1007
Imperative Programming
Part II

Agenda

- We've seen the basic ideas of sequence, iteration and selection.
- Now let's look at what else we need to start writing useful programs.

Details now start to be really important.

Reading

Finish reading Part I, chapters 1 and 2.

Start looking at Part IV, the Java Language Reference.

Note, there is a lot of detail in these chapters. Don't expect to read them once and be done.

Displaying Messages

System.out.println(“Hello world”);

- Been using this to display text on the computer screen. How does it work?

Objects, of course!

- System.out.println(“Hello world”);
- out is another kind of object – a PrintStream object.
- A stream is a sequence of characters, with a source and a destination.
- *System.out* is an object connected to the computer display.

println and print

System.out.println(“Hello world”) ;

- Display message, followed by a newline.
  - next message appears on a next line.

System.out.print(“Hello world”) ;

- Just display message.
  - next message appears on the same line as the last.

\n

\n is the character representation of newline.
System.out.print(“Hello World\n”) ;
has the same result as:
System.out.println(“Hello World”) ;

System.out.println(“Hello World\n”) ;
will result in two newlines.

Displaying messages using a loop

```
// This is real Java syntax
while (true)
{
   System.out.println(“Hello”);
}
```

```
Hello for ever…
```

Counting

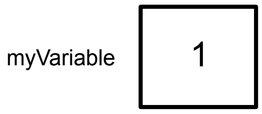
- How do we display our message just 10 times?
- We obviously need to count 1 to 10, then stop.
- We need a counter! How?

A counter

- We need a container to hold a counter, which can be incremented (add 1).
- The container is a *Variable*.
- A variable can hold an integer value we can count with.

Let’s think variable

- A variable is a container:



- It can hold a value,
- and needs a name or identifier.

What is a value?

- Values are things like an integer or floating point number, or a character, or text…
- Values themselves are abstract, intangible.
- So we use representations of values in order to work with them.

Representations

- 1, I, One, one, one, ONE
  - all representations of one.
- In the computer, integers are represented by binary numbers (e.g., 32-bit 2s complement binary numbers).
  - 11001010010111010000110001111001

Other representations

- Floating point numbers are represented using IEEE 754 format.
- Characters are represented by Unicode binary character codes.
- Text by a sequence of characters.
- Boolean by binary zero or one.

Why talk about representations?

- Representations have finite ranges.
  - 32-bit integer ranges from -2147483648 to 2147483647
- A variable holding an integer representation cannot have a value outside the range.

Note the use of this phrase.

- Floating point representations are approximations.
  - Need to check results very carefully.

Questions?

Type

- A variable container is very specific about the kind of values it can hold.
- A *type* defines what kind of value.
- To use a variable you have to state what type of value it can hold.
- We typically say “a variable has a type”.

Common types

- boolean – true or false
- int – 32-bit 2’s complement integer
- long – 64-bit 2’s complement integer
- char – 16-bit unsigned Unicode character code
- float – 32-bit floating point
- double – 64-bit floating point

(Check book for more detail)

Just checking - What has type?

- A value has a type that defines what kind of value it is.
- A variable has a type that determines what kind of values it can hold.
- To store a value (or really its representation) in a variable, the types must match.

Shape?

- It may help to think of a type denoting a shape.
- Only values of the right shape can fit in a variable of a given shape.

Type int

- int is the name of the integer type (32-bit 2's complement).
- A variable named size of type int can be *declared* like this:

```
int size;
```

- You *must* declare a variable before you can use it.

Declaration?

- Anything you name (such as a variable) must be introduced first, in order to know what is being named.
- The introduction, or *declaration*, gives the name and type of the thing being named.
- Once declared a name can be used but not before.

Missing declaration...

- If you use a name that has not been declared the Java compiler will complain!

```
compiling: T1.java
T1.java:5: Undefined variable: counter
   counter = 10 ;
   ^
1 error
```

Primitive types

- The types listed earlier (and a few others) are *primitive* types.
- Why? They are directly represented by typical processors (and, hence, the JVM).
- They are the most efficient.

Non-primitive types?

