C++ Basics

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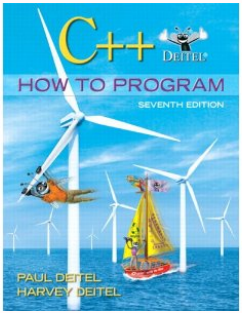
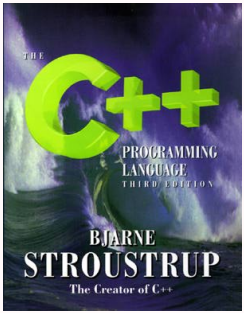
1. References

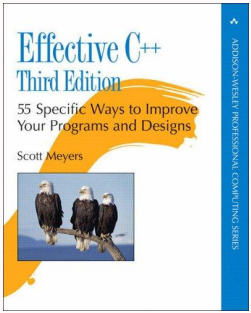
Many find Deitel quintessentially readable; most find Stroustrup inscrutable and overbearing:

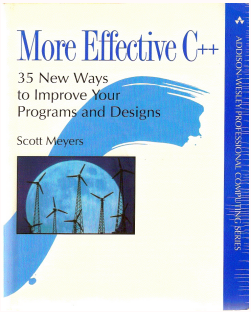




1.1. Meyers Texts

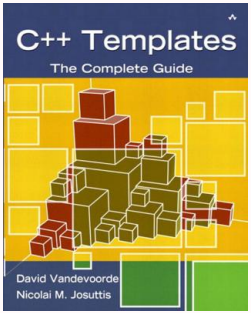
Two excellent books if you know C++. Scott Meyers provides two references, each with Items that expose subtleties about correct use of the C++ language. I'll refer to these Items throughout the course:

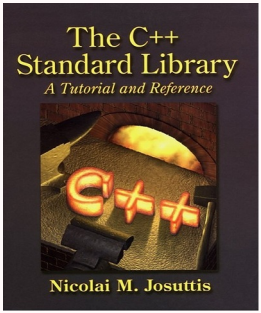




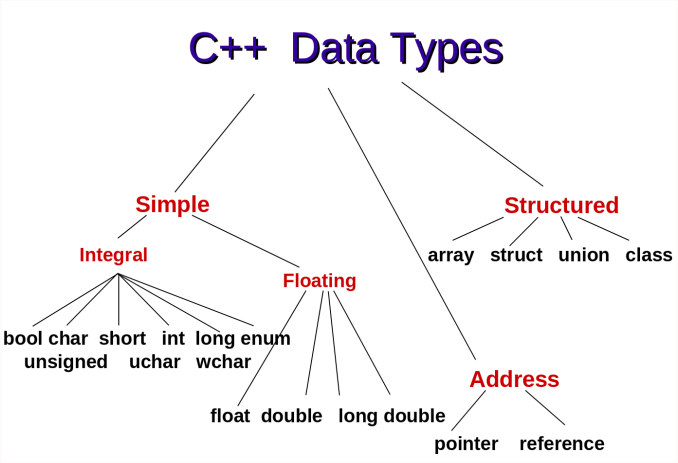
1.2. Templates and STL

The Vandevoorde & Josuttis text is a great introduction to C++ templates; and Josuttis' STL reference is excellent:





2. Data



2.1. Simple Data Types

- **bool** can be true or false
- **enum**s define constant values
- Named constants are preferable to # **define**, which is a C artifact (Meyers Item # 1):
  - const char STAR = '*';
  - const unsigned MAX = 100;

2.2. Mixed Type Expressions

- Are promoted or truncated:
  1. int(2.3) evaluates to 2
  2. float(2/4) evaluates to 0.0
  3. 4/8 evaluates to 0
  4. float(4)/8 evaluates to 0.5
  5. 2.0/4 evaluates to 0.5
- Prefer C++ cast (Meyers Item #2):
  static_cast<float>(5/10) evaluates to 0.0

2.3. Structured Data Types

- **union**s: obviated by inheritance
- **struct**s: same as classes except for default protection:
  - Default protection of class is **private**
  - Default protection of struct is **public**
- Arrays, like C, are passed by reference
- Classes are covered in slides about classes

3. Expressions

- Composed of operators, variables, constants and parentheses
- Logical operators: `&&, ||, !`
- Relational operators: `<, >, ==, !=, <=, >=`
- However, an expression can be considered as a Boolean condition where `0` is false and all other values are true:

```
int x = rand();
if (x) ...
```

- Of course, the rules for mixed types still apply, so `2/4` evaluates to `0`

3.1. Operators

- unary, binary, and ternary describe the number of operands that an operator uses.
- For example, `-7` is **unary** minus; i.e., one operand
- `3 - 7` is **binary** minus; i.e., two operands
- There is only one **ternary** operator and it's very useful; for example, the following expression evaluates to the larger of the two operands: `(a > b) ? a : b`

3.2. Prefix and Postfix Operators

- Prefix operators are evaluated in place.
- Postfix operators are evaluated at the end of the statement

```
1 #include <iostream>
2 int main() {
3   int i = 0, j = 0;
4   std::cout << ++i << std::endl;    //output is 1
5   std::cout << j++ << std::endl;    //output is 0
6   std::cout << i << j << std::endl; //output is 11
7   return 0;
8 }
```

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3.3. Insertion/Extraction Operators

