate a random number between 1 and 6 and simply print the number out. Look in the Sun Java documentation for the class `java.util.Random`. See if you can find an instance method for generating a random number.

A.3 Leap Years [1,7]

Write a program in which the user enters a year and the program says whether it is a leap year or not.

A.3.1 Hint

Look up the rules for deciding whether a year is a leap year. Try typing *rules for leap year* into Google or some other search engine. Part of the rule will say the year, n, must be divisible by 4.

Having found the rules you need to think of a boolean expression involving the year n which is true if n is a leap year and false otherwise. It will be of the form

```
n%4==0 && ...
```

The program will first ask the user to enter an integer. You will store the input in an `int` variable, n. Then you will use the above boolean expression in an `if` statement, to decide whether to print `yes` or `no`.

You do not, at this stage, need to worry about handling illegal input from the user.

A.4 Drawing a Square [1,7]

Using `lineTo` and `moveTo`, from `element.jar`, write a program that asks the user to enter an integer size which draws a square of that size.

A.4.1 Hint

Assuming the square starts at co-ordinate $(origX, origY)$, you need to work out (not very difficult!) the co-ordinates of the three other corners of the square assuming its side has length n. Four calls to `lineTo` is more or less all you need.

A.5 How Old Are You? [1,7] (age.class)

Try out this program:

```
import java.util.Calendar;
class age
{

 public static void main( String []  args)
 {
   Calendar rightNow = Calendar.getInstance();
   int year =rightNow.get(rightNow.YEAR);
   int month =rightNow.get(rightNow.MONTH);
   int day =rightNow.get(rightNow.DAY_OF_MONTH);
   System.out.println(year);
   System.out.println(month);
   System.out.println(day);
 }

}
```

Write a program which asks the user for their date of birth and then tells them how old they are.

A.5.1 Hint

Having input the user's date of birth, you will have three integers `day`, `month` and `year` from the user and three integers from the system (see above). You then subtract this year from the year entered by the user and then subtract one if the month entered by the user is after this month or the months are the same and the day entered by the user is after today's day. (Careful about how the months are represented!)

A.6 Guessing Game [1,8]

Write a program that tries to guess the number thought of by the user. The number is between 0 and 1000. If the computer's guess is too high, the user should enter 2. If the computer's guess is too low, the user should enter 1. If the computer's guess is correct, the user should enter any integer except 1 or 2. Print out how many guesses it took the computer. Also print out if the user cheated!

A.6.1 Hint

You need a loop. You can use a boolean variable `finished` to get out of the loop. Before you enter the loop set finished to `false`. The loop should look like this:

```
while(!finished)
{


}
```

When the game is over, set `finished` to true. Then the loop will terminate.

Store the lowest and highest possible values. Each time choose half way in between. Use integer division by two to achieve this. Half way in between will be $(highest + lowest)/2$. Depending on whether the user enters 1 or 2 there will either be a new highest or a new lowest. If the computer doesn't guess by chance, eventually the highest and the lowest will become the same value. If this is not the right answer then the user must have cheated!

A.7 Mouse Motion [1,8] (mouseInRect.class)

Write a Java program which displays a small square of a colour of your choice. The left hand corner of the square must have one co-ordinate equal to the day of the month you were born, the other co-ordinate of the left hand corner must be the integer corresponding to the month you were born (Jan=1, Feb=2, etc.). The side of the square must correspond to your age in years. The square must change to a different colour when the mouse is inside it and back to the original colour when the mouse is not inside it. The program must keep responding to the mouse in this way. You should use the element package and the Drawing window described in Chapter 3.

A.7.1 Hint

- Your program should contain an infinite loop, so it goes on for ever.
- You will probably use the following methods from the element package:
  - getMouse()
  - contains
  - setForeground
  - fill
- You will need to work out some boolean expressions to test whether the mouse is inside the square that you have drawn. See the `contains` method for this.

A.8 Maze [1,8] (maze.class)

Write a Java program that represents a maze. The maze must have a start and a finish. The idea is to move the mouse from the start to the finish without going outside the maze. The program should give an error message if the mouse goes off the path of the maze and force the user to start again by ending the program. If the user gets from the start to the finish successfully the program should display to the user how long it took in seconds.