- Yes, they not only exist but will be very important.
- Every kind of value we use must have a type: Address, BankAccount, Date, Book,…
- Non-primitive types are abstractions, constructed from primitive types.
- They are classes.

String

- String is the type of a sequence of character or text:
  - “This is a String”
- It is a non-primitive type that is widely used.
- A String is actually an *object*.
- There is a class String.

Questions?

Integer variables

- What can you do with them?
- First declare your variable:
  - int myInteger;
- What is the value of this variable?
- It hasn’t got one – you *must* give it one before you can use it.

Initialising

```
int myInteger = 10;
```

- Declare myInteger and give it an initial value.
- Always, ALWAYS, initialise a variable.
- Actually you have no choice! The Java compiler will make sure you do.

10?

- 10 is a *literal* value of type int.
- All primitive types have literal values that can be used directly in a program.
- 3.141 is a floating point literal of type double.
- true and false are the boolean literals.

More initialising

- double d = 1.23456789;
- boolean b = false;
- char c = ‘a’;
- float f = 1.234F;
- int x = 0xff;
- String s = “Hello”;

(Many more examples in book.)

Changing a variable’s value

- A variable is changed by an *assignment expression*.

  age = 20;
- The value 20 (or really its representation) is stored into the variable container.
- The old value is overwritten and lost.

= or =

- Note that we have now used = for two things.

  int length = 5;

  length = 20;
- Intialisation v. assignment.
- Subtle but different.

State

- The state of a program is given by:
  - the Java Virtual Machine
  - the value of the variables
- The basic idea of computation is to transform the initial state to the final state.
- Each program instruction clicks the state forward one step.

Wrong state?

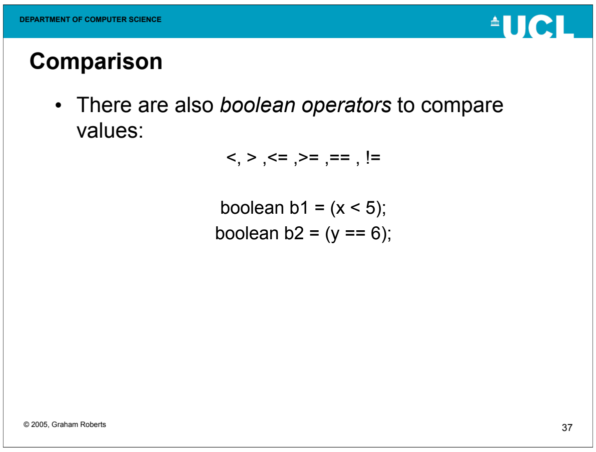
- A computation can fail if any invalid state is reached (e.g., a variable has the wrong value).
- A typical computation may proceed through billions of states...

Operators and expressions

- An operator applies an operation to values!
- +,-,/,*

  x = 2 + 3;

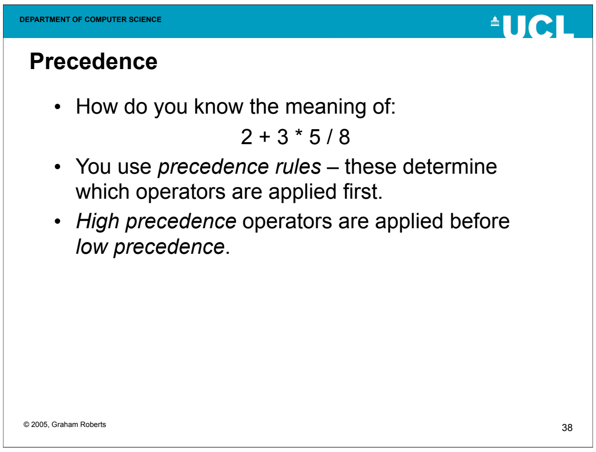
  y = 3.2 * 2.4;
- We can combine variables, operators and literals to write *expressions*.



