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COMP1007 Methods

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Review so far

- We have:
  - sequence, iteration, selection.
  - variables, assignment, operators.
  - expressions, statements and compound statements.
  - and other useful bits.
- We want to build classes.
- But we need more building blocks...

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Longer programs

- So far we have written rather small programs.
- We want to write bigger and more interesting programs!!
- Really long programs.
- But using only loops and selection doesn't scale up.

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But...

- We start to get management problems.
- Working with a huge long list of simple statements is tedious.
- Worse, it is hard to see what the program does without plodding through the detail.
- There's just no real structure...

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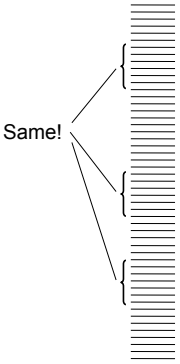
Repetition...

- The same sub-sequence of statements often occurs in several places…
- And loops don't help.
- Bad news - we don't want to have duplicate lines of code.



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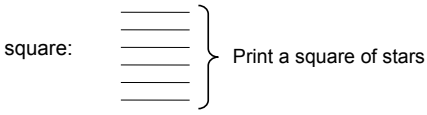
Suppose...

- We take a sub-sequence of statements and give it a name.



- And package the name and statements together.

Abstraction in action!

- We can now refer to 'square' to denote the statement sequence.
- Write the sequence once and refer to it from many places in the program.
- Wow - we've exploited abstraction!

Method

- The name + statement sequence gives us a method (a routine to do something).
- We can use the name to call the method on an object:

```
obj.square();
```

Note the parentheses. We use them to denote a call being made.

Calling you...

```
obj.square();
obj.square();
obj.square();
```

- The method can be repeatedly called as many times as we want.
- But only needs to be written and debugged once.

Procedures, functions?

- Some programming languages have procedures or functions don't they?
- Yes, but Java is Object-Oriented.
- Objects have methods.
- A method is called for an object.
  - Remember robot.forward() etc.

Methods and Classes

```
class MyClass
{
  public void methodOne()
  {
    // Statements
  }
  public void methodTwo()
  {
    // Statements
  }
   etc…
}
```

A class can declare a number of methods. Each method can be called on an instance object of the class.

```
MyClass obj = new MyClass() ;
obj.methodOne() ;
obj.methodTwo() ;
```


So let's write a square method...

```
class MyClass
{
  public void square()
  {
    for (int i = 0 ; i < 4 ; i++)
    {
      System.out.println("****");
    }
  }
  // More methods can be added here.
}
```

Note that the method is declared in a (very simple) class.

Hey, I've been writing methods all the time!

public void

- *public* — the method can be called from anywhere within a program. Providing it is called on an object that is accessible.
- *void* — is a type, the empty type that has no values. It means our method returns no value.

Calling square()

```
Class MyClass
{
  // …
  public static void main(String[] args)
  {
    MyClass myObject = new MyClass();
    myObject.square();
    myObject.square();
    myObject.square();
  }
}
```

Create an object using new, then call the square method.

Remember, a class defines how an *instance* object is implemented.

main?

- The method named main has a special role.
  - It is *public*.
  - Is *void* (returns no value).
  - It is the first method called to start the program running.
    - Create an object, call methods.
  - And *static*…

Static?

- A static method does not need to be called on an object.
- Main has to be static as there are no objects available before it is called…
- Main creates the initial object(s) needed by the program and calls their methods.
  - The object(s) then do the work.

Other static methods?

- Your exercise classes only ever need to declare one static method – main!
- Don't write any other static methods.
  - Static methods do have valid uses as providers of utility functions and services.
  - But you need to know when to use them.
  - If in doubt don't.

What is a program?

- Our view of what a program is starting to develop:
  - Not simply a sequence of statements.
  - But a collection of objects described by classes, where the objects call each other's methods.

Writing a program

- Identify objects needed.
  - Responsibilities and collaborations.
- Identify classes from objects.
- Write classes.
  - Methods, variables, etc.
- Run program by creating object(s) in a main method, and then calling object methods.
  - Objects then call each other's methods.