A.8.1 Hint

First make a simple shape for the maze. Mine was like this:

```
DrawingWindow d = new DrawingWindow(500,500);
                Text s =  new Text("start");
                Text f = new Text("end");
                s.center(new Pt(250,400));
                f.center(new Pt(255,200));
                Circle start= new Circle(250,400,30);
                Rect mid1 = new Rect(240,200,10,200);
                Circle finish= new Circle(255,200,30);
                d.fill(start);
                d.fill(mid1);
                d.fill(finish);
                d.setForeground(Color.white);
                d.draw(s);
                d.draw(f);
```

Then have a loop which gets the position of the mouse and checks where it is. Use the `contains()` method for this. For example, `start.contains(p1)` will be true if and only if point `p1` is inside the start circle. etc. Use `long b=System.currentTimeMillis();` to get the current time.

A.9 Hangman [1,9] (hangman.class)

The computer thinks of a word. (In fact, 'hard-wire' the word into your program.) The user tries to guess the word by trying a letter at a time. If the letter is in the word, then the computer

shows the user where it fits. Carry on in this way until either the user runs out of goes (say 9) or the user guesses the word.

A.9.1 Hint

This is an exercise in using the methods in `java.lang.String`. I start off with two Strings, `orig` which is the computer's guess and another one, `user`, which is simply a String of the same length consisting of dashes. `"-------"`. Every time the user has a guess, if the character they input is in `orig` I replace the corresponding dash in `user` by the input letter. The game is over when the two Strings are equal or the user has used up all the goes.

Again, you need a loop. You must read in a character typed by the user. The way I did this was with:

```
in.nextLine().charAt(0)
```

i.e. the first character typed in by the user.

The other methods that I needed were `length` and `compareTo`. To make it easier I defined two methods:

```
static char getGo()
```

which prompts the user for input and returns the character the user entered, and

```
static String upDate(String sofar, String orig, char g)
```

which returns the new String for `sofar` assuming the original string is `orig` and the character guessed by the user is `g`. To compute this we loop through `orig` looking for `g`. If we find `g` we update `sofar`.

A.10 Roman Numerals [1,9] (Roman.class)

Romans used a strange way of representing numbers which we call *roman numerals*. In roman numeral notation, M stands for 1000, D for 500, C for 100, L for 50, X for 10, V for 5 and I for one. In order to compute the integer value of a roman numeral, you first look for consecutive characters where the value of the first is less than the second. Take, for example XC and CM. In these cases you subtract the first from the second, so for example XC is 90 and CM is 900. Having done that, you simply add up all the values of such pairs and then to this add the values of the remaining individual roman numerals so, for example, MMMCDXLIX is 3449 and MCMXCIX is 1999.

Write a program which allows the user to enter a roman numeral and then displays its decimal value.

A.10.1 Hint

Write a method `static int value(char a)` which for each single character roman numeral returns its decimal value. This method will use a sequence of `if` statements (or a switch

statement if you like).

You can then have another method `static int value(String a)` which returns the value of a complete roman numeral. All you have to do is loop through the `String`, a character at a time. Every time you must look at the next character (if there is one) as well. If the next character is greater than the current one then you must subtract the values and 'jump' two ahead. Otherwise, add the value of the current numeral and jump one ahead.

I do not want you to do any error checking. As long as the program correctly calculates the values of proper roman numerals you will have completed this challenge.

A.11 Shuffling a Pack of Cards (1) [1,10] (deal1.class)

Write a program that shuffles 52 cards randomly. Your program should output the 52 having been shuffled. You may assume that the cards are numbered 1 to 52.

A.11.1 Hint

The way I did it was as follows:
Create an array a of 52 integers. For each i store i at position i in the array. Generate a random number k between 1 and however many cards left in the array (use `java.util.Random`). Print out $a[k]$. Then move all the elements of the array which are to the right of k one to the left. ($a[i] = a[i + 1]$), in effect deleting $a[k]$. Subtract one from the total number of cards left in the array. Repeat this 52 times.

A.12 Shuffling a Pack of Cards (2) [1,10] (deal2.class)

Write a program that shuffles 52 cards randomly. Your program should output the 52 having been shuffled. This time you must output Strings like "five of clubs" or "ace of spades" instead of just a number.