Comparison

- There are also *boolean operators* to compare values:

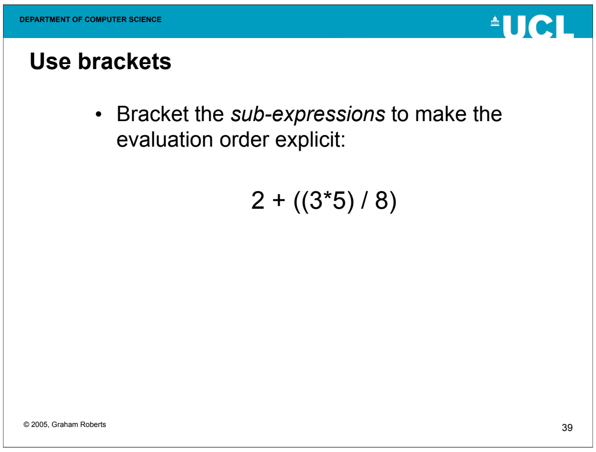
```
<, > ,<= ,>= ,== , !=

boolean b1 = (x < 5);
boolean b2 = (y == 6);
```



Precedence

- How do you know the meaning of:

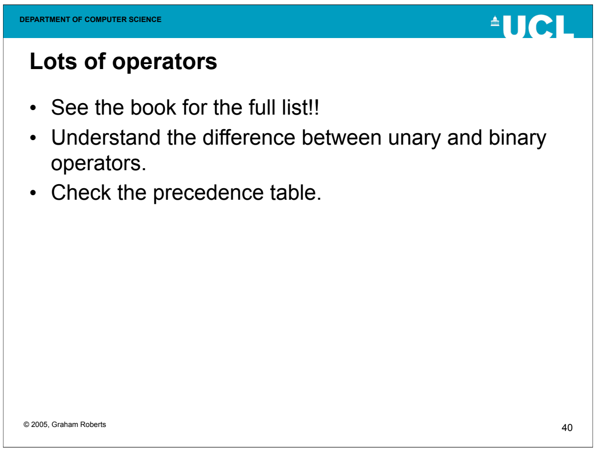
  2 + 3 * 5 / 8
- You use *precedence rules* – these determine which operators are applied first.
- *High precedence* operators are applied before *low precedence*.



Use brackets

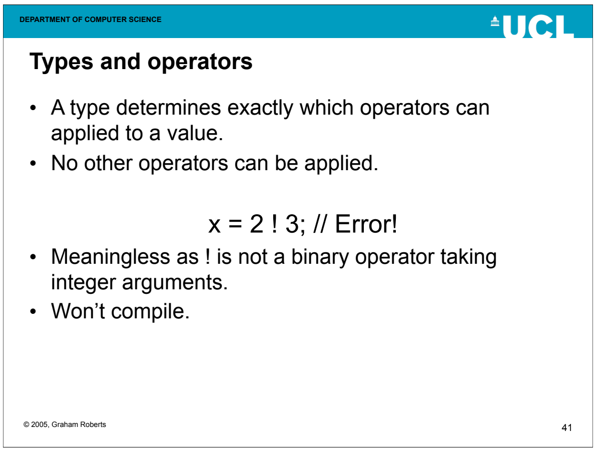
- Bracket the *sub-expressions* to make the evaluation order explicit:

  2 + ((3*5) / 8)



Lots of operators

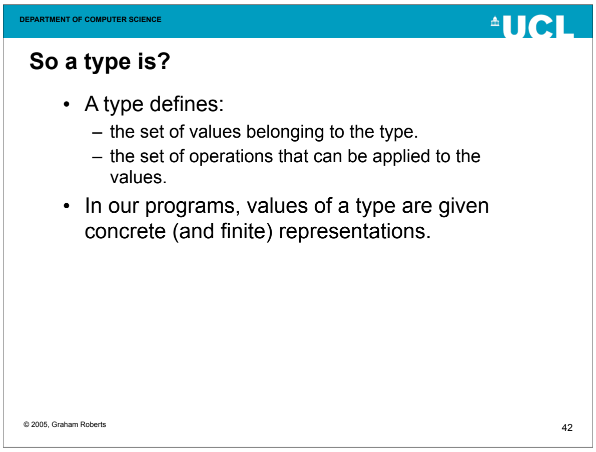
- See the book for the full list!!
- Understand the difference between unary and binary operators.
- Check the precedence table.



