# 122COM: Introduction to C++

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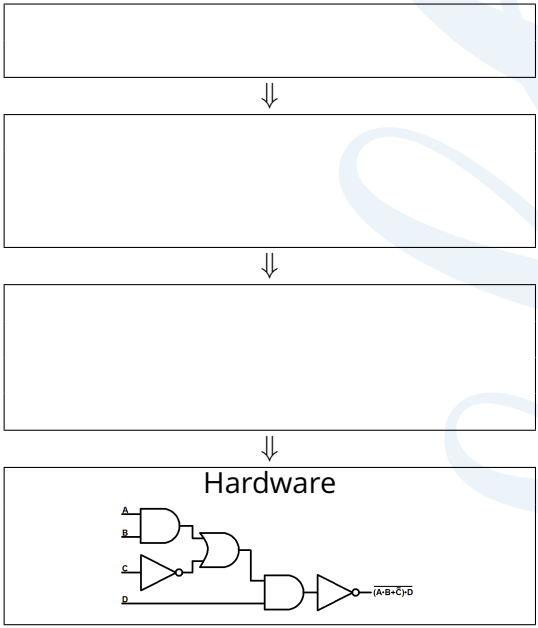
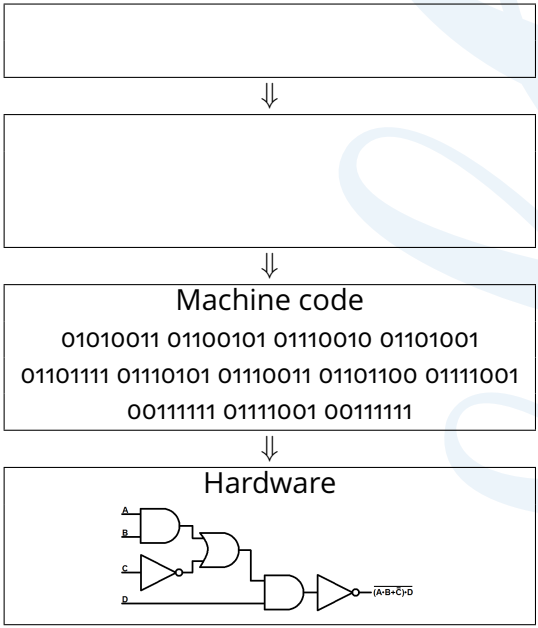
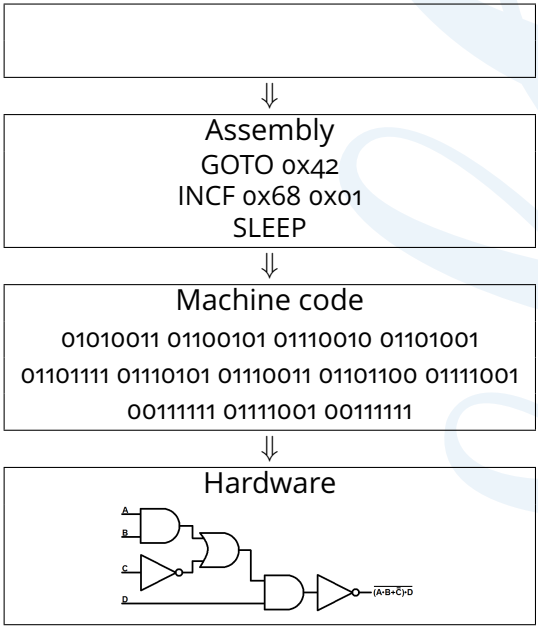
# Overview

# Highs and lows

- Programming languages split into levels.
- Low level languages are machine code, assembly language.
- High level languages are Python, C++, Java etc.




