COM1003
Java Programming

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Input, Output, Strings and Characters

This lecture will

- Introduce the **`sheffield`** package
- Explain the difference between basic types and objects
- Explain the **`String`** class and demonstrate some of its methods
- Introduce the Java type **`char`** for storing and manipulating Unicode characters

Constants v. Variables

- The declaration of a constant contains the additional word, **`final`**, and you can't change its value
- You can change variables but up to now we haven't done that much
- In the exercises there was an example which worked out the area of a circle πr^2
- π was a constant and the radius was a variable but neither actually changed

Constants v. Variables

- This works out the volume of a sphere which is $\frac{4}{3}\pi r^3$

```
public class Sphere {
   public static void main (String [] args) {
      int radius = 10;
      System.out.print("The volume of a sphere with " +
            " radius " + radius + " is ");
      System.out.println(
            4.0/3.0 * Math.PI * Math.pow(radius, 3));
   }
}
```

The plus sign joins strings which must not contain a line break

We need at least one decimal point to avoid integer division

This constant is always available as is Math.E

This is a method to raise its first parameter to the power of the second

Parameters of methods are separated by commas

Constants v. Variables

- This works out the volume of a sphere which is $\frac{4}{3}\pi r^3$

```
public class Sphere {
   public static void main (String [] args) {
      int radius = 10;
      System.out.print("The volume of a sphere with "+
            " radius " + radius + " is ");
      System.out.println(
            4.0/3.0 * Math.PI * Math.pow(radius, 3));
   }
}
```

- Actually it only works out the volume of a sphere with radius 10

EasyReader

- Many programs need to input data from the keyboard and output a result
- Java provides extensive, versatile input and output (I/O) facilities
- It doesn't provide simple, relatively foolproof ones
- To start with we are going to use EasyReader a class that contains a lot of methods to read things in

Reading things in

This says what we mean by keyboard

This asks the user a question and reads the answer in

```
import sheffield.*;

public class Sphere {
   public static void main (String [] args) {
      EasyReader keyboard = new EasyReader();
      double radius = keyboard.readDouble(
            "What is the radius of your sphere? ");
      System.out.print("The volume of a sphere with " +
            "radius " + radius + " is ");
      System.out.println(
            4.0/3.0 * Math.PI * Math.pow(radius, 3));
   }
}
```

Reading things in

```
import sheffield.*;

public class Sphere {
   public static void main (String [] args) {
      EasyReader keyboard = new EasyReader();
      double radius = keyboard.readDouble(
            "What is the radius of your sphere? ");
      System.out.print("The volume of a sphere with " +
            "radius " + radius + " is ");
      System.out.println(
            4.0/3.0 * Math.PI * Math.pow(radius, 3));
   }
```

```
U:…myjava>java Sphere
What is the radius of your sphere? 1
The volume of a sphere with radius 1 is 4.1887902047863905
U:…myjava>
```

Using EasyReader

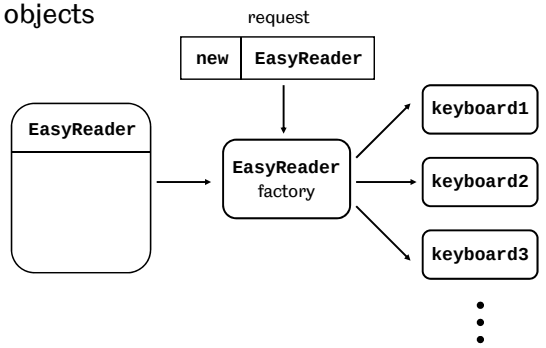
- To use **EasyReader**, we create an **EasyReader** object:

```
EasyReader keyboard = new EasyReader();
```

- This is a variable declaration, but **EasyReader** is a class (not a basic type) so we use the keyword **new** and call a special method, called a **constructor**, which has the same name as the class

A class is a 'blueprint' for objects

- We can make as many instances of a class as memory allows; it's like a factory that makes objects



Using EasyReader

- To use **EasyReader**, we create an **EasyReader** object:

```
EasyReader keyboard = new EasyReader();
```

- A new **instance** of the class **EasyReader** is created; an **object** of type **EasyReader**
- After the assignment the variable **keyboard** refers to the new **EasyReader** object that has just been created

Objects and methods

- One advantage of using objects it that they have **methods**
- We have seen the **print** and **println** method but each class has its own set of methods and every object of that class can use them

```
EasyReader keyboard = new EasyReader();
double radius =
      keyboard.readDouble("What radius? ");
```

readDouble is one of the many methods of **EasyReader**

Objects and basic types

```
EasyReader keyboard = new EasyReader();
double radius =
      keyboard.readDouble("What radius? ");
```

