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Loops and Arrays

(slides adapted from D. Millard)

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Recap

- ▶ Object-oriented programming
 - ▶ Classes / objects
- ▶ Variables
 - ▶ capturing object properties
- ▶ Methods
 - ▶ representing object behaviours
- ▶ Computational thinking
- ▶ Encapsulation
 - ▶ **private** vs **public**
 - ▶ Constructor

Objectives

- ▶ Looping
 - ▶ **while**
 - ▶ **do . . . while**
 - ▶ **for**
- ▶ Arrays
 - ▶ indexes
- ▶ “for each” loop

Readings

- ▶ Chapter 4.9 of **Barnes and Kölling [2016]**

Looping

- ▶ Sometimes we want a computer to do something
over and ...
over and ...
over and ...
over and ..
over again ...
- ▶ We can achieve this with a **loop**
- ▶ A programming structure that performs a series of instructions **repeatedly** until some specified condition is met

There are different kinds of loops...

- ▶ **while**
- ▶ **do . . . while**
- ▶ **for**
- ▶ “**for** each” (enhanced **for**)
- ▶ Recursion (not really a loop but has repetitive behaviour)

While: The Monarch of Loops

- ▶ The **fundamental loop**
- ▶ All of the other loops can be built from this

While

Just like an if statement

```
while ( condition ) {  
    code to run;  
}
```

```
if (condition) {  
    code to run;  
}
```

Zero or more

- ▶ The condition is checked at the **start** of the loop
- ▶ so the code inside **may not run at all**

While

Example 1 (1/2)

Example 1

```
int i = 0;
while (i<10){
    System.out.println("The number is " + i);
    i= i+1;
}
System.out.println("i is now " + i);
```

Vevox (106-493-186)?

What numbers will be printed by the loop and the final statement?

While

Example 1 (2/2)

Example 1

```
int i = 0;
while (i < 10) {
    System.out.println("The number is " + i);
    i = i + 1;
}
System.out.println("i is now " + i);
```

Answer

- ▶ *i* starts as 0 and the loop stops when *i* becomes equal to 10.
- ▶ So the loop will print the numbers 0, 1, ..., 9
- ▶ and the final statement will print number 10

While

Example 2 (1/2)

Example 2

```
int i = 10;
while (i<10) {
    System.out.println("The number is " + i);
    i= i+1;
}
System.out.println("i is now " + i);
```

Vevox (106-493-186)?

What numbers will be printed by the loop and the final statement?

While

Example 2 (2/2)

Example 2

```
int i = 10;
while (i < 10) {
    System.out.println("The number is " + i);
    i = i + 1;
}
System.out.println("i is now " + i);
```

Answer

- ▶ *i* starts as 10 and the loop stops when *i* becomes equal to 10.
- ▶ So the body of the loop will not start at all
- ▶ and the final statement will print number 10

While

Example 3 (1/2)

Example 3

```
int i = 0;
while (i < 10) {
    System.out.println("The number is " + i);
    i = i * 1;
}
System.out.println("i is now " + i);
```

Vevox (106-493-186)?

What numbers will be printed by the loop and the final statement?

While

Example 3 (2/2)

Example 3

```
int i = 0;
while (i < 10) {
    System.out.println("The number is " + i);
    i = i * 1;
}
System.out.println("i is now " + i);
```

Answer

- ▶ This is called an **infinite loop**. They cause programs to hang and/or crash.
- ▶ So the **final statement will not start** at all
- ▶ **Always check that you loops will end!**

Blackboard Tests for While Loops

Looping

While: The Monarch of Loops

Do ... While

For Loop

Arrays

For Each Loop

Summary

Do While

```
do {  
    code to run;  
} while (condition);
```

```
while (condition) {  
    code to run;  
};
```

Once or more

- ▶ The condition is checked at the **end** of the loop
- ▶ so the code inside **run at least once**

Do While

Example 4 (1/2)

Example 4

```
int i = 0;
do {
    System.out.println("The number is " + i);
    i= i+1;
} while (i<10);
System.out.println("i is now " + i);
```

Vevox (106-493-186)?

What numbers will be printed by the loop and the final statement?