Machine code
01010011 01100101 01110010 01101001
01101111 01110101 01110011 01101100 01111001
00111111 01111001 00111111
Hardware
A
B
C
D
$\overline{(A \cdot B + \bar{C}) \cdot D}$


Assembly
GOTO 0x42
INCF 0x68 0x01
SLEEP
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01010011 01100101 01110010 01101001
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Hardware
A
B
C
D
(A·B+C)·D

High level languages

```
i+=1
```

⇓

Assembly

```
GOTO 0x42
INCF 0x68 0x01
SLEEP
```

⇓

Machine code

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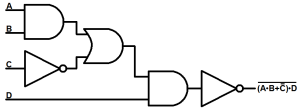
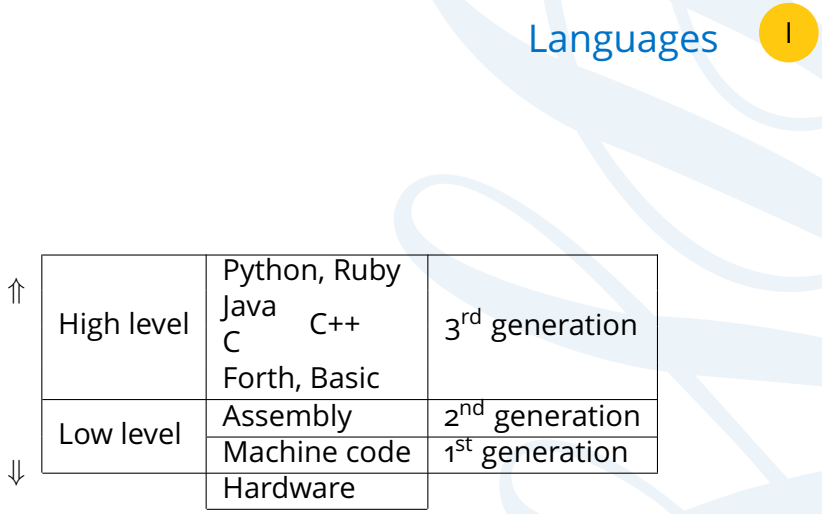
⇓

Hardware



# Languages



| | | | |
|---|---|---|---|
| ⇑ | High level | Python, Ruby<br>Java C++<br>C<br>Forth, Basic | 3rd generation |
| | Low level | Assembly | 2nd generation |
| | | Machine code | 1st generation |
| ⇓ | | Hardware | |

# Low level

Machine code

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- 1st generation.
- Really hard to understand.
- Really hard to write.
- The actual instructions to the hardware.

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- 1-to-1 correspondence with what is run.

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  - Same C/Python/C++/Java code.

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# History of C++

So far you have used Python.

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Now going to learn C++.

- Created somewhere in 1979-1983.
- Based on C (created 1972).
  - Going to be learning C++11 (approved 2011).
- C++14 has been approved (2014).
  - No support yet.
- 99.9% backwards compatible.
  - All the way to C.

- Supports the same paradigms as Python.
  - Objected oriented, functional, declarative etc.

# Expectations


- All students are expected to learn some C++.
- In future weeks we will be looking at generic programming concepts.
  - Sorting.
  - Searching.
  - Data structures.
- Those weeks will be taught in Python and C++.
  - Everyone else will have some mandatory C++ tasks.
  - BIT & MC students can choose Python or C++ most tasks.
  - Will be specified at the time.
- BIT will not be examined on C++ code.
  - May be examined on language differences.
  - High/low languages.
  - Compiling.
  - Static/dynamic typing.
  - Stack/heap memory.

# About C++


Most significant difference...

- C++ is statically typed.
  - Python is dynamically typed.

- In Python variables keep track of values AND type.

```
var = 42          # type(var) = <type 'int'>
var = 'foo'       # <type 'str'>
var = 0.123       # <type 'float'>
```

- In C++ variables have one type forever.
  - Have to specify type when creating.

```
int    var1 = 42;
string var2 = "foo";
float  var3 = 0.123;
```

# Data types


In C++ have to specify a variable's type.

- So what types are available?
- Thousands (at least).
  - You can create your own.
- Few standard ones.
- Most basic data types are called primitive types.