- This can be read as "send the **readDouble** message to the object called **keyboard**, and store the result in the variable **radius**"
- **radius** is a location in memory where a real number is stored
- **keyboard** is a location in memory where a pointer to an object is stored

This is important

EasyReader's readInt() method

```
import sheffield.*;
public class WallPaper {

   public static void main(String[] args) {
      // get the dimensions of the room from the user
      EasyReader keyboard = new EasyReader();
      int length = keyboard.readInt("Enter the length: ");
      int width = keyboard.readInt("Enter the width: ");
      int height = keyboard.readInt("Enter the height: ");

      // do the calculations
      int carpetSize = length*width;
      int wallpaperSize = 2*height*(length+width);

      // print the result
      System.out.println("Your room needs " + carpetSize +
               " square metres of carpet and");
      System.out.println(wallpaperSize +
               " square metres of wallpaper");
   }
}
```

Running the program

- The user input is shown in yellow

```
U:…myjava>java WallPaper
Enter the Length: 5
Enter the width: 8
Enter the height: 3
Your room needs 40 square metres of carpet and
78 square metres of wallpaper
```

Importing the sheffield package

```
import sheffield.*;
```

This makes EasyReader available

```
public class WallPaper {
   public static void main(String[] arg) {
      // get the dimensions of the room from the user
      EasyReader keyboard = new EasyReader();
      int length = keyboard.readInt("Enter the length: ");
      int width = keyboard.readInt("Enter the width: ");
      int height = keyboard.readInt("Enter the height: ");

      // do the calculations
      int carpetSize = length*width;
      int wallpaperSize = 2*height*(length+width);

      // print the result
      System.out.println("Your room needs " + carpetSize +
               " square metres of carpet and");
      System.out.println(wallpaperSize +
               " square metres of wallpaper");
   }
}
```

The sheffield package

- As well as **`EasyReader`** we have created two other classes to help you get started with Java's IO
- The full set is **`EasyReader`**, **`EasyWriter`** and **`EasyGraphics`**
- They are all bundled together in the **`sheffield`** package
- A package is a collection of related Java classes

Importing EasyReader

- The **`import`** statement makes all classes in the package called **`sheffield`** available for use in the program:

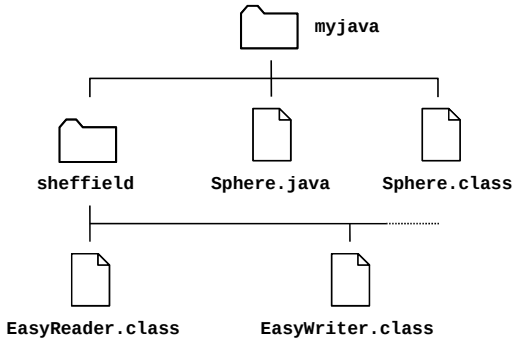
```
import sheffield.*;
```

- If we only want to use **`EasyReader`**, we could write:

```
import sheffield.EasyReader.*;
```

- The import only works if the sheffield package, which is in a directory, is in the same directory as your program

Importing and path names



The EasyWriter class

- **`EasyWriter`** is another class of the **`sheffield`** package that provides methods similar to **`System.out.print`** and **`System.out.println`**, but allows formatted output of numbers too
- Avoid using both **`System.out`** and **`EasyWriter`** in the same program
- If you don't need formatted output just use **`System.out`**

Formatted output with EasyWriter

- To use **EasyWriter** we need to import the **sheffield** package as with **EasyReader** and create an instance of the **EasyWriter** class (i.e., an **EasyWriter** object) before its methods can be invoked:

```
EasyWriter screen = new EasyWriter();
screen.println(42);
```

- If you don't need formatted output, its easier to use **System.out** (and the program is at least on line shorter).

Formatted output of integers

- Integer numbers can be aligned within a field:

```
EasyWriter screen = new EasyWriter();
screen.println(3189,6);
screen.println(13,6);
screen.println(534,6);
```

Parameters are separated by commas

```
3189
  13
 534
```

- The first parameter is the number to be output and the second is the number of character positions it is to take up. The integer is aligned to the right within these character positions

Formatted output of real numbers

- If the **println** method is called with only a real number as a parameter it is the same as **System.out.println**
- If it is called with two parameters, a real number and then an integer the second parameter specifies the number of decimal places the first will be printed out to
- If it is called with a third parameter the final parameter specifies how many character positions it will take up

Formatted output of real numbers

```
screen.println(3.14159265359);
screen.println(3.14159265359,3);
screen.println(3.14159265359,4,10);
```

```
3.14159265359
3.142
    3.1416
```

- Where the number of decimal places is specified **println** rounds rather than truncates