Types and operators

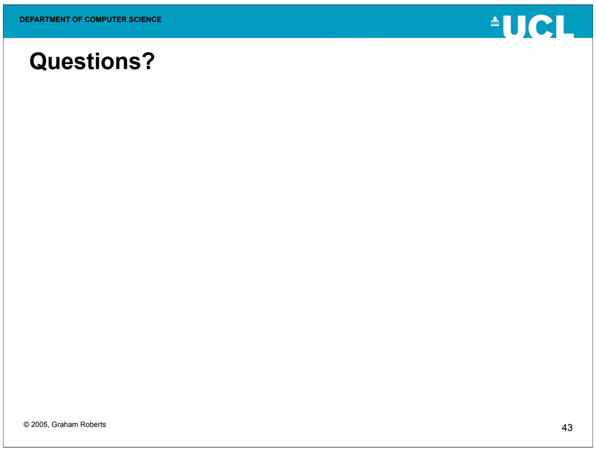
- A type determines exactly which operators can applied to a value.
- No other operators can be applied.

  x = 2 ! 3; // Error!
- Meaningless as ! is not a binary operator taking integer arguments.
- Won't compile.

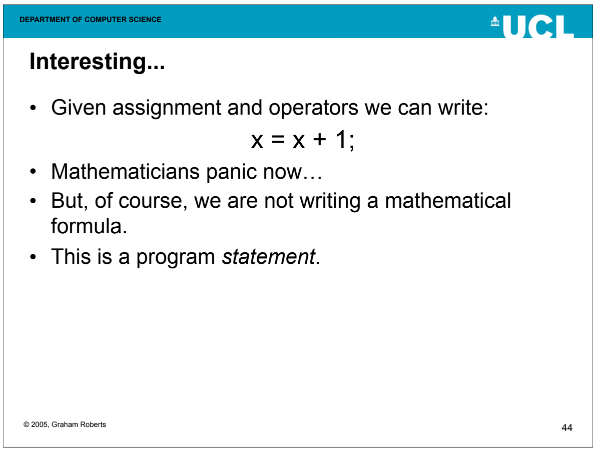


So a type is?

- A type defines:
  - the set of values belonging to the type.
  - the set of operations that can be applied to the values.
- In our programs, values of a type are given concrete (and finite) representations.



Questions?

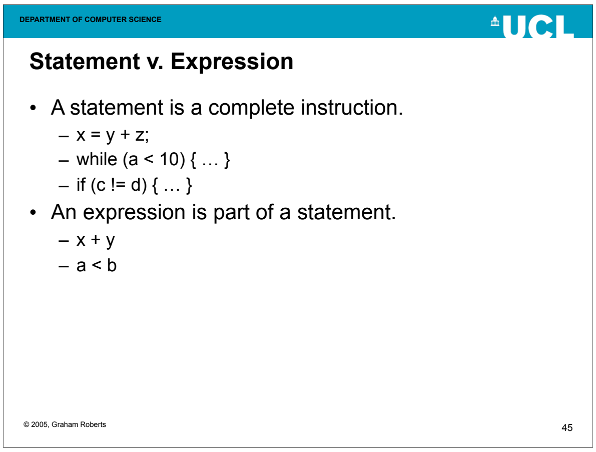


Interesting...

- Given assignment and operators we can write:

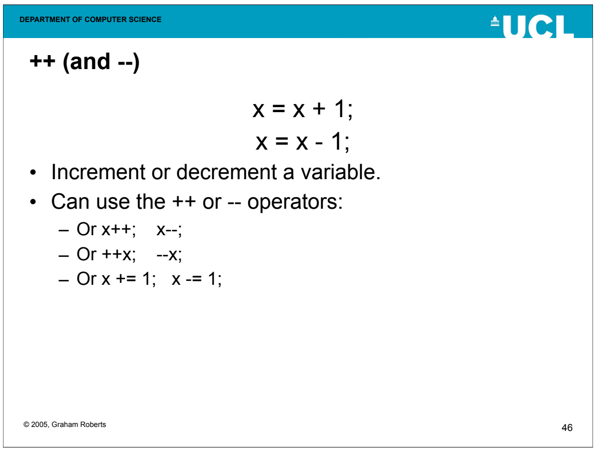
  x = x + 1;

- Mathematicians panic now…
- But, of course, we are not writing a mathematical formula.
- This is a program *statement*.