# Primitive types

- Knowing what the different variables are.
- Knowing all the primitives and the variations.
- Knowing ranges/sizes.

| Type | Bytes | Values |
|---|---|---|
| bool | 1 | true/false |
| char | 1 | 'a', 'Z', '6', '+' |
| int | 4 | -2147483647 $\rightarrow$ 2147483647 |
| unsigned int | 4 | 0 $\rightarrow$ 4294967295 |
| float | 4 | 1.234, -0.0001 |
| double | 8 | 1.23456789, -0.000000001 |
| void | | |

Sizes are correct for a 32bit machine.

# Syntax


Moving from Python to C++.

- Not as bad/scary as it seems.
- Same basic structure.
- Slightly different syntax.

# Hello World!

C

Python.

```
print('Hello World!')
```

# Hello World!


Python.

```
print('Hello World!')
```

```
import sys

def main():
    print('Hello World!')

if __name__ == '__main__':
    sys.exit(main())
```

# Hello World!


Python.

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print('Hello World!')
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import sys

def main():
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C++.

```
#include <iost
using namespac

int main()
{
    cout << "H

    return 0;
}
```

# Hello World!


Python.

```
print('Hello World!')
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def main():
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C++.

```
#include <iost
using namespac

int main()
{
    cout << "H

    return 0;
}
```

- All programs in C++ **MUST** have exactly one `main()` function.
- C++ uses { and } instead of indentation.
  - You should still have indentation in C++ but is aesthetic only.
- Semi-colons at the end of lines.

# if statements


Same rules as Python.

- Slightly different syntax.
- and is now &&.
- or is now ||.
- == is still ==.

# if statements


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```
a = 1
b = 2

if a == b and b > 0:
    print('Hello World )
```

# if statements


Same rules as Python.

- Slightly different syntax.
- and is now &&.
- or is now ||.
- == is still ==.

```
a = 1
b = 2

if a == b and b > 0:
    print('Hello World )
```

```
int a = 1;
int b = 2;

if( a == b &&
{
    cout << "H
}
```

# Arrays


Similar to Python lists.

- Can't be resized.

```python
sequence = [1, 2, 42, 69, 8]
sum = 0

for i in range(len(sequence)):
    sum += sequence[i]
```

```c
int sequence[5] = {1, 2, 42, 69, 8};
int sum = 0;

for( int i=0; i<5; i+=1 )
{
    sum += sequence[i];
}
```

# Arrays II

A

Three ways to create a C array.

1. Just supply size

```
int   arrayOfInt[3];
char  arrayOfChars[5];
float arrayOfFloats[2];
```

2. Supply size and initialisation list

```
int   arrayOfInt[3]    = { 42, 69, 12 };
char  arrayOfChars[5]  = { 'A', 'z', '9' }
float arrayOfFloats[2] = { 1.23, 0.001, 8.
```

3. Just initialisation list (will figure out the size)

```
int   arrayOfInt[]    = { 42, 69, 12 };
char  arrayOfChars[]  = { 'A', 'z', '9' }
float arrayOfFloats[] = { 1.23, 0.001, 8.
```

# New and improved!

So far looked at the old style arrays.

- Carried forward from C.
- Still used today.
- C++03 introduced an alternative.
  - STL arrays.

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```
#include <array>
using namespace std;

int main()
{
    int oldArray[5] = {1,2,3,4,5};
    array<int,5> newArray = {1,2,3,4,5};

    cout << oldArray[0] << " " << newArray[0] << endl;

    return 0;
}
```

# There's two of them?

Two types of arrays.

- Old style arrays are still very common.
  - Legacy.
  - Want you to start off using the new ones.
- What was wrong with the old ones?
- New arrays are safer.
  - Avoid overflows.
- Easier to use.
  - Sorting, searching, reversing, iterating etc.
- Are backwards compatible with old code.

# Vectors

Problem, C++ arrays have a set size.

- Saw we had to provide a size when declaring arrays.

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C++ does have 'arrays' that can be resized.

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C++ does have 'arrays' that can be resized.

- Called vectors.
- Uses arrays inside.