A.12.1 Hint

I used two arrays to store the names values and suits of cards:

```
String [ ] val = {"ace","two","three","four",
                              "five","six","seven","eight","nine", "ten",
                              "jack", "queen","king"};

String [ ] suit ={"clubs","diamonds","hearts","spades"};
```

We then need a way of converting numbers from 1 to 52 into these. To do this I used arithmetic; dividing by thirteen for the suit and taking the remainder for the value.

A.13 Noughts and Crosses (1) [1,11] (tictac.class)

Write a program that allows two people to play noughts and crosses on the computer. Your program should stop illegal moves and detect when the game is over and output who has won.

A.13.1 Hint

I represent the noughts and crosses board as an array of nine integers. I use 0, 1 and 2 to represent empty squares, noughts and Xs respectively. I have written some useful methods including:

```
static void initialise() //initialises the board

static boolean boardFull(int [] b) //returns true iff b is full

static boolean lineOfThree(int [] b,int x, int y, int z) // returns true iff pos
x,y,z are all the same but not empty


static boolean isWon(int [] b) // check whether someone has won

static boolean isFree(int [] b, int x) // checks whether x is a free square in b

static int [ ] userGo(int [] b,int xoro) accepts input from user and returns
updated board

static void drawBoard(int[] b) // draws the board on the screen
```

I'm feeling generous at the moment, so I'll even give you my main method!

```
public static void main(String [] args)
{
     initialise(); int xoro=1;
     for(int i=1;i<10;i++){System.out.print(i); if (i%3==0)System.out.println();  }
     draw(board);
     while(!boardFull(board) && !isWon(board))
     {
        board=userGo(board,xoro);
        if (xoro==1) xoro=2; else xoro=1;
        draw(board);
     }
    if (isWon(board)) System.out.println(xoro==1?"x":"o" + " has won");
    else System.out.println("draw");
}
```

A.14 Mastermind [1,11] (mastermind.class)

Implement the well-known game with coloured pegs. You can use digits instead of colours. The computer's pattern of n digits is hard-wired into the program. The user tries to guess the pattern. The computer responds, telling the user two values:

1. how many digits are right and in the right place (the black pegs)
2. how many digits are right but in the wrong place (the white pegs)

Carry on until the user gets it. Tell the user how many guesses it took.

A.15 Noughts and Crosses (2) [1,11] (tictac2.class)

This time, the computer plays against the user. The user should be allowed to go first and the computer must respond each time with a random legal move.

A.15.1 Hint

The way I have done this is very crude. For the computer's move I repeatedly generate a random number between 1 and 9 until I get a free square. That's the move the computer makes.

A.16 Noughts and Crosses (3) [1,11] (tictac3.class)

This time the computer plays against the user. The user should be allowed to go first and the computer must respond each time with a random legal move. But this time if the computer spots an immediate win it goes for it!

A.16.1 Hint

To help me with this I have written the following ugly method:

```
static boolean winning(int [ ]b, int xoro)
  {
      return (b[0]==xoro && b[0]==b[1] && b[1]==b[2]) ||
             (b[3]==xoro && b[3]==b[4] && b[4]==b[5]) ||
             (b[6]==xoro && b[6]==b[7] && b[7]==b[8]) ||
             (b[0]==xoro && b[0]==b[3] && b[3]==b[6]) ||
             (b[1]==xoro && b[1]==b[4] && b[4]==b[7]) ||
             (b[2]==xoro && b[2]==b[5] && b[5]==b[8]) ||
             (b[0]==xoro && b[0]==b[4] && b[4]==b[8]) ||
             (b[2]==xoro && b[2]==b[4] && b[4]==b[6]);
  }
```

A.17 Nim [1,11] (nim.class)

The computer plays against the user. Implement a winning strategy. In nim we have n piles of matches. The user and the computer take it in turns picking up matches. The rules are that on each go you can pick up as many matches as you like from exactly one pile. The person who is left with no matches is the loser.

A.17.1 Hint

This is quite a hard problem. If you can do this then you must be a super geek! The way I did it relies on two observations:

1. Suppose we have some non-negative integers which when XORed together gives a non-zero value (condition 1). There is a way of subtracting a positive amount from one of the numbers to leave a set of non-negative numbers which when XORed together will give zero.
2. Suppose we start with some non-negative integers which when XORed together gives zero (condition 2). If we subtract a non-negative amount from any one of these numbers to leave a set of non-negative integers, this set of numbers when XORed together will always give a non-zero value.