Multiple Main Methods

- Each class can have a main method.
  - But only one per class.
- Typically one is used to run the program.
  - The rest can be used for things like testing objects of each class.
  - Or showing examples of how to use the class.

Questions?

Methods calling methods

```
class MyClass
{
  public void square()
  {
    // As already seen
  }
  public threeSquares()
  {
    square();
    square();
    square();
  }
  etc…
```

square() ; – where's the object?

Same class

- When a method calls another method in the same class:
  - It is called for the *same* object.
- So: square()
  - called for the *same* object threeSquares was called for.

Main…

```
public static void main(String[] args)
{
   MyClass myObject = new MyClass();
   myObject.threeSquares();
}
```

Here is the object.

square() will be called on the same object.

this

Could write:

```
public threeSquares()
{
  this.square();
  this.square();
  this.square();
}
```

this is a variable referring to the object the method was called on.

this is *automatically* declared in every method.

This or not to this…

- Sometimes you have to use this.
- Most of the time it is a matter of style.

Very nice but...

- square can only display a 4x4 square.
- (And I cheat by displaying a whole line of stars at one go!)
- How can we modify square to print any size square?

Parameters

- We want to *parameterise* square.
- That is, be able to write:

```
this.square(3); // 3x3 square
this.square(10);  // 10x10 square
```

- We can say that square takes a parameter or argument.

Square.2

```
public void square(int size)
{
   for (int rows = 0 ; rows < size ; rows++)
   {
      for (int cols = 0 ; cols < size ; cols++)
      {
         System.out.print("*");
      }
      System.out.print("\n");
   }
}
```


Parameter variable

size is a *parameter variable*

```
public void square(int size)
```

- When square is called – this.square(5) – the argument is used to initialise the parameter variable.
- Inside the method body, the value of size can be used (or changed by assignment).
- size is created and initialised by *every* call to square.

Parameterisation

- We now have a way of varying the behaviour of a method depending on which argument value it is called with.
- Square is now more general purpose.
- A better abstraction.

Where can size be used?

```
public void square(int size)
{
  // size useable here only
}
```

- The parameter variable can only be used inside the method.
- In fact, it only exists while the method is executing.

Scope revisited

- We say that the scope of size is given by the method body (which is a compound statement).
- A name can only be used inside the scope it is declared in.
- Nothing outside the scope can see the name or use it.

Lifetime revisited

```
public void square(int size)
{ … }
```

- When the scope is entered, size is created and initialised.
- When the scope is exited, size is thrown away.
- The scope determines the lifetime of size.

New size every time

```
public void square(int size)
{ … }
```

- Whenever the method is called, a new scope is created.
- And a new size variable.
- Once the scope is exited the current size variable is gone for good.

Compound statement (reminder)

- When you see a compound statement:

```
{
  // Statements …
}
```

- you are seeing a scope.
- This includes loop bodies, if statement bodies and class declarations.

Local scope (reminder)

```
while (n < 10)
{
  int x = n + 1 ;
  String s = "Hello";
  …
}
```

A local scope

A Local Variable

Local variables - temporary storage

- Declared within a compound statement, including a method body.
- Local to that scope.
- Lifetime limited to that scope.
- Created when scope is entered.
- Thrown away when scope is exited.
- Every time!

Scope must be obeyed

```
// result not declared before loop
while (x < y)
{
   int result = 0;
   … // Do something
}
result++; // ERROR, result not in scope
```


Nesting Scopes

- You can nest compound statements, so scopes are nested as well.

```
{
  // Outer or nesting scope
  {
    // Inner or nested scope
  }
}
```


Nested Scopes (2)

```
{
    String day = "Monday";
    …
    {
       day = "Tuesday"; // day is accessible in
    }                   // nested scopes
    …
}
```


But...

```
{
    String day = "Monday";
    …
    {
       String day = "Tuesday"; // ERROR day is
       …                       // already in scope
    }
    …
}
```

For loop scope rule

```
for (int i = 0 ; i < 10 ; i++) // i is a for loop variable
{
   System.out.print(i + " ");
}
i = 6; // Error, not in scope
for (int i = 0 ; i < 10 ; i++)   // i can be re-declared here.
{                                // The two i's are different
   System.out.print(i + " "); // and the scopes disjoint.
}
```


Names can be reused

- Providing the same name is declared in disjoint scopes, the name can be reused.
- If you are unsure about how the rules apply, write some test programs to try them out.