Do While

Example 4 (2/2)

Example 4

```
int i = 0;
do {
    System.out.println("The number is " + i);
    i= i+1;
} while (i<10);
System.out.println("i is now " + i);
```

Answer

- ▶ *i* starts as 0 and the loop stops when *i* becomes equal to 10.
- ▶ So the loop will print the numbers 0, 1, ..., 9
- ▶ and the final statement will print number 10

Do While

Example 5 (1/2)

Example 5

```
int i = 10;
do {
    System.out.println("The number is " + i);
    i= i+1;
} while (i<10);
System.out.println("i is now " + i);
```

Vevox (106-493-186)?

What numbers will be printed by the loop and the final statement?

Do While

Example 5 (2/2)

Example 5

```
int i = 10;
do {
    System.out.println("The number is " + i);
    i= i+1;
} while (i<10);
System.out.println("i is now " + i);
```

Answer

- ▶ *i* starts as 10 and the loop stops when *i* becomes **no less than 10**.
- ▶ So the loop will print the numbers 10
- ▶ and the final statement will print number 11

Do While

Relationship with **while** loop

How can a **do** . . . **while** loop, i.e.,

```
do {  
    code to run;  
} while (condition);
```

be represented using a **while** loop?

Blackboard Tests for Do...While Loops

Looping

While: The Monarch of Loops

Do ... While

For Loop

Arrays

For Each Loop

Summary

For Loop: Deterministic Loop

```
for (initialisation; condition; statechange)
{
    code to run;
}
```

Counting

The for loop is a simple way of repeating a block of code when you know in advance **how many iterations** (times around the loop) that you want.

For Loop

Example 6

Example 6

Initialisation



Condition



StateChange



```
for (int i = 0; i < 10; i = i + 1)
{
    System.out.println("The number is " + i);
}
```

For Loop

Example 7 (1/2)

Example 7

```
for (int i = 0;    i < 10;    i = i + 1)
{
    System.out.println("The number is " + i);
}
System.out.println("i is now " + i);
```

Vevox (106-493-186)?

What numbers will be printed by the loop and the final statement?

For Loop

Example 7 (2/2)

Example 7

```
for (int i = 0;    i < 10;    i = i + 1)
{
    System.out.println("The number is " + i);
}
System.out.println("i is now " + i);
```

Answer

- ▶ Notice the scope of `i`.
- ▶ `i` can only be used within the body of the loop
- ▶ The code cannot be compiled

For Loop

Relationship with **while** loop

How can a **for** loop, i.e.,

```
for (initialisation; condition; statechange)
{
    code to run;
}
```

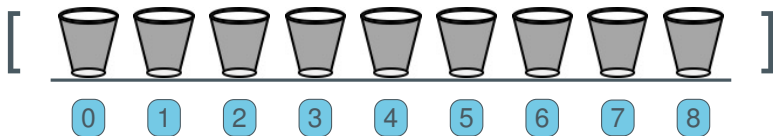
be represented using a **while** loop?

- ▶ **for** loop is often neater than **while** loop with the same functionality.

Arrays

- ▶ Sometimes we want to **group** things together
 - ▶ “things” being **objects** and **primitives**
- ▶ The most fundamental collection is an **Array**
- ▶ If a variable is a cup ...

an array is a shelf of cups



Arrays

More details (1/2)

- ▶ Arrays are **objects**
- ▶ But they have their own **special syntax**
- ▶ To **declare** an Array:

```
int [] numberStore;
```

or

```
int numberStore[];
```

Both of these are valid.
They do the same thing!

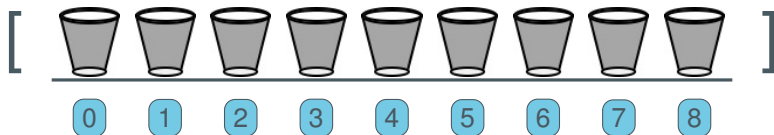
Arrays

▶ To **instantiate** an Array:
More details (2/2)

```
numberStore = new int [10];
```

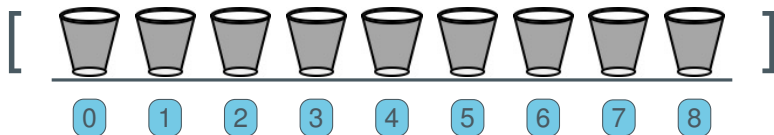
This is the **length** you want the array to be (the number of cups)

N.B that we are creating an object here (using the **new** keyword), but we don't call a constructor. Arrays have their own special syntax.



