Writing and Understanding C++

- There are language independent skills in programming (C++, Java, ...)
- However, writing programs in any language requires understanding the syntax and semantics of the programming language

- Syntax is similar to rules of spelling and grammar:
  - *i before e except after c*
  - The relationship between a command and a quote, "this is a fact," or "this is a fact",

- Semantics is what a program (or English sentence) means
  - You ain’t nothing but a hound dog.
  - La chienne de ma tante est sur votre tete.

- At first it seems like the syntax is hard to master, but the semantics are much harder
  - Natural languages are more forgiving than programming languages.
Toward an Understanding of C++

- Traditional first program, doesn’t convey power of computing but it illustrates basic components of a simple program

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

// traditional first program

int main()
{
    cout << "Hello world" << endl;
    return 0;
}
```

- This program must be edited/typed, compiled, linked and executed.
- Other languages don’t use compile/link phase, examples?
What’s a namespace?

- In “standard” C++, objects and types are classified as to what namespace they’re in. Hierarchy is good.

```cpp
#include <iostream>

// traditional first program

int main()
{
    std::cout << "Hello world" << std::endl;
    return 0;
}
```

- It’s much simpler to “use” a namespace, in small programs there won’t be any conflicts (and small is fairly big)
Anatomy of a C++ Program

- `#include` statements make libraries of classes and functions accessible to the program
  - Compiler needs access to interface, what the functions look like, but not to implementation
    - This is purpose of header files of source code
  - Linker/Loader needs access to implementations
    - This is purpose of Makefile/IDE libraries of object code
  - Helps programmers develop code independently

- **Comments make programs readable by humans**
  - The cost of program maintenance is often far greater than the cost of program development
  - Use comments liberally, but make them meaningful
More C++ Anatomy

- **Programmer-defined functions**
  - Functions are abstractions: help you to reuse ideas and code
  - The square root key on a calculator invokes a function
  - The chorus of a song is a similar abstraction
  - One word, e.g., “chorus”, takes the place of many or represents a concept
- **A program is a collection of functions and classes**
- **Programs may be implemented in more than one file, but there is only one main function**
  - Execution of the program begins with main
  - The main function returns a value to the operating system or environment
Dennis Ritchie

- Developed C and Unix
- Shared 1983 Turing award and National Medal of Science in 1999

“We wanted to preserve not just a good environment in which to do programming, but a system around which a fellowship could form”

- Unix was
  - Free to Universities
  - Expensive originally
  - Linux precursor?
Execution and Flow Control

- **Execution of C++ programs is organized around statements**
  - A statement executes, it may cause another statement to execute
  - Statements execute sequentially, or as governed by control that repeats a group of statements or selects one of several groups to execute
    - Control statements covered later; for now sequential flow

- **Syntax determines what’s in a statement, semantics determines construction of program from statements**

- **Output will be part of our programs**
  - `cout` is the output stream, objects are placed on the stream
  - Objects are strings, numbers, many other *types*
Stream output

- `cout` is the standard output stream, use `cerr` for errors and other streams later. Accessible via `#include<iostream>

- Objects inserted onto stream with insertion operator `<<`
- Different objects separated by insertion operator `<<`

```
cout << "yadda yadda yadda" << endl;
cout << " gross = " << 12*12 << endl;
cout << 5 << " in. = "
     << 5*2.54 << " cm. " << endl;
```

- **String literals** in quotes, other expressions are evaluated before being output.
  - `endl` is the “end of line” object (IO manipulator)
  - Can also output "\n" or "\t" or "\"" (escape sequences)
More about streams and syntax

- **C++ statements are terminated by a semi-colon**

  ```
  cout << 3.14159*10*10 << " = area "
  << " of circle with radius = "
  << 10 << ", circ = " << 2*10*3.14159
  << endl;
  ```

- **Thinking ahead:**
  - Repetition of radius, problems?
  - Repetition of $\pi$, problems?
  - What’s better, several statements, or one long statement?
  - Evaluating expressions: rules of arithmetic?
  - Differences between $2*3$ and $2*3.0$?
Functions: Abstractions, shortcuts

- Can you write a program that prints “This rocks” $10^6$ times?
  - Only statements permitted are cout $<<$ and functions
    - If you know about loops, you have amnesia
  - Naïve solution requires one function and one million print statements, can we improve on this?

- How do you attack this problem?
  - Think of a problem that’s similar, but simpler. Solve it.
  - Generalize solution to the more complex/bigger problem

  - Hello(); vs cout $<<$ “Hello World” $<<$ endl;
Toward Using Functions

#include <iostream>
using namespace std;
int main()
{
    cout << "  ||||||||||||||||  " << endl;
    cout << "  |              |  " << endl;
    cout << "  |    o    o    |  " << endl;
    cout << " _|              |_ " << endl;
    cout << "|_                _|" << endl;
    cout << "  |   |______|   |  " << endl;
    cout << "  |              |  " << endl; return 0;
}

- Prints head, but not as modular as program using functions  
  - Harder to modify to draw differently
Programmer-defined Functions