If we start by offering the user some piles satisfying condition 2 then we can always win because the number of matches is being reduced at each go and when all the piles are zero, they satisfy condition 2.

So, the only problem is to work out how to convert the piles from condition 1 to condition 2. This is one way of doing it:

1. First I XOR all the piles together to produce `xorall`.
2. You then look for a with pile n matches such that when XORed with `xorall`, the result is less than n. Try all piles until you find one satisfying this. That's the computers turn.

A.18 Clock [1,12]

Simplify the following program for animating two clock hands `[LectureElements/bigClock.java]` LectureElements/bigClock.java using methods you have defined yourself .

A.19 Spell-Checker [2,7]

1. Find out about the *Soundtex* algorithm.
2. Write a method that implements it.
3. Write a spell-checker that goes through a file and every time it finds a word not in the dictionary it offers the user a list of *similar* words using Soundtex to choose from. It prompts the user either to accept the word or to enter a replacement. New words entered by the user should be stored in a local dictionary.

A.20 Diary Program [2,9]

A diary consists of a number of events. Each event has three associated bits of information.

1. The date when the event takes place.
2. The number of days before they wish to be reminded of the event.
3. The text of the event.

You must write a system that gives the user the following choices:

1. Add an event.
2. See all today's events (you must find today's date). Each event must be displayed one at a time, each time asking the user if they want to:
   (a) Delete the event.
   (b) Change the date of the event.
   (c) Change the number of days before they wish to be reminded of the event.
   (d) Continue.
3. See all today's reminders. Each event must be displayed one at a time, each time asking the user if they want to:
   (a) Delete the event.
   (b) Change the date of the event.
   (c) Change the number of days before they wish to be reminded of the event.
   (d) Continue.
4. See all events on a particular day. Each event must be displayed one at a time, each time asking the user if they want to:
   (a) Delete the event.
   (b) Change the date of the event.
   (c) Change the number of days before they wish to be reminded of the event.
   (d) Continue.
5. See all events on a particular time interval (forget leap years). Each event must be displayed one at a time, each time asking the user if they want to:
   (a) Delete the event.
   (b) Change the date of the Event.
   (c) Change the number of days before they wish to be reminded of the Event.
   (d) Continue.
6. See all Events, each time asking the user if they want to:
   (a) Delete the Event.
   (b) Change the date of the Event.
   (c) Change the number of days before they wish to be reminded of the Event.
   (d) Continue.
7. Update the diary file.
8. Exit the system.

You must design a `Diary` class and an `Entry` class. Your `Diary` class should contain a Vector of Objects of type `Entry`. Your diary should be stored in a file. This file should be read into memory when you start the system and it should be updated when you leave the system. All changes should be done in memory.

Consider the program [`LectureSimpleObjects/diary.java`] Add the extra options to the diary user interface.

A.20.1 Hints

You need three classes:

- A Date class with three fields:
  - int day
  - int month
  - int year
- An Event class with 3 fields:
  - String text
  - Date date
  - int reminder
- A Diary class with 2 fields:
  - Person owner
  - Vector events

A.20.2 Methods needed for Date Class

- `public boolean Equals(Date d)` returns true if and only if this date is same as d.date like this:

```
public boolean Equals(Date d)
{
 return (d.day==day && d.month==month && d.year==year);
}
```

- `public boolean Before(Date d)` returns true if and only if this date is before `d`.
- `public boolean After(Date d)` returns true if and only if this date is after `d`.
- `public boolean withinRange(int n,Date d)` returns true if and only if this date is less than n days before `d`.
- `public static Date read()` prompts user for date and returns whatever user enters.
- `public String toString()` converts `Date` to `String`.

A.20.3 Methods needed for Event Class

- `public boolean Equals(Date d)` returns `true` if and only if the date of this Event is same as `d.date` like this:

```
public boolean Equals(Date d)
{
 return (date.equals(d));
}
```

- `public boolean Before(Date d)` returns `true` if and only if this event's date is before `d`.
- `public boolean After(Date d)` returns `true` if and only if this event's date is after `d`.
- `public boolean Before(Date d)` returns `true` if and only if this event's date is before `d`.
- `public boolean withinRange(int n,Date d)` returns `true` if and only if this event's date is less than `n` days before Date `d`.
- `public static Event read()` prompts user for Event and returns whatever user enters.
- `public String toString()` converts Event to String.