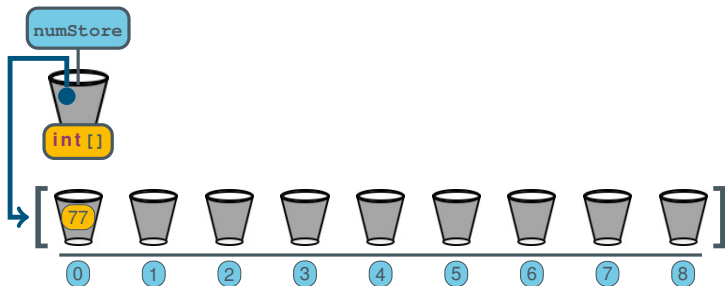
- ▶ An index is the position in the array.
- ▶ Java arrays start at 0

Length



- ▶ The length is the **number of indexes**
- ▶ Here the length is 9

Using indexes (insertion)



<code>int [] numStore;</code>	←	Declaration
<code>numStore = new int [9];</code>	←	Instantiation
<code>numStore[0] = 77;</code>	←	Assignment
<code>System.out.println(numStore[0]);</code>	←	Retrieval

Array rules

- ▶ An array can hold objects or primitives
- ▶ An array is an **object**, regardless of what it contains
- ▶ Arrays care about **type**
 - ▶ if you declare an **int** [] you can only put **ints** in it¹

When you play with arrays...

- ▶ you will learn to know and hate the
 - ▶ `ArrayIndexOutOfBoundsException`
- ▶ This happens when you try and access an index that isn't there
- ▶ Lets use a **for** loop to expose this

Iterating Over an Array (1/2)

```
int numStore = new int[9];  
//some missing code to fill the array with values  
  
for (int i = 0; i < 9; i=i+1) {  
    System.out.print("Number at position " + i);  
    System.out.println(" is " + numStore[i]);  
}
```

Arrays are powerful because we can use a variable as the array index. This means we can iterate over them in a loop.

Iterating Over an Array (2/2)

```
int numStore = new int[9];  
//some missing code to fill the array with values  
  
for (int i = 0; i < 10; i=i+1) {  
    System.out.print("Number at position " + i);  
    System.out.println(" is " + numStore[i]);  
}
```

But make sure the index is always valid (in bounds). Otherwise the program will crash when it reaches the line that tries to use an index that is **out of bounds**

For Each Loop (1/2)

- ▶ Iterating over an array is so common that ...
- ▶ ... Java now includes a loop specifically to do it.
- ▶ The “**for each**” loop (aka enhanced **for** loop) is **designed to work with collections** like arrays

```
for (type variableName : collection) {  
    code to run;  
}
```


For Each Loop (2/2)

```
for (int i = 0; i < 10; i=i+1) {  
    System.out.print("Number at position " + i);  
    System.out.println(" is " + numStore[i]);  
}
```

becomes

```
for (int n : numStore) {  
    System.out.println("Number is " + n);  
}
```

- ▶ Like the **for** loop, the “**for each**” loop is a shortcut, that is a bit **neater** than writing the code the long way.
- ▶ But it can only be used for **access** (e.g. `n = n + 1` would not increment the value in the array)
- ▶ And it hides the current index

Summary

- ▶ Looping
 - ▶ **while**
 - ▶ **do ... while**
 - ▶ **for**
- ▶ Arrays
 - ▶ indexes
 - ▶ **for each** loops

Blackboard Tests for For Loops

Blackboard Tests for For Each Loops

YOUR QUESTIONS

- ▶ David J. Barnes and Michael Kölling. *Objects First with Java: A Practical Introduction using BlueJ*. Pearson, sixth edition edition, 2016 (Chapter 4.9)