

# 122COM: Introduction to C++

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# Overview

## 1 Languages

## 2 C++

### ■ Variables

## 3 Syntax

### ■ Conditionals

### ■ Arrays

### ■ Loops

#### ■ while

#### ■ for

### ■ Compiling

### ■ Debugging

## 4 Recap

# Expectations

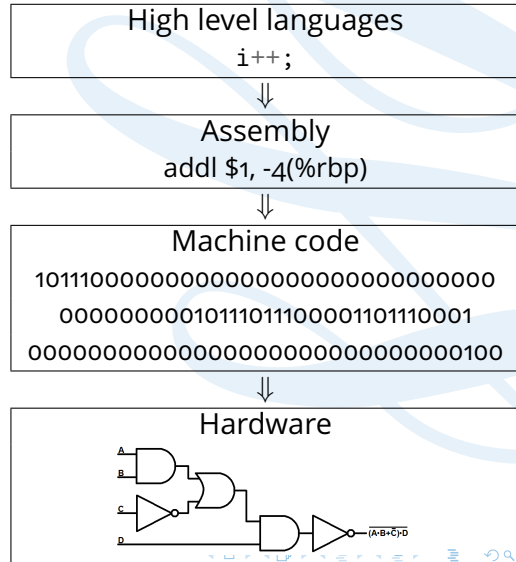
- All courses expected to be aware of different languages.
  - Advantages and disadvantages.
- BIT & MC are allowed to do most of 122COM in Python3.
  - Can choose C++11 if they wish.
- Everyone else is expected to move to C++11 for the remainder of 122COM.

- All students are expected to learn some C++.
- In future weeks will mostly be looking at generic programming concepts.
  - Will be taught in Python and C++.
- BIT & MC students.
  - Python or C++ unless task says otherwise.
  - Will not be tested on C++ code.
    - May be tested on language differences.
    - High/low languages.
    - Compiling.
    - Static/dynamic typing.
- Everyone else.
  - C++ unless task says otherwise.

- Programming languages split into levels.
- Low level languages are machine code, assembly language.
- High level languages are Python, C++, Java etc.
  - Not a binary classification, e.g. C++ is lower level than Python.

## Highs and lows

1



## Machine code

- 1<sup>st</sup> generation.
- Really hard to understand.
- Really hard to write.
- The actual instructions to the hardware.

```
11100101110001110100010111111100
00101010100000000000000000000000
10000011010001011111110000000001
10111000000000000000000000000000
00000000010111011100001101110001
00000000000000000000000000000100
```

## Languages

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0010101010000000000000000000000000
10000011010001011111110000000001
1011100000000000000000000000000000
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000000000000000000000000000000100
```

## Assembly

- 2<sup>nd</sup> generation.
- Hard for humans to understand.
- Hard for humans to write.
- 1-to-1 correspondence with what is run.

```
movl $42, -4(%rbp)
addl $1, -4(%rbp)
```



## Languages

C++

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Python, C, C++, Java, PHP, Perl etc.





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■ 3<sup>rd</sup> generation.

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- Easy for humans to write...compared to the alternatives.

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- Portable.
  - Different machine/processor/OS == different compiler.
  - Same C/Python/C++/Java code.

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- Easy for humans to write...compared to the alternatives.
- Portable.
  - Different machine/processor/OS == different compiler.
  - Same C/Python/C++/Java code.

```
int i=42;  
i++;
```

# History of C++

I

So far you have used Python.

So far you have used Python.  
Now going to learn C++.

# History of C++

I



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So far you have used Python.  
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).
  - Limited support yet.
- 99.9% backwards compatible.
  - All the way to C.
- Supports the same paradigms as Python.
  - Objected oriented, functional, declarative etc.

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;
```

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 primitives.

- 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 → 2147483647
unsigned int	4	0 → 4294967295
float	4	1.234, -0.0001
double	8	1.23456789, -0.000000001
void		

Sizes are correct for a 32bit machine.

## Moving from Python to C++.

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



## Basic Python.

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

# Hello World!

C

Hello World!

C

## Basic Python.

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

## More complete Python

```
import sys

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

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

lec\_hello.py

## Basic Python.

```
print('Hello World!')
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## More complete Python

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lec\_hello.py

Hello World!

C

## C++.

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

int main()
{
    cout << "Hello World!" << endl;

    return 0;
}
```

lec\_hello.cpp

## Basic Python.

```
print('Hello World!')
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## More complete Python

```
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lec\_hello.py

## C++.

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

int main()
{
    cout << "Hello World!" << endl;

    return 0;
}
```

lec\_hello.cpp

- 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.

Same rules as Python.

- Slightly different syntax.
- and is now &&
  - Although and does work with some compilers.
- or is now | |
  - Although or does work with some compilers.
- == is still ==.

