122COM: Introduction to C++

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Languages

C++
Variables

Syntax
Conditionals
Arrays
Loops
  while
  for
Compiling
Debugging

Recap

Overview

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Languages

C++
Variables

Syntax
Conditionals
Arrays
Loops
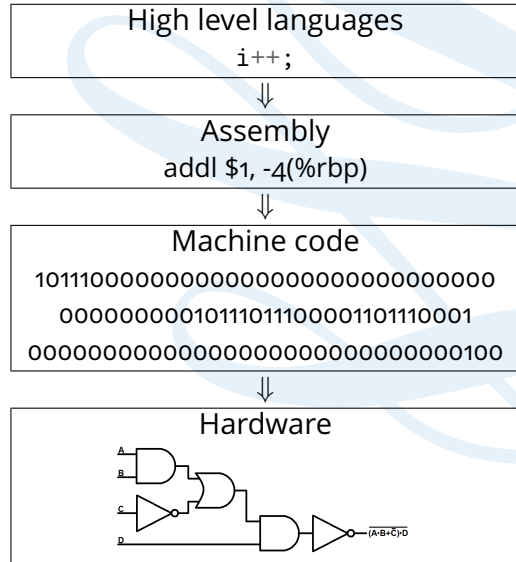   while
   for
Compiling
Debugging

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.

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Languages

C++
Variables

Syntax
Conditionals
Arrays
Loops
  while
  for
Compiling
Debugging

Recap

Expectations

C

- 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.

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Languages

C++
Variables

Syntax
Conditionals
Arrays
Loops
  while
  for
Compiling
Debugging

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Highs and lows

- 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.

High level languages
`i++;`

⇓

Assembly
addl $1, -4(%rbp)

⇓

Machine code
10111000000000000000000000000000 00000000010111011100011011100001 00000000000000000000000000000100

⇓

Hardware

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C++
Variables

Syntax
Conditionals
Arrays
Loops
    while
    for
Compiling
Debugging

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Low level

ⅰ

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

```
11100101110001110100010111111100
00101010000000000000000000000000
10000011010001011111110000000001
10111000000000000000000000000000
00000000010111011100011011100001
00000000000000000000000000000100
```

Assembly
- 2nd 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)
```

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Languages

C++
Variables

Syntax
Conditionals
Arrays
Loops
 while
 for
Compiling
Debugging

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High level

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

- 3rd generation.
- Favour programmer, not machine.
- Easy for humans to understand...compared to the alternatives.
- Easy for humans to write...compared to the alternatives.
- Portable.
  - Different machine/processor/OS == different compiler.
  - Same C/Python/C++/Java code.

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

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C++
Variables

Syntax
Conditionals
Arrays
Loops
while
for
Compiling
Debugging

Recap

History of C++

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.

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Languages
C++
Variables
Syntax
Conditionals
Arrays
Loops
while
for
Compiling
Debugging

Recap

About C++ 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;
```

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Languages

C++
Variables

Syntax
Conditionals
Arrays
Loops
while
for
Compiling
Debugging

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Data types

C

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.

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Languages
C++
Variables
Syntax
Conditionals
Arrays
Loops
while
for
Compiling
Debugging

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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 → 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.

Syntax C

Moving from Python to C++.

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

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C++
  Variables
Syntax
  Conditionals
  Arrays
  Loops
    while
    for
  Compiling
  Debugging

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Hello World! C

Basic Python.

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

More complete Python

```python
import sys

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

if __name___ == '__main__':
    sys.exit(main())
```
lec_hello.py

C++.

```cpp
#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.

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Languages

C++
  Variables

Syntax
  Conditionals
  Arrays
  Loops
    while
    for
  Compiling
  Debugging

Recap

if statements

C

Same rules as Python.

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

```python
a = 1
b = 2

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

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

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

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Languages
C++
  Variables
Syntax
  Conditionals
Arrays
  Loops
   while
   for
Compiling
  Debugging

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Arrays   C

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]
```

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

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

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Languages

C++
Variables

Syntax
Conditionals
Arrays
Loops
while
for
Compiling
Debugging

Recap

Vectors

Problem, C++ arrays have a set size.

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

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

∎ Called vectors.
∎ Use arrays inside.