- They are binary, left associative operators that evaluate to the operator
- For example, the stream insertion operator, *operator* $\ll$ evaluates to *operator* $\ll$, which is why the following expression works:

```
The expression:
   cout << x << y << endl;
is actually:
   (((cout << x) << y) << endl);
where (cout << x) places the value of x into the
output stream and evaluates to cout <<
so that the expression becomes:
   ((cout << y) << endl);
which places y into the output stream and evaluates to
   (cout << endl);
```


4. Control Structures

- selection: **if**, **if/else**, **switch**
- repetition: **for**, **while**, **do/while**
- In general, I much prefer clarity and readability to obfuscated, hacked, terse code. Thus, I prefer the use of brackets because they promote readability. The first example below is preferable to the second:

```
int sum = 0;
for (unsigned i = 0; i < MAX; ++i) {
  sum += i;
}

int sum = 0;
for (unsigned i = 0; i < MAX; ++i) sum += i;
```

4.1. switch

- If a **switch** value matches a **case** value, then it matches all cases until a **break** is encountered:

```
int count = 0;
int index = 1;
switch (index) {
  case 0: ++count;
  case 1: ++count;
  case 2: ++count;
  case 3: ++count;
  case 4: ++count;
  case 5: ++count;
  default: ++count;
}
cout << count << endl;  // prints 6
```

4.2. switch/case/break is useful

- We may wish to match several values, so multiple case values w/out a break are like logical or. In the next example, we can match either upper or lower case letters:

```
int count = 0;
char ch = 'b';
switch (ch) {
  case 'A' : case 'a': ++count; break;
  case 'B' : case 'b': ++count; break;
  case 'C' : case 'c': ++count; break;
  default: cout << "Oops" << endl;;
}
```

4.3. Short-circuit Evaluation

- If evaluation of the first operand obviates evaluation of the second, then the second operand is not evaluated.
- Short-circuit evaluation can be useful. If number happens to be zero, then we won't get a division by zero error in the following example:

```
float sum = 0.0;
int number = rand();
if ( number != 0 && sum/number > 90.0) {
  ...
}
```

4.4. for

- The scope of the loop control variable (LCV) (in this case i) is the loop body:

```
for (int i = 0; i < MAX; ++i) {
  cout << i;
}
i is out of scope here
```

- The following hack would be more readable if the programmer used **while** (true)

```
// Obfuscated code; great for job security!
i = 0;
for ( ; ; ) {
  if (i > MAX) break;
  cout << ++i;
}
```

5. Functions

- Can be void or return a value.
- Each C++ program contains a function called main, which returns an integer.
- There are two acceptable forms of main:

```
**********************************
int main() {
  return 0;
}
**********************************
int main(int argc, char* argv[]) {
  return 0;
}
**********************************
and the return statement is optional
```

5.1. Parameter Transmission Modes

- The C language has one mode
- C++ has three modes:
  1. **value**: default; makes local copy
  2. **reference**: use &; pass the address
  3. **const reference**: for large objects

```
1 #include <iostream>
2 void f(int x) { ++x; }
3 void g(int& x) { ++x; }
4 int main() {
5   int i = 0, j = 0;
6   f(i);
7   g(j);
8   std::cout << i << j << std::endl; //output is 01
9 }
```

5.2. Arrays are passed by reference

```
 1 #include <iostream>
 2 const int MAX = 3;
 3 void f(int a[]) {
 4   for (int i = 0; i < MAX; ++i) {
 5     a[i] = i;
 6   }
 7 }
 8 int main() {
 9   int a[3];
10   f(a);
11   std::cout << a[2] << std::endl; //output is 2
12 }
```

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5.3. Static Function Variables

- Initialized upon first entry to the function
- Usually stored in global data segment

```
 1 #include <iostream>
 2 void f() {
 3   static int count = 0;
 4   int index = 0;
 5   std::cout << ++count << ++index << std::endl;
 6 }
 7 int main() {
 8   f();
 9   f();
10 }
************ output ****************
11
21
```

5.4. Default Parameter Values

- If no value is passed to formal parameter, a default value is assigned, left to right.
- Thus, x, on line 2, is assigned the ascii code for 'A', which is 65, on line 7:

```
 1 #include <iostream>
 2 void f(int x = 0, char ch = 'Z') {
 3   std::cout << x << ", " << ch << std::endl;
 4 }
 5 int main() {
 6   f(17, 'B');
 7   f('A');
 8   f();
 9 }
************ output ****************
17, B
65, Z
0, Z
```


5.5. Function Overload

- Two functions with same name but different parameter types
- The function return value cannot be used to resolve overload

```
#include <iostream>
void write(double x) {
  std::cout << "x is " << x << std::endl;
}
void write(int i) {
  std::cout << "i is " << i << std::endl;
}
int main() {
  double x = 2.5;
  write(7);  // output: i is 7
  write(x);  // output: x is 2.5
}
```

5.6. Command Line Parameters

- You can pass values into function main
- argc is number of parameters passed; argv is an array of C strings containing the values
- There's always at least one parameter passed: the name of the executable

```
 1 #include <iostream>
 2 int main(int argc, char* argv[]) {
 3   for (int i = 0; i < argc; ++i) {
 4     std::cout << argv[i] << '\t';
 5   }
 6   std::cout << std::endl;
 7 }
************ invocation ************
$ ./a.out 2 4 cat
************ output ****************
./a.out 2 4 cat
```

6. Namespaces

- We can use the scope operator (colon → ::) to access all three instances of number:

```
#include <iostream>
int number = 99;
namespace A {
  int number = 23;
}
int main() {
  int number = 0;
  std::cout << ::number << std::endl;
  std::cout << A::number << std::endl;
  std::cout << number << std::endl;
  return 0;
}
```