CS-202

C++ Primer (continued)

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Course Week

Course , Projects , Labs:

Monday	Tuesday	Wednesday	Thursday	Friday
			Lab (9:00-12:50)	
	CLASS		CLASS	
PASS Session	PASS Session	**Project DEADLINE**	NEW Project	

Your 1st Lab is today Thursday 8/31.

Your 1st Project will be announced today Thursday 8/31.

- Project is graded.
- Project Deadline is next Wednesday night 9/6 *(firm)*.

Today's Topics

Operators & Expressions

C++ Input/Output

Namespaces & Resolution

Statements & Flow Control

Scope & Resolution

Arrays

Operators & Expressions

Standard Arithmetic Operators

Precedence rules – standard rules

- Parentheses
- Multiplication (*), Division (/), Addition (+), Subtraction (-)
- Modulo (%)
- Exponents … (Note: Do not use (^) for exponents.)

Standard Relational Operators

Testing for:

- Equality (==) , Inequality (!=)
- Less (<) , More (>)
- Less/Equal (<=) , More/Equal (>=)
- Evaluate to (`true`) or (`false`)

Standard Logical Operators

Evaluating:

- Logical AND (&&) , OR (||) , NOT(!)
- Evaluate to (`true`) or (`false`)

Standard Bitwise Operators

Useful to conduct Bitwise operations:
(Boolean , bit-by-bit operations on Registers)

- AND (&) , OR (|) , XOR (^) , NOT(~)
- Bitwise Shifting Left (<<) , Right (>>)

Operators & Expressions

Operators (General)

A variety of operators in programming languages:

- Unary, Binary, Ternary
  (depends on number of operands, i.e. things they operate on)

Represented by special symbolic characters

- (+) means add($\cdot$, $\cdot$) , hence a binary operator.

Operators & Expressions

Expressions

Simple units of operands and operators combine into larger units, according to strict rules of precedence and associativity.

- Expression is each aggregate computable unit (simpler or larger).

Conditional Ternary Operator (?)

Composed of Expressions:

```
(Test_Expression) ? (Expression_If_TRUE) : (Expression_If_FALSE)

5==7 ? printf("5 equals 7") : printf("5 does not equal 7");

int a = (5==7) ? 1 : -1 ;
```

Operators & Expressions

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5==7 ? printf("5 equals 7") : printf("5 does not equal 7");
```

```
int a = (5==7) ? 1 : -1 ;
```

Operators & Expressions

Unary Operators

- Logical Negation (!)
  (! true) is false
  (! false) is true

- Post-Increment (• ++) and Post-Decrement (• --)
  (x ++) evaluates to (x) , x is increased by 1
  (x --) evaluates to (x), x is decreased by 1

- Pre-Increment (++ •) and Pre-Decrement (-- •)
  (++ x) evaluates to (x + 1) , x is increased by 1
  (-- x) evaluates to (x – 1) , x is decreased by 1

Operator Precedence Order

Postfix operators: ++ -- (left to right)
Prefix operators: ++ -- (right to left)
Unary operators: + - ! (right to left)
* / % (left to right)
+ - (left to right)
< > <= >=
== !=
&&
||
? :
Assignment operator: = (right to left)

Operators & Expressions

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Postfix operators: ++ -- (left to right)
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Unary operators: + - ! (right to left)
* / % (left to right)
+ - (left to right)
< > <= >=
== !=
&&
||
?:
Assignment operator: = (right to left)

Expression Examples:

A)
```
3  *  6  / 9
( 3  *  6 )  / 9
18 / 9
2
```

B)
```
int x, y, z;
x  =  y  =  z  =  0;
```

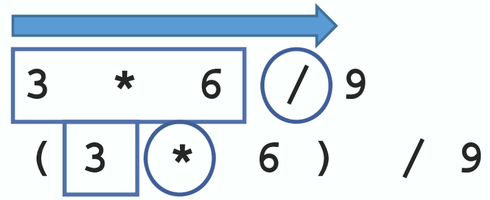
Operators & Expressions

Operator Precedence Order

Postfix operators: ++ -- (left to right)
Prefix operators: ++ -- (right to left)
Unary operators: + - ! (right to left)
* / % (left to right)
+ - (left to right)
< > <= >=
== !=
&&
||
?:
Assignment operator: = (right to left)

Expression Examples:

A)



B)

