

# *Basic syntax in C++*

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# Brief History of C

- ▷ C was developed in 1967 mainly as a language for writing operating systems and compilers
  - Think about the gcc compiler and Linux today
  - You can compile the gcc compiler yourself
  - You can get the latest linux kernel (core of the linux operating system) from [www.kernels.org](http://www.kernels.org) and compile it yourself
- ▷ C was the evolution of two previous languages: B and BCPL
  - Both used to develop early versions of UNIX at Bell Labs
- ▷ C became very popular and was ported to variety of different hardware platforms
  - C was standardized in 1990 by International Organization for Standardization (ISO) and American National Standards Institute (ANSI)
    - ANSI/ISO 9899: 1990

# Object Oriented Programming and Birth of C++

- ▷ By 1970's the difficulties of maintaining very large software projects for companies and businesses had lead to structured programming
  - From Wikipedia:  
**Structured programming** can be seen as a subset or subdiscipline of procedural programming, one of the major programming paradigms. It is most famous for removing or reducing reliance on the GOTO statement (also known as "go to")
- ▷ By late 70's a new programming paradigm was becoming trendy: object orientation
- ▷ In early 1980's Bjarne Stroustrup developed C++ using features from C but adding capabilities for object orientation

# What is 'Object Oriented Programming' anyway?

- ▷ Objects are software units modelled after entities in real life
  - Objects are entities with attributes: length, density, elasticity, thermal coefficient, color
  - Objects have a behavior and provide functionalities
    - A door can be opened
    - A car can be driven
    - A harmonic oscillator oscillates
    - A nucleus can decay
    - A planet moves in an orbit
- ▷ Object orientation means writing your program in terms of well defined units (called objects) which have attributes and offer functionalities
  - Program consists in interaction between objects using methods offered by each of them

# C++ is not C !

- ▷ Don't be fooled by the name!
- ▷ C++ was developed to overcome limitations of C and improve upon it
  - C++ looks like C but feels very differently
  - C++ shares many basic functionalities but improves upon many of them
    - For example input/output significantly better in C++ than in C
- ▷ C excellent language for structural programming
  - Focused around actions on data structures
  - Provides methods which act on data and create data
- ▷ C++ focused on inter-action between objects
  - Objects are 'smart' data structures: data with behavior!

# What You Need to compile your C++ Program?

- ▷ On Linux machines you should have the g++ compiler installed by default
- ▷ On Windows you can use the C++ compiler provided by the free version of Visual Studio
- ▷ On Mac OS, you can install the g++ compiler via XCode, available for free on Mac App Store

# Structure of a C++ Program

```
// your first C++ application!  
#include <iostream> // required to perform C++ stream I/O  
  
// function main begins program execution  
int main() {  
    return 0; // indicate that program ended successfully  
} // end function main
```

# Precompiler/Preprocessor Directives

What is the preprocessor? What does it do?

```
// your first C++ application!  
#include <iostream> // required to perform C++ stream I/O  
  
// function main begins program execution  
int main() {  
    return 0; // indicate that program ended successfully  
}  
// end function main
```

`iostream` will be included before compiling this code!



# What does the Preprocessor do?

Pre-compile only

```
// Foo.h
class Foo {
public:
    Foo() {};
    Foo(int a) { x_ = a; };

private:
    int x_;
};
```

```
// ExamplePreprocessor.cpp
#include "Foo.h"

int main() {

    return 0;
}
```

```
$ g++ -E ExamplePreprocessor.cpp > prep.cc
$ cat prep.cc
# 1 "ExamplePreprocessor.cpp"
# 1 "<built-in>"
# 1 "<command line>"
# 1 "ExamplePreprocessor.cpp"

# 1 "Foo.h" 1
class Foo {
public:
    Foo() {};
    Foo(int a) { x_ = a; };

private:
    int x_;
};
# 3 "ExamplePreprocessor.cpp" 2

int main() {

    return 0;
}
```

- ▷ Replace user directives with requested source code
  - Foo.h is included in ExamplePreprocessor.cpp

# Comments in C++

```
// your first C++ application!  
#include <iostream> // required to perform C++ stream I/O  
  
// function main begins program execution  
int main() {  
    return 0; // indicate that program ended successfully  
  
} // end function main
```

- ▷ Comments preceded by `//`
  - Can start anywhere in the program either at the **beginning** or right after a statement in the middle of the line

# Compiling a C++ application

```
$ g++ -o Welcome Welcome.cpp
```

**Name of the binary output**

**C++ file to compile and link**

```
$ ls -l
-r--r--r-- 1 rahatlou None 1379 Apr 18 22:55
Welcome.cpp
-rwxr-xr-x 1 rahatlou None 476600 Apr 18 22:57
Welcome
```