Statement v. Expression

- A statement is a complete instruction.
  - x = y + z;
  - while (a < 10) { … }
  - if (c != d) { … }
- An expression is part of a statement.
  - x + y
  - a < b

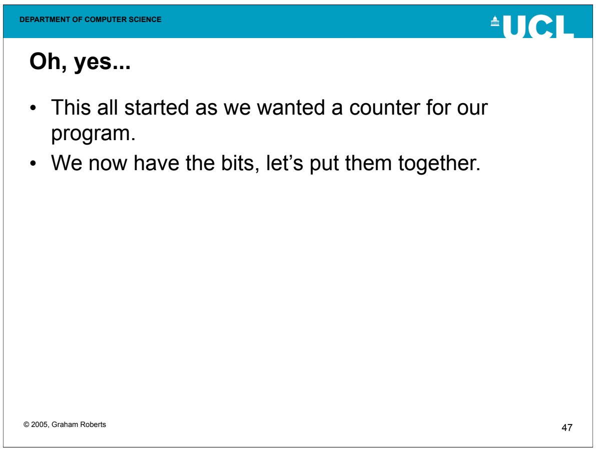


++ (and --)

x = x + 1;

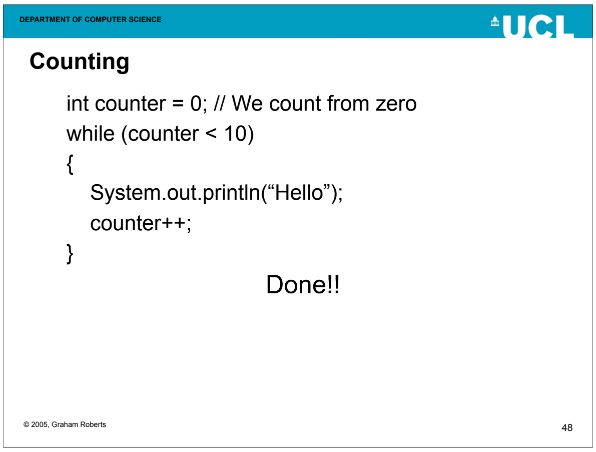
x = x - 1;

- Increment or decrement a variable.
- Can use the ++ or -- operators:
  - Or x++;   x--;
  - Or ++x;   --x;
  - Or x += 1;   x -= 1;



Oh, yes...

- This all started as we wanted a counter for our program.
- We now have the bits, let’s put them together.



Counting

```
int counter = 0; // We count from zero
while (counter < 10)
{
   System.out.println(“Hello”);
   counter++;
}
```

Done!!

A bit more...

```
int counter = 0; // We count from zero
while (counter < 10)
{
   System.out.print(“Hello ”);
   System.out.println(counter);
   counter++;
}
```

Result...

```
Hello 1
Hello 2
Hello 3
Hello 4
Hello 5
Hello 6
Hello 7
Hello 8
Hello 9
Hello 10
```

Correct???

A bit more compact...

```
int counter = 0; // We count from zero
while (counter ++  <  10)
{
   System.out.println(“Hello ” + counter);
}
```

Note the way this code is laid out. Use indentation and blank space to the best effect.

Are there other kinds of loop?