A.20.4 Methods needed for Diary Class

- `public Diary addEvent(Event e)`
  like this:

```
public Diary addEvent(Event e)
{
 events.addElement(e);
 return new Diary(events,owner);
}
```

Appendix B

Exams

Important: the information and advice given in the following sections are based on the examination structure used at the time this guide was written. However, the University can alter the format, style and requirements of an examination paper without notice. Because of this, we strongly advise that you check the instructions on the paper you actually sit.

B.1 Exam Guidelines

B.1.1 Useful Information

Make sure that you have understood the rubric. Take your time deciding which questions to attempt. The exam lasts for three hours, so you have forty-five minutes per question. Notice that each question is broken into three sections, worth 9, 8 and 8 marks respectively. These are in increasing order of difficulty. The first two sections of each question are usually either book work or an exercise very similar to those in the subject guides. This should be an extra incentive for you to attempt all the exercises in the subject guides.

The third section of each question usually allows you to demonstrate your programming skill.

Do NOT answer more than four questions.

B.1.2 Java 1.5 Changes

The exam paper below was written before the introduction of Java 1.5. Future exams will have the same format as the one below. We now, however, use Java 1.5. The main difference is that the class `java.util.Scanner` is now usually used, as in these guides, instead of the older `java.io.BufferedReader`.

B.1.3 Time Allowed

This exam lasts three hours.

B.2 The Exam

There are six questions in this paper. You should answer no more than FOUR questions. Full marks will be awarded for complete answers to a total of FOUR questions. Each question carries 25 marks. The marks for each part of a question are indicated at the end of the part in [.] brackets.

There are 100 marks available on this paper.

No calculators should be used.

QUESTION 1

1. (a) Write three assignment statements whose effect is to swap the contents of variables x and y.

   (b) Briefly explain why the following program has a compilation error:

```
class f
{
   int x=false;
}
```

   (c) What is the output of the following Java program?

```
class f
{
   public static void main(String [ ]  args)
   {
    System.out.println(7+2*3);
   }
}
```

   Justify your answer.

[9 Marks]

2. (a) What is the output of the following?

```
class H
{
   public static void main(String [ ]  args)
   {
        i=0;
        while (i<5) {System.out.println(i);i=i+1;}
   }
}
```

   (b) Rewrite program H above using a *for* loop.

[8 Marks]

3. Write a method which sorts an array of `int`s into ascending order and discuss the time complexity of your method.

[8 Marks]

QUESTION 2

1. (a) Given that the ASCII code for the character `b` is 98, what is the ASCII code for the character `a`?

   (b) What is the output of the following Java program?

```
class ascii
{
        public static void main(String[] args)
        {
           System.out.print((int) 'a');
        }
}
```

   (c) What is the output of the following Java program?

```
class ascii
{
        public static void main(String[] args)
        {
           System.out.print((char) 98);
        }
}
```

   (d) What does the following program do?

```
import java.io.*;
class one
{
        public static void main(String args[]) throws Exception
        {
                FileReader f =  new FileReader("aaa");
                int x; x=f.read(); x=f.read();
                System.out.print((char)x);
        }
}
```

[9 Marks]

2. Write two fragments of code that illustrate how to output the contents of a file
   (a) by reading it character by character.
   (b) by reading it line by line.

[8 Marks]

3. Write a method which prints out the number of occurrences of each letter in a file called "aaa". You should distinguish between upper and lower case letters.

[8 Marks]

QUESTION 3

1. Define a class called *Date* which has three fields *day*, *month* and *year* all of type *int* and one constructor with three *int* parameters.

[9 Marks]

2. Write two instance methods, *isEqual* and *isBefore* for the class *Date*. Both methods should have one parameter d of type *Date*. The method *isEqual* should return *true* if this date is equal to d and *false* otherwise. The method *isBefore* should return *true* if this date is before d and *false* otherwise.

[8 Marks]

3. Define a class called *Person* consisting of a name which is of type *String* and a date of birth which is of type *Date*. Write a constructor with two parameters (one of type *String* and the other of type *Date*) for *Person* and an instance method *isYounger*, with one parameter p of type *Person*, for checking whether this person is younger than p. (You should use the *isBefore* method of the last question.)