```
int x, y, z;
x = y = z = 0;
```

Operators & Expressions

Operator Precedence Order

Postfix operators: ++ -- (left to right)
Prefix operators: ++ -- (right to left)
Unary operators: + - ! (right to left)
* / % (left to right)
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< > <= >=
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Assignment operator: = (right to left)

Expression Examples:

A)
```
3  *  6  / 9
( 3  *  6 )  / 9
18 / 9
2
```

B)
```
int x, y, z;
x = y = z = 0;
x = y = z = 0;
x = y = z = 0;
```

Operators & Expressions

Operator Precedence Order

Postfix operators: ++ -- (left to right)
Prefix operators: ++ -- (right to left)
Unary operators: + - ! (right to left)
* / % (left to right)
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< > <= >=
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? :
Assignment operator: = (right to left)

Arithmetic precision of calculations

- C++ Rules are a VERY important consideration here !
- Expressions in C++ might not evaluate as you'd "expect"!

"Highest-order operand" determines type of arithmetic "precision".

Operators & Expressions

Operator Precedence Order

Postfix operators: ++ -- (left to right)
Prefix operators: ++ -- (right to left)
Unary operators: + - ! (right to left)
* / % (left to right)
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< > <= >=
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Assignment operator: = (right to left)

Arithmetic precision of calculations

"Highest-order operand" determines type of arithmetic "precision".

- 17 / 5 evaluates to 3 in C++!

Both operands are integers, hence integer division is performed.

- 17.0 / 5 evaluates to 3.4 in C++!

Highest-order operand is double, hence double precision division is performed.

Operators & Expressions

Operator Precedence Order

Postfix operators: ++ -- (left to right)
Prefix operators: ++ -- (right to left)
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Assignment operator: = (right to left)

Arithmetic precision of calculations

"Highest-order operand" determines type of arithmetic "precision".

- 17 / 5 evaluates to 3 in C++!
  Both operands are integers, Integer division.
- 17.0 / 5 evaluates to 3.4 in C++!
  Highest-order operand is double, Double precision division.

- ```
  int intVar1 = 1, intVar2 = 2;
  double doubleVar = intVar1 / intVar2;
  ```

doubleVar is 0.0 !
  ```

Operators & Expressions

Operator Precedence Order

Postfix operators: ++ -- (left to right)
Prefix operators: ++ -- (right to left)
Unary operators: + - ! (right to left)
* / % (left to right)
+ - (left to right)
< > <= >=
== !=
&&
||
? :
Assignment operator: = (right to left)

Arithmetic precision of calculations

"Calculations executed sequentially"

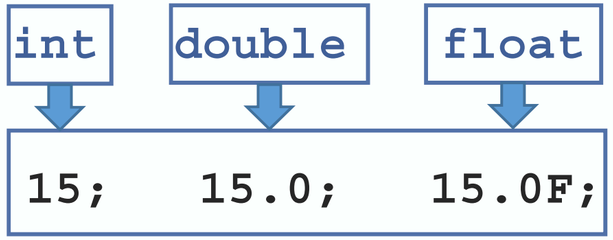
- 1 / 2 / 3.0 / 4 performs 3 separate divisions.
  (1 / 2) equals 0
  (0 / 3.0) equals 0.0
  (0.0 / 4) equals 0.0!

- "Just one operand" can change the result of a large expression.
- Have to bear in mind all operands & operators rules!

Operators & Expressions

Type Casting Operator ( )• or (•)

Perform explicit type-casting conversion
Can add ".0" to literals to force precision:




```
convertedVar = (new_type)originalVar;
convertedVar = new_type(originalVar);

double x = (double) intVar1 / intVar2;
double x = double( intVar1 / intVar2 );
```

Casting to force double-precision division among two integer variables! DOES IT?