- Yes!
- We have:
  - while loops
  - do loops
  - for loops

While loops

- Seen them already:

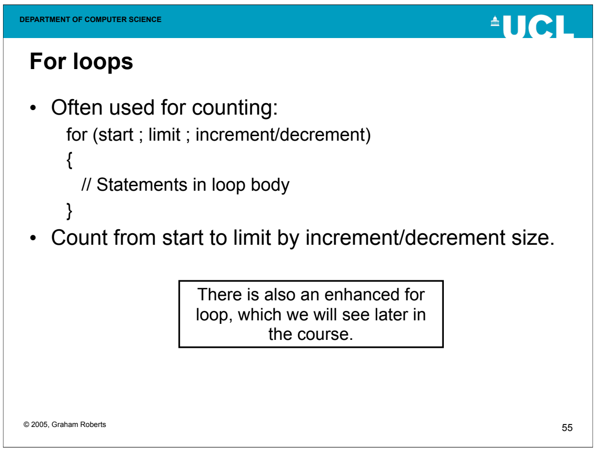
```
while (boolean-expression)
{
   // Statements in loop body
}
```

- The loop body will be executed *zero* or more times.

Do loops

```
do
{
   // Statements in loop body
}
while (boolean-expression);
```

- The loop body will be executed *one* or more times.



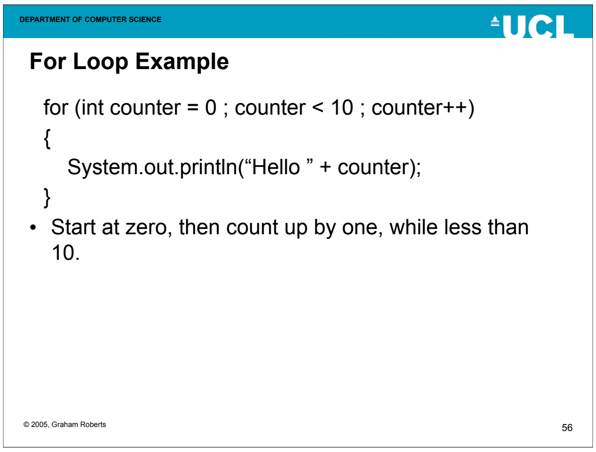
For loops

- Often used for counting:

```
for (start ; limit ; increment/decrement)
{
   // Statements in loop body
}
```

- Count from start to limit by increment/decrement size.

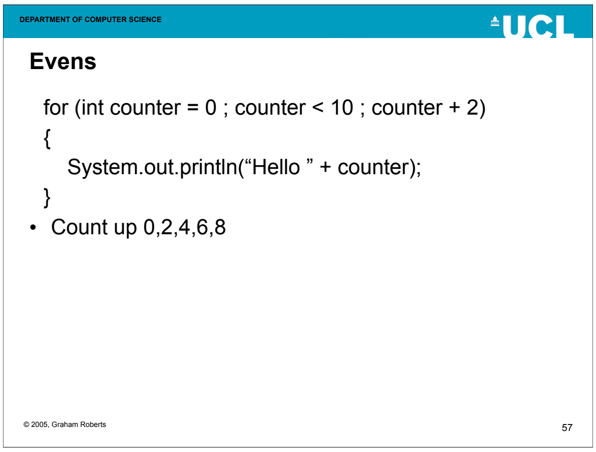
There is also an enhanced for loop, which we will see later in the course.



For Loop Example

```
for (int counter = 0 ; counter < 10 ; counter++)
{
   System.out.println(“Hello ” + counter);
}
```

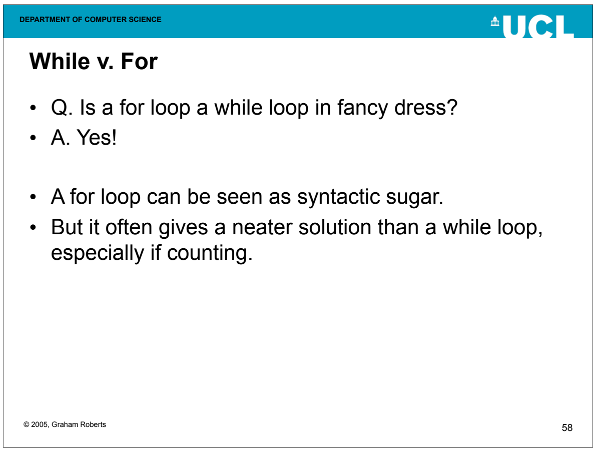
- Start at zero, then count up by one, while less than 10.