```cpp
#include <iostream>
using namespace std;
// functions appear here

int main()
{
    Hair();
    Sides();
    Eyes(); Ears(); Smile();
    Sides();
    return 0;
}
```

- What are advantages of this `main` over one in which several output statements appear in `main`.
  - New hair style? Stretched head?
  - Are these advantages?
  - How is width of head determined? Drawbacks? Solutions?
Advantages of Functions

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

// functions appear here

int main()
{
    Hair();
    Sides();
    Eyes(); Ears(); Smile();
    Sides();
    return 0;
}

  - Advantages in extending program rather than modifying program.
  - Multiple heads (totem poles)
Totem Functions

```c
int main()
{
    Head1();
    Head2();
    Head3();
    return 0;
}
```

- What changed between the two runs of the program?
- Can you write `Headxx()`?
  - Is `Head1` a good name?
  - Does `Headxx` call other functions?
  - Suppose we used graphics instead of `cout <<`?
Parameterized Functions

- A square root function that only returns square root of 2 isn’t very useful
  - $F = \sqrt{2}$, so 2 is a parameter/argument to the function
  - Useful parameter to head-drawing functions?
    - ...
    - ...
  - What about happy birthday printing argument/parameter?

- Functions have parameters, *arguments are passed* to functions

  `Birthday("Fred");  // sing to fred`
  `Birthday("Ethel");  // sing to ethel`
#include <iostream>
using namespace std;

void WinBigMoney(string name)
{
    cout << "Hello " << name << " you may have "
         << " won $1,000,000" << endl;
    cout << name << "", please call 1-900-IMN-IDIOT"
         << endl;
}

int main()
{
    WinBigMoney("owen"); WinBigMoney("susan");
    WinBigMoney("bill gates");
    return 0;
}

- **Parameter list provides** *type and name of parameter*
  - Argument type must match parameter type
  - Function’s *prototype* based on types only, not names
Parameterized Functions for Songs

- **On his farm Old MacDonald had a X that that says Y**
  - pig, oink
  - cow, moo

```
void Verse();
```

- **Five bottles of Z on a wall, five bottles of Z**
  - cola
  - lemonade

```
void Verse();
```

- **Mama’s going to buy you a X, and if that X Y**
  - Mocking bird, don’t sing
  - Looking glass, get’s broke

```
void Verse();
```
Calling Functions: where, when, how?

- Some functions are imported from libraries
  - Function prototypes specified in header files, implementations linked later
  - Compiler “sees” prototype before client code calls function
- Some functions are in the same file in which they’re called
  - Function declaration is the prototype only
  - Function definition includes the implementation

```c
void Verse(string name);  
void Verse(string name)  
{  
  cout << "hi " << name << endl;
}
```

- Declaration or definition must appear before call
  - Ok to put declaration before, definition after call
  - Ok to put main last, all definitions first (problems?)
Ada Lovelace, 1816-1853

- Daughter of Byron, advocate of work of Charles Babbage, designer of early “computer” (the Analytical Engine)
  - Made Babbage’s work accessible
    “It would weave algebraic patterns the way the Jacquard loom weaved patterns in textiles”
- Tutored in mathematics by Augustus de Morgan
- Marched around the billiard table playing the violin
- Ada is a notable programming language
Program Style

- **People who use your program don’t read your code**
  - You’ll write programs to match user needs

- **People who maintain or modify your program do read code**
  - Must be readable, understandable without you next door
  - Use a consistent programming style, adhere to conventions

- **Identifiers are names of functions, parameters, (variables, classes, ...)**
  - Sequence of letters, numbers, underscore __ characters
  - Cannot begin with a number (we won’t begin with __)
  - big_head vs. BigHead, we’ll use AlTeRnAtInG format
  - Make identifiers meaningful, not droll and witty