Questions?

More parameters

- A method can have any number of parameters.
- But good practice means no more than 5 or 6 maximum.

Another method

```
public void rectangle(int nRows, int nCols, char c)
{
   for (int rows = 0 ; rows < nRows ; rows++)
   {
      for (int cols = 0 ; cols < nCols ; cols++)
      {
         System.out.print(c);
      }
      System.out.print("\n");
   }
}
```

```
rectangle(3,7,'#') ;
rectangle(10,4,'+') ;
```


Parameter Types

```
rectangle(int nRows, int nCols, char c)
```

- Parameter variables are declared with types.
- The values supplied in the method call must have matching types:

```
rectangle(5,7,'c'); // OK
rectangle(2.3,5,"hello"); // Error!!
```

Typical error message

- compiling: Rectangle.java

```
Rectangle.java:7: Incompatible type for method.
Explicit cast needed to convert double to int.

   rectangle(4.5,6,'#');
             ^
1 error
```


Remember main?

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

- main is called to run your program.
- It takes a String array as an argument.
- What is the contents of the array when the method is called?

Command line arguments

- When you run a program you can type additional arguments on the command line:

```
java MyProg hello world
```

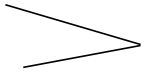
Arguments to the program.

Displaying the arguments

```
public static void main(String[] args)
{
  for (String arg : args)
  {
    System.out.println(arg);
  }
}
```


You see:

```
Prompt> java Args a few words
a
few
words
Prompt>
```



Arguments displayed here.

Functions

- Suppose we want a method that looks like a function.
  - Like Math.cos(x), for example.
- Need to be able to do a calculation and return a value from a method.

return

- The return statement allows a method to return a value:

```
public int f(int x)
{
  x *= 2;
  return x;
}
```

Declare the type of the value returned

Return the value of x.

Effect of return

- Can now write: int y = myObject.f(10);
- Return causes the method to terminate, and return a value.
- (Effectively a jump to the end of the method body.)
- The type of the returned value must be declared.

Must return a value

- If a method is declared as returning a type, then it must contain a return statement.
- Otherwise the compiler will complain!

```
T2.java:8: Return required at end of int f(int).
  int f(int x)
    ^
1 error
```


Can have multiple returns

```
public int f(int x)
{
  if (x < 10)
  {
    return x * 2;
  }
  else
  {
    return x * 3;
  }
}
```

Notice that regardless of what the value of x is, one return statement will always be executed.

This must always be the case.

Also

```
public int f(int x)
{
  return x * 2;
  System.out.println(x);
}
```

The print statement can never be executed!

The compiler will treat this as an error. It uses flow analysis to determine what can be executed.

Only one value

- A method can only return one value.
- Methods declared void don't return values.
  - public void f(int x) { … } // No return
- Void is the empty type and has no values that could be returned.
  - But can use return on its own to return from (terminate) a void method.

Methods as functions

- Methods can be written to look like mathematical functions:
  - sqrt, pow, sin, cos, log, etc.
- However, beware, not all function methods behave like mathematical functions...

Mathematical functions

- Always return the same value when applied to the same argument(s).
  - Referential transparency.
- But methods can be written to return different values when called with the same argument(s).
- Methods can also have side-effects (e.g., doing input or output).

Summary

- We now have methods.
- To make methods more useful we need parameters.
- Local variables, scope and lifetime, combine with compound statements and method bodies.
- Methods can return values.