[8 Marks]

QUESTION 4

1. (a) Give a boolean expression which evaluates to `true` if the variable `x` has the value 3 and which evaluates to `false` otherwise.

   (b) Give a boolean expression which evaluates to `true` if the variable `x` has the value 7 or the value 9 and which evaluates to `false` otherwise.

   (c) Give a boolean expression which evaluates to `true` if the variable `x` has the value 1 and the variable `y` has the value 2 and the variable `z` is even and which evaluates to `false` otherwise.

   (d) Give a boolean expression which evaluates to `true` if the variables `x`, `y` and `z` all have the same value and which evaluates to `false` otherwise.

   [9 Marks]

2. (a) Here is the body of a method:

```
{
     return 3;
}
```

   What is its return type?

   (b) Here is the body of a method:

```
{
        int x;
        if (x==k) return "hello"+" world";
        else return "";
}
```

   What is its return type?

   (c) Here is the body of a method:

```
{
        System.out.println(3);
}
```

   What is its return type?

   (d) Here is the body of a method:

```
{
        return("hello".charAt(2));
}
```

   What is its return type?

   [8 Marks]

3. Write a method whose heading is `static Vector convert(Object [ ] a)` which given an array of Objects, returns a Vector of the same Objects in the same order.

   [8 Marks]

QUESTION 5

1. (a) Explain briefly the purpose of packages in Java.

   (b) Explain briefly the purpose of the `import` statement in Java.

   (c) Rewrite the following Java class so it does not have any `import` statements.

```
import java.io.*;
class Echo
{
    public static void main(String[] args) throws IOException
    {
      BufferedReader in =
      BufferedReader(new InputStreamReader(System.in));
      String s =in.readLine();
      System.out.println(s);
    }
}
```

[9 Marks]

2. Given the class C defined as follows

```
class C
{
        int f()
        {
            return 5;
        }
}
```

   Define a class D which extends C and which has one method which *overrides* f and another which *overloads* f.

[8 Marks]

3. (a) The class *Object* has one constructor with no parameters. How would you declare a variable, v, of type *Object* and then assign a value to variable, v, by using the constructor of the class *Object*?

   (b) Define a class called *Array* with one field of type *array of Object* and one instance method *toString()* which returns a String containing the elements of the array separated by commas. Do not define a constructor for the class *Array*.

[8 Marks]

QUESTION 6

1. (a) What is the output of the following program?

```
public class A
{
   public static void main(String[] args)
   {
    try
     {
        Integer.parseInt("rabbit");
        System.out.println("cat");
     }
     catch(Exception e)
     {
        System.out.println("fish");
     }
   }
}
```

   (b) There will be an error when we compile the program below. What is it? Give two different ways of correcting it.

```
import java.io.*;
public class cat1
{
        public static void main(String[] args)
        {
            FileReader f =new FileReader("words");
        }
}
```

[9 Marks]

2. (a) What is the output of the following program?

```
public class A
{
   int f(int n)
   {
     if (n==0) return 1;
     else return n*f(n-1);
   }

   public static void main(String[] args)
   {
    System.out.println(f(3));
   }
}
```

   (b) Write a recursive method `static int fibonacci(int n)` which returns the nth fibonacci number.

[8 Marks]

3. Using exceptions, write a method `static boolean find(String f)` which returns *true* if the file whose name is *f* is found and *false* if it is not found.

[8 Marks]

Appendix C

Previous Exam Questions (With Answers)

QUESTION 1

1. (a) What is the purpose of the *main method* in a Java application?

   (b) When we compile the program below for the first time, what is the name of the new file that will appear in the current directory?

[4 Marks]

2. (a) Briefly describe what methods are and why they are useful in programming.

   (b) What is a recursive method? Give an example of a recursive method.

[6 Marks]

QUESTION 2

1. Briefly explain the purpose of comments in a Java program and briefly describe two different ways of writing comments.

[4 Marks]

2. (a) Describe the syntax of a `for` loop in Java.

   (b) Give an example of a `for` loop that never terminates.

[6 Marks]

QUESTION 3

1. Briefly explain the purpose of *Exceptions* in a Java program.

[4 Marks]

2. (a) List three *primitive types* in Java
   (b) Give an example of a *variable declaration* and explain what it does.
   (c) Give an example of an *assignment statement* and explain what it does.