Same rules as Python.

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

```
a = 1
b = 2

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

Same rules as Python.

- Slightly different syntax.
- and is now &&.
  - Although and does work with some compilers.
- or is now ||.
  - Although or does work with some compilers.
- == is still ==.

```
a = 1
b = 2

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

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

if( a == b && b > 0 )
{
    cout << "Hello World!" << endl;
}
```

Similar to Python lists.

- Can't be resized.

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

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

```
array<int,5> sequence = {1, 2, 42, 69, 8};
int sum = 0;

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



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.

- Called vectors.
- Use arrays inside.

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

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

- Called vectors.
- Use arrays inside.

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

int main()
{
    array<int,5> myArray = {1,2,3,4,5};
    vector<int> myVector = {1,2,3,4};

    myVector.emplace_back(5);

    cout << myArray[0] << endl;
    cout << myVector[0] << endl;
}
```

lec\_vector.cpp

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

- If you are moving to C++ from Python easier to use vectors?
- `append()` → `push_back()` or `emplace_back()`
- `pop()` → `pop_back()`
- slicing → `resize()`

Same rules as Python.

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

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

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

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.

The original C++ for loop.

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

The original C++ for loop.

- Seems very different to the python loop.

## for loops

C

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

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



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(0,10,1):  
    print('Hello World!')
```

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

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(0,10,1):  
    print('Hello World!')
```

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

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

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

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

# Ranged for loops

1

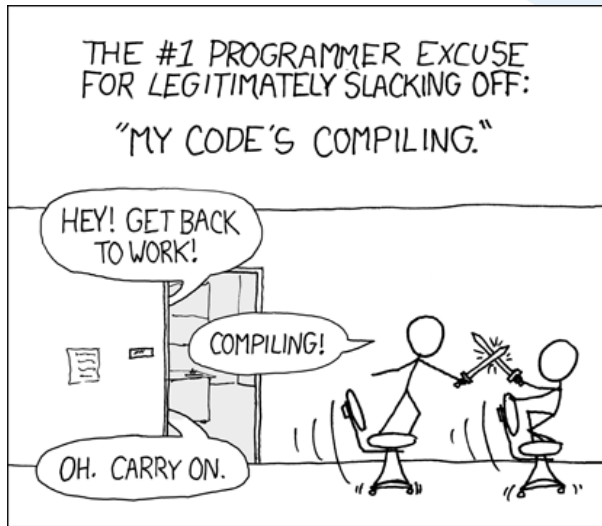
```
sequence = [1,2,3,4,5]
for i in sequence:
    print( i )
```

```
int main()
{
    array<int,5> sequence =
        { 1, 2, 3, 4, 5 };
    for( int i : sequence )
    {
        cout << i << endl;
    }

    return 0;
}
```

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.
- Make you do it yourself in this module so you understand it.
  - Understand what IDE is doing.
  - Understand the configuration options in the IDE.
  - Understand the error messages you get.
  - Once understood then use IDEs.



In Codio we are using the GNU C Compiler (created 1987).

- Available for Linux, Mac and Windows.

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How to compile using g++. **Demo Codio**

- `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.

How to run the program. **Demo Codio**

- `./hello`
  - `./` - it's in the same directory we're in.
  - `hello` - the name of the executable to run.

What if your code is wrong?

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



What if your code is wrong?

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

```
int main()  
{  
    cout << "Hi" << endl;  
  
    for( int i=0; i>10; j+=1 )  
    {  
        cut << "Hello World!" << endl  
    }  
  
    return 0;  
}
```

lec\_error.cpp

# Break



**Important announcement** - Two types of arrays in C++11.

- One is carried forward from C.
  - Still seen regularly.
- C++03 introduced an alternative.
  - STL arrays.

**Important announcement** - Two types of arrays in C++11.

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

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

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

# There's two of them?



Two types of arrays.

- Old style arrays are still very common.
  - Legacy code.
  - Old tutorials.
  - Want you to use 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.

# Why do I care?

- Everyone
  - C++ is widely used, 4<sup>th</sup> on IEEE top language list 2016.
  - Knowledge of multiple languages can help you in understanding the underlying logic concepts.
- Computing - C++ provides more efficient code than Python.
- Computer Science - C++ provides direct memory access, allowing greater understanding of computer memory and important abilities such as concurrent programming.
- Ethical Hackers - C++ provides direct memory access, important in understanding many hacks.
- Games Tech - C++ is a requirement for many games companies, it is an absolute requirement for your 3rd year modules.

# Recap

- C++ is a high level language.
- Compiled.
- Statically typed.
- Arrays cannot be resized.
  - Use new STL arrays.
- Vectors can be resized.
- Investigate C++ classes.
- Investigate STL Algorithm Library.

# The End