- We will be using the free compiler gcc throughout the examples in this course

# Some basic aspects of C++

- ▷ All statements must end with a semi-colon ;
  - Carriage returns are not meaningful and ignored by the compiler
- ▷ Comments are preceded by //
  - Comments can be an entire line or in the middle of the line after a statement
- ▷ Any C++ application must have a **main** method
- ▷ **main** must return an **int**
  - Return value can be used by user/client/environment
  - E.g. to understand if there was an error condition

# What about changing a different type of **main**?

```
// VoidMain.cpp
#include <iostream>
using namespace std;

void main() {

    // no return type

} // end function main
```

```
$ g++ -o VoidMain VoidMain.cpp
VoidMain.cpp:6: error: `main' must return `int'
```

- ▷ Compiler requires **main** to return an **int** value!
- ▷ Users must simply must satisfy this requirement
  - If you need a different type there is probably a mistake in your design!

# Typical Compilation Errors So Far

```
// BadCode1.cpp
#include <iostream>
using namespace std;

int main() { // main begins here

    int nIterations;

    cout << "How many
            iterations? "; // cannot break in the middle of the string!

    cin >> nIteration; // wrong name! the s at the end missing

    // print message to STDOUT
    cout << "Number of requested iterations: " << nIterations << endl;

    return 0 // ; is missing!

} // end of main
```

```
$ g++ -o BadCode1 BadCode1.cpp
BadCode1.cpp: In function `int main()':
BadCode1.cpp:9: error: missing terminating " character
BadCode1.cpp:10: error: `iterations' undeclared (first use this function)
BadCode1.cpp:10: error: (Each undeclared identifier is reported only once for each function
it appears in.)
BadCode1.cpp:10: error: missing terminating " character
BadCode1.cpp:12: error: `nIteration' undeclared (first use this function)
BadCode1.cpp:12: error: expected `:' before ';' token
BadCode1.cpp:12: error: expected primary-expression before ';' token
BadCode1.cpp:19: error: expected `;' before '}' token
```

Some C reminders

# Always initialise your variables!

```
// tinput_bad2.cc  
#include <iostream>  
using namespace std;
```

```
int main() {
```

```
    int iters;
```

```
    cout << "iters before cin: " << iters << endl;
```

```
    cout << "iterations? ";
```

```
    cin >> iters;
```

```
    cout << "requested " << iters << " iterations" << endl;
```

```
    return 0;
```

```
}
```

Random value since  
not initialized!



```
$ g++ -Wall -o tinput_bad2 tinput_bad2.cc
```

```
$ ./tinput_bad2
```

```
iters before cin: 134514841
```

```
iterations? 3
```

```
requested 3 iterations
```

```
$ ./tinput_bad2
```

```
iters before cin: 134514841
```

```
iterations? er
```

```
requested 134514841 iterations
```



# Arrays (same as in C)

```
// vect3.cc
#include <iostream>
using namespace std;

int main() {

    float vect[3] = {0.4,1.34,56.156}; // vector of int
    float v2[3];
    float v3[] = { 0.9, -0.1, -0.65}; // array of size 3

    for(int i = 0; i<3; ++i) {
        cout << "i: " << i << "\t"
              << "vect[" << i << "]: " << vect[i] << " \t"
              << "v2[" << i << "]: " << v2[i] << " \t"
              << "v3[" << i << "]: " << v3[i]
              << endl;
    }

    return 0;
}
```

Index of arrays starts from 0 !!

v2[0] is the first elements of array v2 of size 3.

v2[2] is the last element of v2

What happened to v2?

```
$ g++ -o vect3 vect3.cc
$ ./vect3
i: 0    vect[0]: 0.4
i: 1    vect[1]: 1.34
i: 2    vect[2]: 56.156
```

```
v2[0]: 5.34218e+36    v3[0]: 0.9
v2[1]: 2.62884e-42    v3[1]: -0.1
v2[2]: 3.30001e-39    v3[2]: -0.65
```

# Arrays and Pointers

- The name of the array is a pointer to the first element of the array

```
// array.cpp
#include <iostream>
using namespace std;

int main() {

    int vect[3] = {1,2,3}; // vector of int
    int v2[3]; //what is the default value?
    int v3[] = { 1, 2, 3, 4, 5, 6, 7 }; // array of size 7

    int* d = v3;
    int* c = vect;
    int* e = v2;

    for(int i = 0; i<5; ++i) {
        cout << "i: " << i << ", d = " << d << ", *d: " << *d;
        ++d;
        cout << ", c = " << c << ", *c: " << *c;
        ++c;
        cout << ", e = " << e << ", *e: " << *e << endl;
        ++e;
    }
    return 0;
}
```