[6 Marks]

QUESTION 4

1. (a) What are the possible values that *boolean expression* evaluate to.
   (b) List two boolean operators in Java and, with examples, briefly explain their meaning.

[4 Marks]

2. (a) Describe the similarities and differences between *arrays* and *Vectors* in Java.
   (b) How do you refer to the third element of array x? (Reminder: The third element of an array has exactly two elements before it)
   (c) How do you refer to the third element of `Vector` v? (Reminder: The third element of a `Vector` has exactly two elements before it)

[6 Marks]

QUESTION 5

1. Give an example of a *compilation error* and explain how the compiler informs us of the error.

[4 Marks]

2. (a) Write a complete Java program that tests whether *times* binds more tightly than *plus*. Explain how the output of your program will enable you to decide.

   (b) Explain why it is not necessary to remember the precedence of operators when writing programs.

[6 Marks]

QUESTION 6

1. (a) What does it mean to say that Java is *case sensitive*?
   (b) Give an example of a Java program with an error caused by the fact that Java is case sensitive.

[4 Marks]

2. (a) Consider the two programs below. Explain what each of their outputs is and why.
   (b) Explain the output of the following program:

[6 Marks]

QUESTION 7

1. Write a program that prints out every other character of a file. i.e The first, third, fifth etc. character. The name of the file should be passed to the program as a command line argument.

[7 Marks]

QUESTION 8

Consider the class `Person` Extend the class `Person`, to a class `NatPerson` so that a person also has a nationality which is a `String`. We require two new constructors corresponding to each of the two constructors of `Person`.

[7 Marks]

QUESTION 9

1. What is the output of the program below and why?

2. What is the output of the program below and why?

[7 Marks]

QUESTION 10

1. Given the class `Arrays`: The methods in class `Arrays` can be referred to in other classes. Write a complete Java application which calls some of the methods in the class `Arrays` which asks the user how many numbers they are going to enter, reads in the numbers and prints their average.

[7 Marks]

QUESTION 11

1. Describe the *Bubble Sort* Algorithm.

   [2 Marks]

2. Write a method whose heading is

   ```
   public static void ascendingBubbleSort(int[] a, int size)
   ```

   which sorts an array of `int`s into ascending order.

   [5 Marks]

QUESTION 12

Using `try` and `catch` and the method `Integer.parseInt`, write a static method, `isInt` that takes a `String` as a parameter and returns `true` if the `String` contains only digits and `false` otherwise.

[7 Marks]

QUESTION 13

Write a simple spell checker. You can assume the existence of a file called `words` in the current directory consisting of a big list of English words (courtesy of Unix), one per line. The user simply types the beginning of the word he wants to check as a command line argument. For example,

```
java spell freq
```

will print out all English words starting with `freq`

```
frequencies
frequency
frequent
frequented
frequenter
frequenters
frequenting
frequently
frequents
```

You may also use the `String` method `startsWith`.

[8 Marks]

QUESTION 14

Write a complete program that asks the user to enter two numbers and then prints out the Greatest Common Divisor of the two numbers. Your solution may be iterative or recursive.

[8 Marks]

QUESTION 15

1. Define a class `house` that consists of three fields:
   (a) an `int` which gives its number
   (b) another `int` which gives the number of rooms in the house
   (c) an array of `Persons` living in the house.

   Your definition should include a constructor with three parameters.
2. Define another class called `Street` consisting of two fields
   (a) A `String` representing the name of the street.
   (b) An array of `Houses` in the street.

   Your definition of `Street` should contain a constructor with two parameters and an instance method called `UpMarket` which returns true if every house in the street contains more rooms than people.

[8 Marks]

QUESTION 16

A *palindrome* is a `String` that reads the same backwards as forwards. Write a complete Java program that asks the user to enter a `String`. The program outputs 'Yes' if the `String` entered by the user is a palindrome and 'no' otherwise. The program repeatedly asks the user if he wants another go to enter further `Strings`.