```cpp
#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.push_back(5);

    cout << myArray[0] << endl;
    cout << myVector[0] << endl;
}
```
lec_vector.cpp

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Languages

C++
Variables

Syntax
Conditionals
Arrays
Loops
while
for
Compiling
Debugging

Recap

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() or emplace_back()
- pop() → pop_back()
- slicing → resize()

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Languages

C++
Variables

Syntax
Conditionals
Arrays
Loops
while
for
Compiling
Debugging

Recap

while loops C

Same rules as Python.

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

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

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

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Languages

C++
Variables

Syntax
Conditionals
Arrays
Loops
  while
  for
Compiling
Debugging

Recap

for loops   C

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.

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Languages
C++
  Variables
Syntax
  Conditionals
  Arrays
  Loops
    while
    for
  Compiling
  Debugging

Recap

for loops

C

The original C++ for loop.

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

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

```python
for counter in range(0,10,1):
    print('Hello World!')
```

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

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

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Languages

C++
Variables

Syntax
Conditionals
Arrays
Loops
  while
  for
Compiling
Debugging

Recap

Ranged for loops

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

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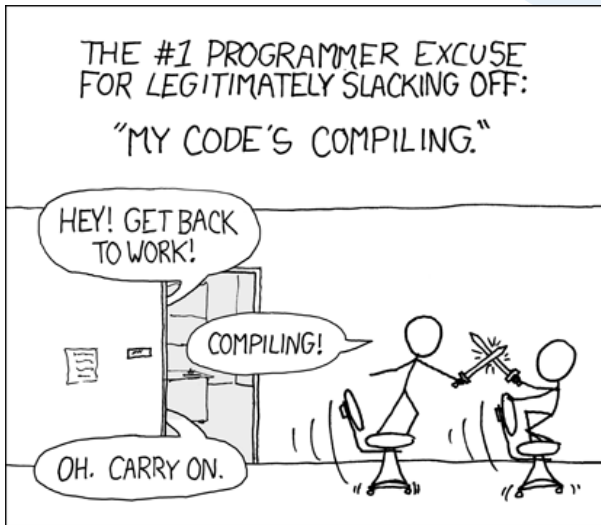- while > for > ranged for

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

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

    return 0;
}
```

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Languages

C++
Variables

Syntax
Conditionals
Arrays
Loops
while
for
Compiling
Debugging

Recap

Compiling

C

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.

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Languages

C++
Variables

Syntax
Conditionals
Arrays
Loops
while
for
Compiling
Debugging

Recap

gcc & g++ C

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

- Available for Linux, Mac and Windows.

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.

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Languages

C++
Variables

Syntax
Conditionals
Arrays
Loops
  while
  for
Compiling
Debugging

Recap

Debugging

What if your code is wrong?

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

    - Spot the errors.

```cpp
int main()
{
    cout << "Hi" << endl;

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

    return 0;
}
```
lec_error.cpp

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Languages

C++
Variables

Syntax
Conditionals
Arrays
Loops
while
for
Compiling
Debugging

Recap

Break

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Languages

C++
  Variables

Syntax
  Conditionals
  Arrays
  Loops
    while
    for
  Compiling
  Debugging

Recap

New and improved!

I

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.

```cpp
#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;
}
```

lec_arrays.cpp

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Languages

C++
Variables

Syntax
Conditionals
Arrays
Loops
  while
  for
Compiling
Debugging

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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.

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Languages

C++
Variables

Syntax
Conditionals
Arrays
Loops
while
for
Compiling
Debugging

Recap

Why do I care?

- Everyone
  - C++ is widely used, 4th 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.

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Languages

C++
Variables

Syntax
Conditionals
Arrays
Loops
while
for
Compiling
Debugging

Recap

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