What happened to e?

```
$ g++ -o array array.cc
$ ./array
i: 0, d = 0x23eec0, *d: 1, c = 0x23eef0, *c: 1, e = 0x23eee0, *e: -1
i: 1, d = 0x23eec4, *d: 2, c = 0x23eef4, *c: 2, e = 0x23eee4, *e: 2088773120
i: 2, d = 0x23eec8, *d: 3, c = 0x23eef8, *c: 3, e = 0x23eee8, *e: 2088772930
i: 3, d = 0x23eecd, *d: 4, c = 0x23eefc, *c: 1627945305, e = 0x23eeec, *e: 2089866642
i: 4, d = 0x23eed0, *d: 5, c = 0x23ef00, *c: 1876, e = 0x23eef0, *e: 1
```

# Another bad example of using arrays

```
// vect2.cc
#include <iostream>
using namespace std;

int main() {

    float vect[3] = {0.4,1.34,56.156}; // vector of int
    float v2[3]; // use default value 0 for each element
    float v3[] = { 0.9, -0.1, -0.65, 1.012, 2.23, -0.67, 2.22 }; // array of size 7

    for(int i = 0; i<5; ++i) {
        cout << "i: " << i << "\t"
              << "vect[" << i << "]: " << vect[i] << " \t"
              << "v2[" << i << "]: " << v2[i] << " \t"
              << "v3[" << i << "]: " << v3[i]
              << endl;
    }

    return 0;
}
```

Accessing out of range component!

```
$ g++ -o vect2 vect2.cc
$ ./vect2
i: 0      vect[0]: 0.4          v2[0]: 5.34218e+36      v3[0]: 0.9
i: 1      vect[1]: 1.34        v2[1]: 2.62884e-42     v3[1]: -0.1
i: 2      vect[2]: 56.156      v2[2]: 3.30001e-39     v3[2]: -0.65
i: 3      vect[3]: 5.60519e-45  v2[3]: 1.57344e+20     v3[3]: 1.012
i: 4      vect[4]: 1.72441e+20  v2[4]: 0.4            v3[4]: 2.23
```

# Example of Bad non-initialized Arrays

```
// vect1.cc
#include <iostream>
#include <cmath>

using namespace std;

int main() {

    float vect[3]; // no initialization

    cout << "printing garbage since vector not initialized" << endl;
    for(int i=0; i<3; ++i) {
        cout << "vect[" << i << "] = " << vect[i]
            << endl;
    }

    vect[0] = 1.1;
    vect[1] = 20.132;
    vect[2] = 12.66;

    cout << "print vector after setting values" << endl;
    for(int i=0; i<3; ++i) {
        cout << "vect[" << i << "] =      " << vect[i] << "\t"
            << "sqrt( vect[" << i << "] ) = " << sqrt(vect[i])
            << endl;
    }

    return 0;
}
```

```
$ ./vect1
printing garbage since vector not initialized
vect[0] = 2.62884e-42
vect[1] = NaN
vect[2] = 0
print vector after setting values
vect[0] =      1.1          sqrt( vect[0] ) = 1.04881
vect[1] =     20.132        sqrt( vect[1] ) = 4.48687
vect[2] =     12.66        sqrt( vect[2] ) = 3.55809
```

# Control Statements in C++

```
// SimpleIf.cpp
#include <iostream>
using namespace std;

int main() { // main begins here

    if( 1 == 0 ) cout << "1==0" << endl;

    if( 7.2 >= 6.9 ) cout << "7.2 >= 6.9" << endl;

    bool truth = (1 != 0);
    if(truth) cout << "1 != 0" << endl;

    if( ! ( 1.1 >= 1.2 ) ) cout << "1.1 < 1.2" << endl;

    return 0;
} // end of main
```

```
$ g++ -o SimpleIf SimpleIf.cpp
$ ./SimpleIf
7.2 >= 6.9
1 != 0
1.1 < 1.2
```

# Declaration and Definition of Variables

```
// SimpleVars.cpp
#include <iostream>
using namespace std;

int main() {

    int samples; // declaration only

    int events = 0; // declaration and assignment

    samples = 123; // assignment

    cout << "How many samples? " ;
    cin >> samples; // assignment via I/O

    cout << "samples: " << samples
         << "\t" // insert a tab in the printout
         << "events: " << events
         << endl;

    return 0;
} // end of main
```

```
$ g++ -o SimpleVars SimpleVars.cpp
$ ./SimpleVars
How many samples? 3
samples: 3         events: 0
```

# Loops and iterations in C++

```
int main() { // main begins here
```

```
    int nIterations;  
    cout << "How many iterations? ";  
    cin >> nIterations;
```

```
    int step;  
    cout << "step of iteration? " ;  
    cin >> step;
```

```
    for(int index=0; index < nIterations; index+=step) {  
        cout << "index: " << index << endl;  
    }  
    return 0;  
} // end of main
```

Maximum

Starting value

```
$ g++ -o SimpleLoop SimpleLoop.cpp  
$ ./SimpleLoop  
How many iterations? 7  
step of iteration? 3  
index: 0  
index: 3  
index: 6
```

step