```
#include <array>
#include <vector>
#include <iostream>
using namespace std;

int main()
{
    array<int,5> myAr
    vector<int> myVec

    myVector.push_bac

    cout << myArray[0
    cout << myVector[
}
```

# Vectors II

C++ vectors are the closest thing to Python lists.

- If you are moving to C++ from Python easier to use vectors?

- append() → push_back() and emplace_back()
- pop() → pop_back()
- slicing → resize()

# while loops


Same rules as Python.

- Slightly different syntax.
- Brackets `()`.
- Braces `{}`.
- Semicolons `;`.

```
counter = 0
while counter < 10:
    print('Hello World!')
    counter += 1
```

```
int counter = 
while( counter
{
    cout << "H
    counter +=
}
```

# for loops


C++ has two kinds of for loops.

- One type similar to Python for loops.
  - Actually a range-based loop.
  - Will be covered later.
- One type similar to a while loop.

# for loops


The original C++ for loop.

```
for( int counter=0; count
{
    cout << "Hello World
}
```

# for loops


The original C++ for loop.

- Seems very different to the python loop.

```
for counter in range(10)
    print('Hello World!')
```

```
for( int counter=0; count
{
    cout << "Hello World
}
```

# for loops


The original C++ for loop.

- Seems very different to the python loop.
- Lots of commonalities.

```
for counter in range(10)
    print('Hello World!')
```

```
for counter in range(0,10
    print('Hello World!')
```

```
for( int counter=0; count
{
    cout << "Hello World
}
```

# for loops


The original C++ for loop.

- Seems very different to the python loop.
- Lots of commonalities.
- Also to while loops.

```
for counter in range(10)
    print('Hello World!')
```

```
for counter in range(0,10
    print('Hello World!')
```

```
for( int counter=0; count
{
    cout << "Hello World
}
```

```
int counter = 0;
while( counter < 10 )
{
    cout << "Hello World
    counter += 1;
}
```

# Ranged for loops

The new C++11 ranged for loop, for iterating over a sequence.

- Less powerful that the old style.
- Easier.
- while > for > ranged for

```
sequence = [1,2,3,4,5]
for i in sequence:
    print( i )
```

```
int main()
{
    array<int,5> sequer
        { 1, 2, 3, 4, 5
    for( int i : sequer
    {
        cout << i << en
    }

    return 0;
}
```

# Compiling


C++ code has to be compiled before it is run.

- So does Python it just happens automatically.
- Compiler converts C++ code into machine code.
- Many IDEs handle compiling for you.
  - Visual Studio, Eclipse etc.

# Compiling


THE #1 PROGRAMMER EXCUSE FOR LEGITIMATELY SLACKING OFF:
"MY CODE'S COMPILING."
HEY! GET BACK TO WORK!
COMPILING!
OH. CARRY ON.

# gcc & g++


GNU C Compiler (created 1987).

- Linux, Mac and Windows.

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How to compile using g++.

- Demo
- g++ –std=c++11 hello.cpp -o hello
  - g++ - the compiler program.
  - –std=c++11 - we want to use the C++11 standard of C++.
  - hello.cpp - the file we want to compile.
  - -o hello - the name of the executable to create.

# Debugging


What if your code is wrong?

- Same as Python.
  - Syntax errors.
  - Runtime errors.
  - Logic errors.

# Debugging


What if your code is wrong?

- Same as Python.
  - Syntax errors.
  - Runtime errors.
  - Logic errors.
  - Spot the errors.

```
int main
{
    cout

    for(
    {

    }

    retu
}
```

# Quiz

# Recap

- C++ is a high level language.
  - 3rd generation.
- Compiled.
- Statically typed.
- Arrays cannot be resized.
  - Use new STL arrays.

# The End