Evens

```
for (int counter = 0 ; counter < 10 ; counter + 2)
{
   System.out.println(“Hello ” + counter);
}
```

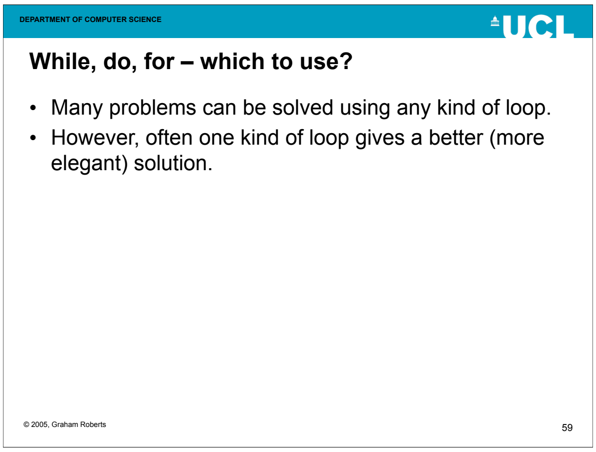
- Count up 0,2,4,6,8



While v. For

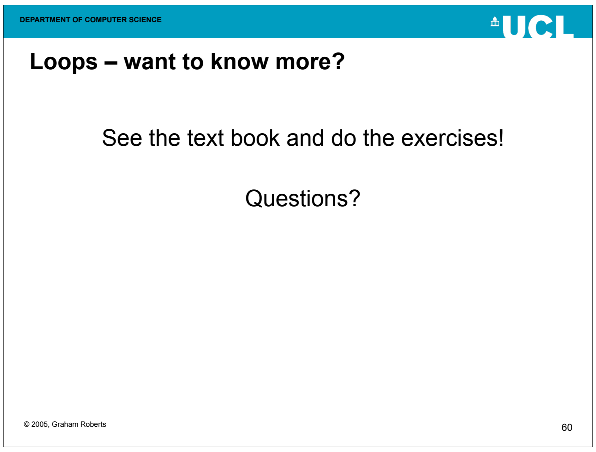
- Q. Is a for loop a while loop in fancy dress?
- A. Yes!

- A for loop can be seen as syntactic sugar.
- But it often gives a neater solution than a while loop, especially if counting.



While, do, for – which to use?

- Many problems can be solved using any kind of loop.
- However, often one kind of loop gives a better (more elegant) solution.



Loops – want to know more?

See the text book and do the exercises!

Questions?

Remember selection?

- The if statement

```
if (boolean-expression)    // Must have the brackets
{
        // Statement sequence
}
else
{
  // Statement sequence
}
```

Short-cut?

- You can write:

```
if (boolean-expression)
   statement;           // No braces
next-statement;
```

- In fact, you can do the same with loops.

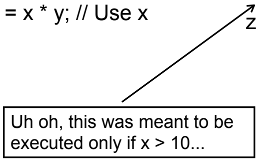
But...

Originally write:

```
if (x > 10)
   x = 10;  // Limit x
z = x * y; // Use x
```

But then change:

```
if (x > 10)
   x = 10;  // Limit x
   y = 1;    // and update y
z = x * y;  // Use x
```



Uh oh, this was meant to be executed only if x > 10...

Moral

Always put the braces in, even when the if statement (or loop) body contains only a single statement.

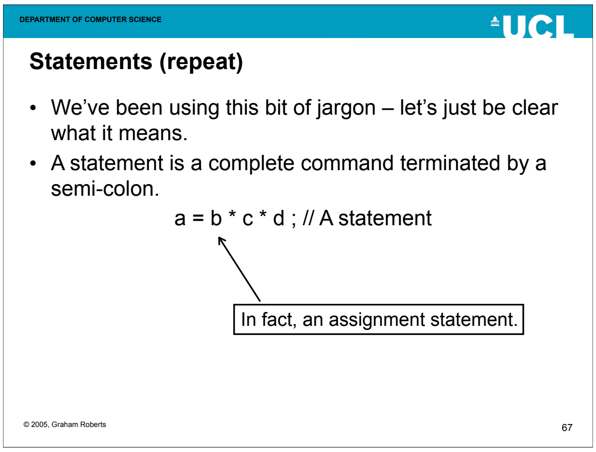
Defensive programming

- Anticipate the kinds of programming errors you might make.
- Write the code in a style that prevents mistakes happening or, at least, makes them stand out.
- Code layout, indentation, use of blank space, use of braces all help.