Alternative C++ expression:

```
double x = static_cast<double>(X);
```

Operators & Expressions

Type Casting Operator ( )• or (•)

Perform explicit type-casting conversion
Can add ".0" to literals to force precision: `15;` `15.0;` `15.0F;`

```
convertedVar = (new_type)originalVar;
convertedVar = new_type(originalVar);
```

valid C++ expression

```
double x = (double) intVar1 / intVar2;
double x = double( intVar1 / intVar2 );
```

Casting to force double-precision division among two integer variables! DOES IT?

Alternative C++ expression:

```
double x = static_cast<double>(X);
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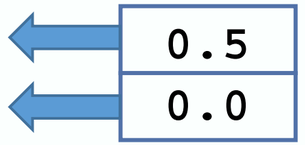
Operators & Expressions

Type Casting Operator ( )• or (•)

Perform explicit type-casting conversion
Can add ".0" to literals to force precision: `15;` `15.0;` `15.0F;`

```
convertedVar = (new_type)originalVar;
convertedVar = new_type(originalVar);
```

```
double x = (double) intVar1 / intVar2;
double x = double( intVar1 / intVar2 );
```



(For `intVar1=1`, `intVar2=2`)

Casting to force double-precision division among two integer variables! DOES IT?

Alternative C++ expression:

```
double x = static_cast<double>(X);
```

Type Conversion

- Implicit (or "Automatic")

  Done by the compiler:

```
17 / 5.5;
```

  "Implicit type cast" 17 → 17.0

- Explicit type conversion

  Programmer-enforced:

```
(double)17 / 5.5;
double(17) / 5.5;
static_cast<double>17 / 5.5;
```

Operators & Expressions

Shorthand Operators

- Arithmetic operation & Assignment

EXAMPLE	EQUIVALENT TO
`count += 2;`	`count = count + 2;`
`total -= discount;`	`total = total - discount;`
`bonus *= 2;`	`bonus = bonus * 2;`
`time /= rushFactor;`	`time = time/rushFactor;`
`change %= 100;`	`change = change % 100;`
`amount *= cnt1 + cnt2;`	`amount = amount * (cnt1 + cnt2);`

Also shorthands:

- Post-increment/decrement: `i++` (increment/decrement *then* evaluate expression)
- Pre-increment/decrement: `++i` (evaluate expression *then* increment/decrement)

Input / Output

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

3   int main( )
4   {
5       int numberOfLanguages;

6       cout << "Hello reader.\n"
7            << "Welcome to C++.\n";

8       cout << "How many programming languages have you used? ";
9       cin >> numberOfLanguages;

10      if (numberOfLanguages < 1)
11          cout << "Read the preface. You may prefer\n"
12               << "a more elementary book by the same author.\n";
13      else
14          cout << "Enjoy the book.\n";

15      return 0;
16  }
```

Console
Input / Output

Console Input / Output

- Console Input and Output objects in C++ are called:
  `cin, cout, cerr`
- Defined in the C++ library called `<iostream>`

Useful for:

- User input
- User output
- Error messages (exclusive stream, redirection if required)

Input / Output

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6       cout << "Hello reader.\n"
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15      return 0;
16  }
```

Preprocessor directives

Note:
`using namespace std;`
Without it:
`std::cout`
`std::cin`
`std::cerr`

Console Output (`std::cout`)

Any standard C++ data can be output:

- Variables
- Constants
- Literals
- Expressions (which can include all of above)

```
cout << numberOfGames << " games played.";
```

2 values are output:

Value of variable `numberOfGames`

Literal string `" games played."`

- Cascading: multiple values in one `cout`.

Note:
Insertion Operators

Input / Output

Output

New lines in output

- Escape sequences are valid: `"\n"` is "newline"

SEQUENCE	MEANING
\n	New line
\r	Carriage return (Positions the cursor at the start of the current line. You are not likely to use this very much.)
\t	(Horizontal) Tab (Advances the cursor to the next tab stop.)
\a	Alert (Sounds the alert noise, typically a bell.)
\\	Backslash (Allows you to place a backslash in a quoted expression.)
\'	Single quote (Mostly used to place a single quote inside single quotes.)
\"	Double quote (Mostly used to place a double quote inside a quoted string.)

A second method:

- Object `std::endl`
- Flushes output buffer (`std::flush`)

Examples:

```
cout << "Hello World\n";

cout << "Hello World" << endl;
```

- Makes sense to *force output* of heavy, crash-prone processes.
- Creates overhead.
- Same in line-buffered context.

Input / Output

Console Input (`std::cin`)

No literals allowed for `cin`

- Must input to a variable

Waits on-screen for keyboard entry

- `cin >> num;`

Value entered at keyboard is 'assigned' to **num**.

```
cin >> firstName >> lastName >> age;
```

Note:
Extraction Operators

- Skips any leading whitespaces, and stops reading at next whitespace.
- Can also be cascaded, separates each "type" of thing we read in.

User Input /Output

Prompt user for input

```
cout << "Enter number of objects: ";
cin >> numOfObjects;
```

Note:
no `"\n"` in cout . Prompt "waits" on same line for keyboard input.

User-friendly input/output design:

- Every `cin` should have a corresponding prior `cout` prompt.

User Input /Output

Prompt user for input

```
1  //Program to demonstrate cin and cout
2  #include <iostream>
3  #include <string>

4  using namespace std;
5  int main( )
6  {
7    string dogName;
8    int actualAge;
9    int humanAge;

10   cout << "How many years old is your dog?" << endl;
11   cin >> actualAge;
12   humanAge = actualAge * 7;

13   cout << "What is your dog's name?" << endl;
14   cin >> dogName;

15   cout << dogName << "'s age is approximately " <<
16          "equivalent to a " << humanAge << " year old human."
17          << endl;

18   return 0;
19 }
```

User Input /Output

Prompt user for input

Sample Dialogue 1

```
How many years old is your dog?
5
What is your dog's name?
Rex
Rex's age is approximately equivalent to a 35 year old human.
```

Sample Dialogue 2

```
How many years old is your dog?
10
What is your dog's name?
Mr. Bojangles
Mr.'s age is approximately equivalent to a 70 year old human.
```

"Bojangles" is not read into `dogName` *because* `cin` *stops input at the space.*

User Input /Output

Prompt user for input

Note:
By default, will skip whitespace !

```
std::noskipws
std::skipws

cin << skipws << … ;
```

Sample Dialogue 1

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How many years old is your dog?
5
What is your dog's name?
Rex
Rex's age is approximately equivalent to a 35 year old human.
```

Sample Dialogue 2

```
How many years old is your dog?
10
What is your dog's name?
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Mr.'s age is approximately equivalent to a 70 year old human.
```

"Bojangles" is not read into `dogName` *because* `cin` *stops input at the space.*

Error Output (`std::cerr`)

`cerr` works same as `cout`

- Mechanism for distinguishing between regular output and error output
- Most systems allow `cout` and `cerr` to be "redirected" to other devices
  e.g., line printer, output file, error console, etc.

Output Format

Numeric values may not display as you'd expect:

```
cout << "The price is $" << price << endl;
```

If `double price = 78.5;` we might get:

```
The price is $78.500000
The price is $78.5
```

- Force Decimals:

```
cout.setf(ios::fixed);
cout.setf(ios::showpoint);
cout.precision(2);
```

Fixed Precision
Show Decimal Point
Set Precision Decimals

File Input / Output

Similarly to **cin**, a combination of:

- **cin >> num;**

Input Object (C++)
Extraction Operator
Variables

At the top:

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

An input stream object (creation just as with any other variable):

```
ifstream inputStream;
```

Connect the **inputStream** variable to a text file (via pathname):

```
inputStream.open("filename.txt");
```

File Input / Output

Read-in by using the Extraction Operator (>>):

```
inputStream >> var;
```

The result is the same as using `cin >> var` except the input is coming from the text file and not the keyboard.