Using text files

- Sometimes it is useful to get programs to take input from a text file or save output to one
  - `new EasyReader()` reads from the keyboard
  - `new EasyReader("file.txt")` reads from the named file
  - `new EasyWriter()` displays to the screen
  - `new EasyWriter("otherfile.txt")` writes to the named file **and destroys any existing version of `otherfile.txt`**

Input from a text file

This line says what file to use. It has to be in the same directory as the program

`readDouble` doesn't need a parameter saying what to type

```
import sheffield.*;
public class CropAreaFromFile {
   public static void main(String[] arg) {
      EasyReader fileInput =
                  new EasyReader("croparea.txt");

      // read the field's length and width
      double width = fileInput.readDouble();
      double length = fileInput.readDouble();

      // write the result
      System.out.println("Your field has an area of "
                  width*length+" metres squared.");
   }
}
```

Running the program

- If the `croparea.txt` file contains the following data:

```
2.5
8.2
```

- Running the program gives

```
U:…myjava>java CropArea
Your field has an area of 20.5 metres squared.
U:…myjava>
```

- If `readDouble` has a parameter it will look messy

```
U:…myjava>java CropArea
What width? What length? Your field has an area of 2(
```

Output to a text file

```
import sheffield.*;
public class FormattedOutputToAFile {
    public static void main(String[] arg) {
        EasyWriter file = new EasyWriter("output.txt");
        double x = 2.184918284982;
        double y = 127.318291823;
        file.println(x);   // same as System.out.println(x)
        file.println(x,3); // show three decimal places
        // show five decimal places in a field of 10 spaces
        file.println(x,5,10);
        file.println(y,5,10);
    }
}
```

- The file `output.txt` is created with the contents:

```
2.184918284982
2.185
   2.18492
 127.31829
```

Input from a GUI

- We won't generally address **graphical user interface** (GUI) programming in this module but a class called **JOptionPane** is easy to use

```
import javax.swing.JOptionPane;
public class TestDialogue {
   public static void main(String[] args) {
      String response =
          JOptionPane.showInputDialog("Enter name: ");
      System.out.println("Hello "+response);
   }
}
```

Note import

- **JOptionPane** is part of Java so it doesn't need to be in the same directory

Output from the program

```
        String response =
            JOptionPane.showInputDialog("Enter name: ");
        System.out.println("Hello "+response);
    }
}
```

Output from a GUI

- The **JOptionPane** class provides a convenient method for displaying a message too:

```
JOptionPane.showMessageDialog(null,
                "Put your message here");
```

- This also needs
  `import javax.swing.JOptionPane;`
- See the online documentation for many other ways of customising the **JOptionPane** input and output dialogs.

Strings

- We have seen variable declarations of two basic types

```
int radius = 10;
double width = 3.5;
```

- And two classes

```
EasyReader keyboard = new EasyReader();
EasyWriter file = new EasyWriter("output.txt");
```

- We can also declare named `String` variables

```
String greeting = "Hello";
```

String

- `int` and `double` are **basic types**
- `EasyReader` is a **class**
- Class identifiers start with capital letters
- Class objects are created with the keyword **new**
- What is `String`?

```
String greeting = "Hello";
```

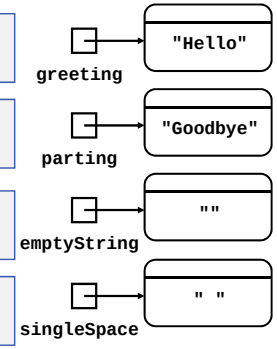
The String class

- A `String` is a sequence of characters of indeterminate length surrounded by a pair of double quotes
- Examples are `"Hello world!"`, `"&*#?"` and `""`
- The `String` data type is not a basic type; it is a **class**
- This `String greeting = "Hello";` is an abbreviation of this

```
String greeting = new String("Hello");
```

Making instances of the String class

```
String greeting = "Hello";
String parting = "Goodbye";
String emptyString = "";
String singleSpace = " ";
```



Line breaks in programs

- Java will allow spaces or line breaks anywhere except within variable names, reserved words and almost all literal values
- Java will allow spaces within String literals but not line breaks

```
System.out.println("and " + wallpaperSize + " square"+
        " metres of wallpaper.");
```

```
System.out.println("and " + wallpaperSize + " square
        metres of wallpaper.");
```

Concatenation

- We **concatenate** (join) strings using the '**+**' operator
- Note that '**+**' is said to be **overloaded**. If the operands are numeric it means addition, if at least one operand is a **character string** it means concatenation

```
System.out.println("There are "+52+" cards");
```

```
There are 52 cards
```

- Character strings can be read in using **EasyReader**

```
String answer = keyboard.readString(
                "Please answer the question ");
```