[8 Marks]

QUESTION 17

Consider the following program:

```
import java.io.*;
public class dog
{
        public static void cat(String s) throws Exception
        {
                BufferedReader inone =new BufferedReader(new FileReader(s));
                int t=inone.read();
                while (t!=-1)
                {       System.out.print((char)t);
                        t=inone.read();
                }
        }
        public static void main(String[] args) throws Exception
        {cat(args[0]);}
}
```

1. What happens if we type in `java dog dog.java`?

   [2 Marks]

2. When does the variable `t` get the value -1?

   [2 Marks]

3. What would happen if the input file was empty? Why?

   [2 Marks]

4. What is the value of the expression, `"hello".charAt(0)` ?

   [2 Marks]

5. Let `s` be a `String`. Write an expression which yields the last character in `s`.

   [4 Marks]

6. Write a complete Java program called `swapab` that writes the contents of a file to standard output swapping all 'a's for 'b's and all 'b's for 'a's. For example to run the program on a file called `fred`, we type: `java swapab fred`.

   [13 Marks]

QUESTION 18

1. Briefly describe the class `Vector` and how it compares with an array.

   [4 Marks]

2. Assuming v is an object of class `Vector`, what is wrong with the boolean expression v.elementAt(0)==1?

   [2 Marks]

3. Briefly explain the need for the Java classes such as Integer, Character, and Boolean.

   [3 Marks]

4. Assuming that the zeroth and first elements of the `Vector` v are Integers, write a statement whose effect is to add a new element to v. The value of this new element is the sum of the first two elements of v. Fully explain your answer.

   [8 Marks]

5. Write a method whose heading is
   `static double average(Vector v)`
   which returns the average of all elements in a non-empty `Vector` of Integers.

   [8 Marks]

QUESTION 19

1. What is a recursive method?

   [2 Marks]

2. Write a method `int power(int n, int m)`, which implements exponentiation (n to the power m) recursively in terms of multiplication (Assume $m \geq 0$).

   [5 Marks]

3. Write a method `int power(int n, int m)`, which implements exponentiation iteratively.

   [5 Marks]

Appendix D

Multiple Choice Questions

Consider the following program and then answer the questions that occur on the next pages.

```
class HorizLine
{
   int length;

   public HorizLine(int l)
   {length=l;}

   public void Draw()
   {for (int i=0;i<length;i++)System.out.print("*");
   }

   public void Drawln()
   {Draw();
    System.out.println("");
   }
}


class BetterLine extends HorizLine
{
  char endchar;
  char middlechar;

  public BetterLine(char end,char middle, int len)
  {
   super(len);
   endchar=end;
   middlechar=middle;
  }

  public void Draw()
  {for (int i=0;i<length;i++)
   if (i==0 || i == length-1)  System.out.print(endchar);
   else System.out.print(middlechar);
  }
}
```

QUESTION 20

Consider the program on page 114. How many instance variables does the class `BetterLine` have? (including the instance variables it inherits)

(a) 0
(b) 1
(c) 2
(d) 3
(e) 4

QUESTION 21

Consider the program on page 114.

How would an instance of `HorizLine` be declared?

(a) `b HorizLine;`
(b) `HorizLine b;`
(c) `HorizLine(b);`
(d) `HorizLine();`
(e) None of the above.

QUESTION 22

Consider the program on page 114.

How would an instance of `HorizLine` be created?

(a) `b=new HorizLine;`
(b) `new HorizLine(b);`
(c) `b=new HorizLine(5)`
(d) `b=HorizLine(i);`
(e) None of the above.

QUESTION 23

Consider the program on page 114.

How many of the statements below are true?

- `HorizLine` is a constructor
- `Draw` is a constructor
- `Drawln` is a constructor
- `BetterLine` is a constructor

(a) 0
(b) 1
(c) 2
(d) 3
(e) 4

QUESTION 24

Consider the program on page 114.

Which one of the statements below is true?

(a) The method `Draw` in class `BetterLine` is an example of *method overriding*
(b) The method `Draw` in class `BetterLine` is an example of *method overloading*
(c) The method `Draw` in class `BetterLine` is an example of *method overcasting*
(d) The method `Draw` in class `BetterLine` has two parameters
(e) None of the above.

Appendix E

Reading List

Reading List

[Bis01] Judith Bishop. *Java Gently - Third Edition*. Addison-Wesley, 2001.

[CK06] Quentin Charatan and Aaron Kans. *Java - In Two Semesters - Second Edition*. McGraw-Hill, East London Business School, 2006.

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[LO02] Kenneth A. Lambert and Martin Osborne. *Java - A Framework for Programming and Problem Solving*. Brookes-Cole, 2002.

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