Check that EOF hasn't been reached:

```
if ( !inputStream.eof() )
```

Close with :

```
inputStream.close();
```

File Input / Output

Output (similarly):

An output stream object (creation just as with any other variable):

```
ofstream outputStream;
```

Open file to write:

```
outputStream.open("filename.txt", ofstream::out);
```

or

```
outputStream.open("filename.txt");
```

Write-out by using the Insertion Operator (<<):

```
outputStream << var;
```

Close with :

```
inputStream.close();
```

File Input / Output

```
1  #include <iostream>
2  #include <fstream>
3  #include <string>

4  using namespace std;
5  int main( )
6  {
7       string firstName, lastName;
8       int score;
9       fstream inputStream;

10      inputStream.open("player.txt");

11      inputStream >> score;
12      inputStream >> firstName >> lastName;

13      cout << "Name: " << firstName << " "
14           << lastName << endl;
15      cout << "Score: " << score << endl;
16      inputStream.close();

17      return 0;
18 }
```

player.txt

```
100510
Gordon Freeman
```

Sample Dialogue

```
Name: Gordon Freeman
Score: 100510
```

Namespaces - Resolution

Namespaces

Collection of name definitions

Most common is `namespace std`

- Has all standard library definitions we need

The `using` keyword: Instruct the compiler to resolve names

Examples:

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

or

```
#include <iostream>
using std::cin;
using std::cout;
```

Namespaces - Resolution

Namespaces

Collection of name definitions

- Most common is **`namespace std`**
- ➢ Has all standard library definitions we need

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Examples:

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or

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Includes entire standard library of name definitions:
`cout , cin , cerr , endl`

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Most common is **`namespace std`**

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Examples:

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using namespace std;
```

or

```
#include <iostream>
using std::cin;
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```

Includes entire standard library of name definitions:
`cout , cin , cerr , endl`

Specify just the objects we want

Namespaces - Resolution

Resolution Operator (::)

Explicit resolution under Namespace

Objects: `std::cout`

Functions: `std::count( its, itl, val)`

In case of conflict, it *might* supersede any `using` keyword usage:

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

namespace ns{
    …
    int cout;
    …
}
```

Namespace declaration

Namespaces - Resolution

Resolution Operator (::)

Explicit resolution under Namespace

Objects: `std::cout`

Functions: `std::count( its, itl, val)`

In case of conflict, it *might* supersede any `using` keyword usage:

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

```
namespace ns{
    …
    int cout;
    …
}
```

Namespace declaration

- `cout` evaluates to `std::cout`
- `ns::cout` evaluates to the variable in `ns`

Statements

A complete unit of execution (equivalent to a sentence in a language).

- Expression statements
  - Assignment expressions
  - Use of (++) or (--)
  - Method invocations
  - Object creation

End with semicolon (`;`)

- Flow Control statements
  - Selection structures
  - Repetition/Iteration structures

Follow Scope rules

Statements

Flow Control Statements

- If / then / else

```
if (x == 0)
 cout << "0";
cout << "Done";
```

```
if (x == 0)
 cout << "0";
else
 cout << "not 0";
cout << "Done";
```

Brace-enclosed **Block**

```
if (x == 0){
 cout << "x is ";
 cout << "0";
}
else{
 cout << "x is ";
 cout << "not 0";
}
cout << "Done";
```

Block: a group of zero or more statements that are grouped together by delimiters (in C++ braces '{' and '}')

- Good practice is to include the curly braces even for single-liners.

Statements

Flow Control Statements

- If / then / else

```
if (x == 0)
 cout << "0";
cout << "Done";
```

```
if (x == 0)
 cout << "0";
else
 cout << "not 0";
cout << "Done";
```

Note (take care!) :

```
if (x = 0)
 cout << "1";
cout << "Done";
```

Brace-enclosed **Block**

```
if (x == 0){
 cout << "x is ";
 cout << "0";
}
else{
 cout << "x is ";
 cout << "not 0";
}
cout << "Done";
```

Block: a group of zero or more statements that are grouped together by delimiters (in C++ braces '{' and '}')

- Good practice is to include the curly braces even for single-liners.

Flow Control Statements

- Switch

- The switching value must evaluate to an integer or enumerated type
- The case values must be constant or literal or enum value
- The case values must be of the same type as the switch expression

Notes:
- **`break`** statements are typically used to terminate each **`case`**.
- It is usually a good practice to include a **`default`** case.