More selection?

- Yes.
- Check out the *switch* statement.
- Look at the *conditional operator* (a ternary operator).

- All in the book!

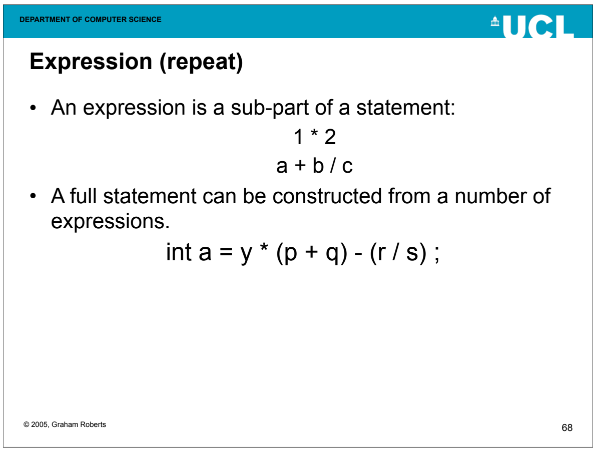


Statements (repeat)

- We've been using this bit of jargon – let's just be clear what it means.
- A statement is a complete command terminated by a semi-colon.

a = b * c * d ; // A statement

In fact, an assignment statement.



Expression (repeat)

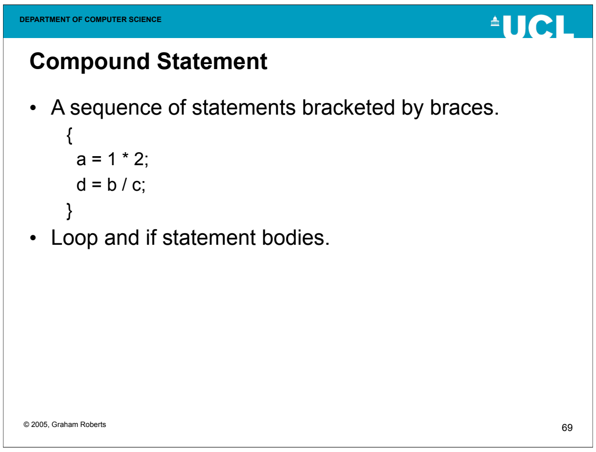
- An expression is a sub-part of a statement:

1 * 2

a + b / c

- A full statement can be constructed from a number of expressions.

int a = y * (p + q) - (r / s) ;

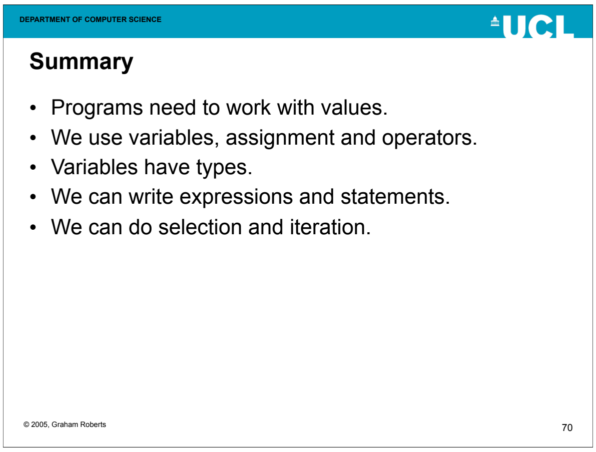


Compound Statement

- A sequence of statements bracketed by braces.

```
{
  a = 1 * 2;
  d = b / c;
}
```

- Loop and if statement bodies.



Summary

- Programs need to work with values.
- We use variables, assignment and operators.
- Variables have types.
- We can write expressions and statements.
- We can do selection and iteration.