Escape sequences

- It is possible to put double quotes and other unprintable characters (e.g. tab key) into **String** literals using an **escape sequence** – two characters that result in just one

Escape sequence	Meaning
\t	tab
\n	newline character
\"	double quote character
\\	backslash (the character '\')

Don't use this as an alternative to **println**

Example – concatenation

```
public class StringJoin {

   public static void main(String[] args) {
         String s1 = "Hello";
         String s2 = "Hello Hello";
         String s3 = s1 + s2;
         String s4 = s1 + " " + s2;
         String s5 = "He said \"Hello\".";
         String s6 = "He said \"" + s4 + "\".";
         System.out.println(s6);
   }
}
```

```
He said "Hello Hello Hello".
```

Classes can have methods

- The method **length()** returns the number of characters in a **String**

```
import sheffield.*;
public class StringLength {
   public static void main(String[] args) {
      EasyReader keyboard = new EasyReader();
      String s =
         keyboard.readString("Enter string: ");
      System.out.println(
         "Length is: +s.length());
   }
}
```

```
Enter string: Hello
Length is: 5
```

Substrings

- We can extract part of a **`String`** using the **`substring`** method
- Specify the position of the first character and the position after the last character with character positions are counted from zero

```
s1 = "Sheffield";
s2 = s1.substring(2,7);   // s2 is "effie"
s3 = s1.substring(0,4);   // s3 is "Shef"
```

- Calling **`substring`** with one parameter means the section from the start position specified to the end

Other methods of the String class

- **`trim()`**
  Creates a new String with spaces and tab characters removed from both ends of the **`String`** it is applied to but not ones that occur in the middle
- **`toLowerCase()`** & **`toUpperCase()`**
  Creates a new String with the case modified
- **`indexOf(otherString)`**
  When applied to a String it finds the position of the String supplied as a parameter

Using `String` methods

```
public class StringTest {
   public static void main(String [] args)  {
      String aboutACat = "The cat sat on the mat";
      System.out.println(aboutACat.toUpperCase());
      System.out.println(aboutACat.substring(3,7));
      System.out.println(aboutACat.
            substring(3,7).toUpperCase().trim());
      System.out.println(aboutACat.indexOf("cat"));
   }
}
```

```
U:…myjava>java StringTest
THE CAT SAT ON THE MAT
 cat
CAT
4
```

The `char` data type

- A variable of basic type **`char`** can be used to store a single character from the **Unicode** character set which has replaced ASCII
- The actual Unicode characters that are displayed are determined by a **character encoding**, the most common being UTF-8, which maintains ASCII codes for ASCII characters
- The Unicode standard defines more than 100,000 characters and each character maps onto a Unicode integer

Assignment with the char type

- Single quotes are used to denote a literal character value

```
char capitalE = 'E';
char at = '@';
char space = ' ';
```

- For the single quote value you need an escape character too

```
char prime = '\'';
```

Converting a char to Unicode

```
import sheffield.*;
public class CharToUnicode {
   public static void main(String[] args) {
      EasyReader keyboard = new EasyReader();
      char ch =
         keyboard.readChar("Type a character: ");
      System.out.print("Unicode number is: ");
      System.out.println((int)ch);
   }
}
```

readChar is another **EasyReader** method

```
Type a character: F
Unicode number is: 70
```

Converting Unicode to char

```
import sheffield.*;
public class UnicodeToChar {

   public static void main(String[] args) {

      EasyReader keyboard = new EasyReader();
      int number = keyboard.readInt(
         "Type a decimal Unicode number: ");
      System.out.print("char is: ");
      System.out.println((char)number);

   }
}
```

```
Type a decimal Unicode number: 71
char is: G
```

Strings and chars

- A **`String`** of length 1 is not the same as a **`char`**
- **`String`** literals are delimited with double quotes
- **`char`** literals are delimited with single quotes
- Both `String s = 's';` ✘

  and `char c = "c";` ✘

  will cause compilation errors

The char type and concatenation

- You can use the + operator to concatenate a character with a character string

```
int cardNo = 6;
char suit = 'D';
System.out.println("The suit is "+suit);
```

```
The suit is D
```

- But not to concatenate a character with a number

```
int cardNo = 6;
char suit = 'D';
System.out.println(cardNo+suit);
```

```
74
```

Summary of key points

- `EasyReader` and `EasyWriter` provide input and output
- An **object** is and **instance** of a class and created using `new` (except `String` objects)
- Basic type variables and object variables are very different
- Objects have lots of useful methods
- The `char` basic type stores a Unicode character which is also a number but isn't a `String` of length 1
- `char`s are delimited with single quotes and `String`s with double quotes