```
switch(cardValue) {
 case 11:
  cout << "Jack";
  break;
 case 12:
  cout << "Queen";
  break;
 case 13:
  cout << "King";
  break;
 default:
  cout << cardValue;
  break;
}
```

Flow Control Statements

- Switch

- The switching value must evaluate to an integer or enumerated type
- The case values must be constant or literal or enum value
- The case values must be of the same type as the switch expression

Notes:
- **break** statements are typically used to terminate each **case**.
- Without a **break** statement, cases "fall through" to the next statement.

```
switch(cardValue) {
 case 11:
  cout << "Jack";
  
 case 12:
  cout << "Queen";
  
 case 13:
  cout << "King";
  
 default:
  cout << cardValue;
  
}
```

Flow Control Statements

- While

Executes a block of statements while a particular condition/expression is **`true`**

```
int count = 0;
while(count < 10) {
     cout << count;
     count++;
}
```

- Do While

Performs at least one block execution

```
int count = 0;
do {
     cout << count;
     count++;
} while(count < 10   &&   count > 0)
```

Flow Control Statements

- For

  Iterate over a range of values.

```
for ( init; term; incr ) {
    …
}
```

- The *initialization* expression initializes the loop it is executed once, as the loop begins.
- Loop ends when the *termination* expression evaluates to **`false`**.
- The *increment* expression is invoked after each iteration.

```
for (int count = 0; count < 10; count++) {
   cout << count;
}

for (int count = 25; count < 50; count += 5){
   cout << count;
}
```

Flow Control Statements

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  Iterate over a range of values.

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for ( init; term; incr ) {
    …
}
```

- The *initialization* expression initializes the loop it is executed once, as the loop begins.
- Loop ends when the *termination* expression evaluates to **`false`**.
- The *increment* expression is invoked after each iteration.

```
for ( ; ; ) {
    cout << "Running" << endl;
}
```

```
for (int count = 0 ; ; ++count){
    cout << count;
}
```

Scope

You can define new variables in many places in your code.
So where is it in effect / What is its Variable Scope?

- The set of statements in which the variable is known to the compiler.

Where a variable can be referenced from in your program
Limited to the code block in which the variable is defined

```
if(age >= 18) {
  bool adult = true;
  cout << adult;
}
cout << adult;
```

```
bool adult = false;
if(age >= 18) {
  bool adult = true;
  cout << adult;
}
cout << adult;
```

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}
cout << adult;
```

```
bool adult = false;
if(age >= 18) {
  bool adult = true;
   cout << adult;
}
cout << adult;
```

The Block Scope {}
(it's more generic)

```
bool adult = false;
{
  bool adult = true;
  cout << adult;
}
cout << adult;
```

Scope Resolution (Ambiguities)

Revisiting `using namespace std;`

Functions: `std::count( its, itl, val)`

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

int count = 0;
int increment() {
  return ++count;
}
```

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

int increment() {
  int count = 0;
  return ++count;
}
```

Long error code…

```
error: reference to 'count' is ambiguous: note: candidates are: int count In file included from
/usr/include/c++/4.9/algorithm:62:0, from 2: /usr/include/c++/4.9/bits/stl_algo.h:3947:5: note: template<class
_IIter, class _Tp> typename std::iterator_traits<_Iterator>::difference_type std::count(_IIter, _IIter, const
_Tp&) count(_InputIterator __first, _InputIterator __last, const _Tp& __value)
```

Scope Resolution (Ambiguities)

Revisiting `using namespace std;`

Functions: `std::count( its, itl, val)`

Why?

```
#include <algorithm>

int increment() {
  using namespace std;
  int count = 0;
  return ++count;
}
```

```
#include <algorithm>
int count = 0;

int increment(){
    using namespace std;
    return ++count;
}
```

Ambiguous

Scope Resolution (Ambiguities)

Revisiting `using namespace std;`
Functions: `std::count( its, itl, val)`

Rule looks at Global Scope

- Behaves "as-if" it's placed together with `#include` statements, even though it's trying to import names into the Local Scope only.

```
#include <algorithm>

int increment() {
  using namespace std;
  int count = 0;
  return ++count;
}
```

```
#include <algorithm>
int count = 0;

int increment(){
    using namespace std;
    return ++count;
}
```

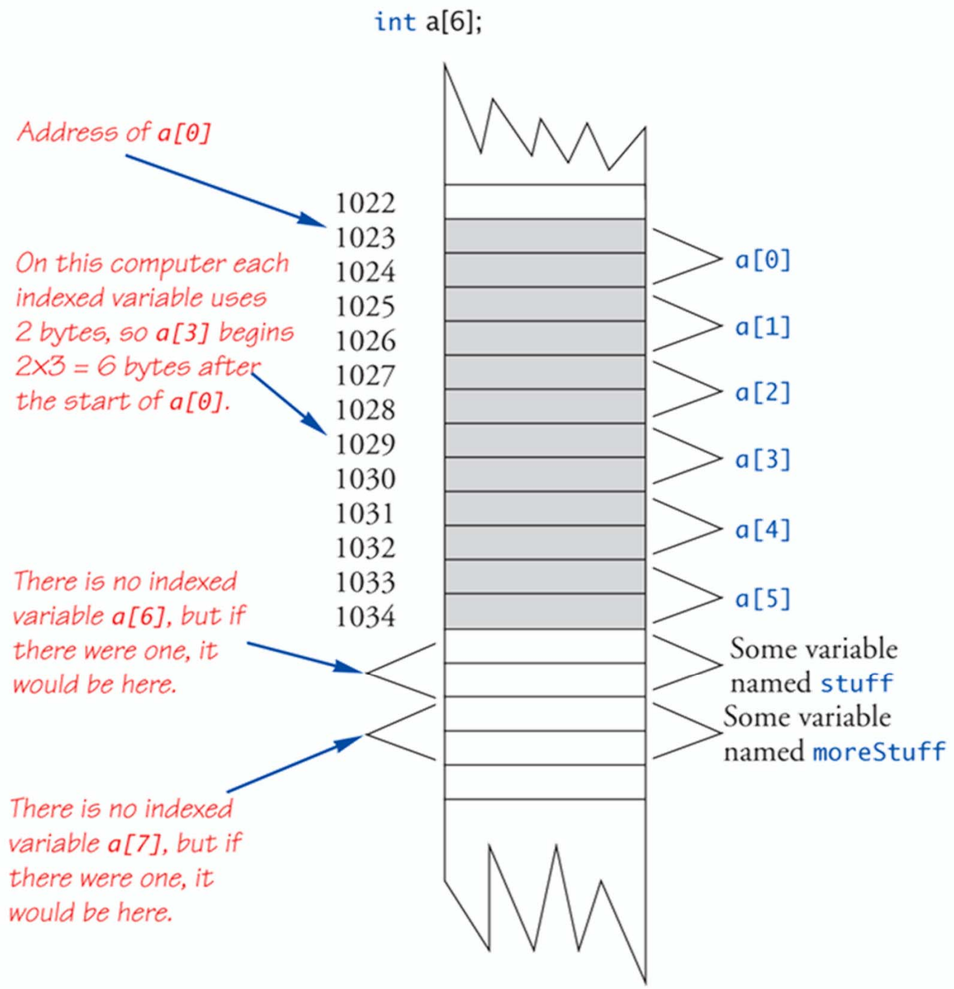
Ambiguous

Arrays

A collection of related data items.

- Can be of any data type.
- They are static
  Their size does not change.

They are declared contiguously in memory. In other words, an array's data is stored in one big block, together.



Arrays

Recall simple variables:

- Allocated memory in an "address"

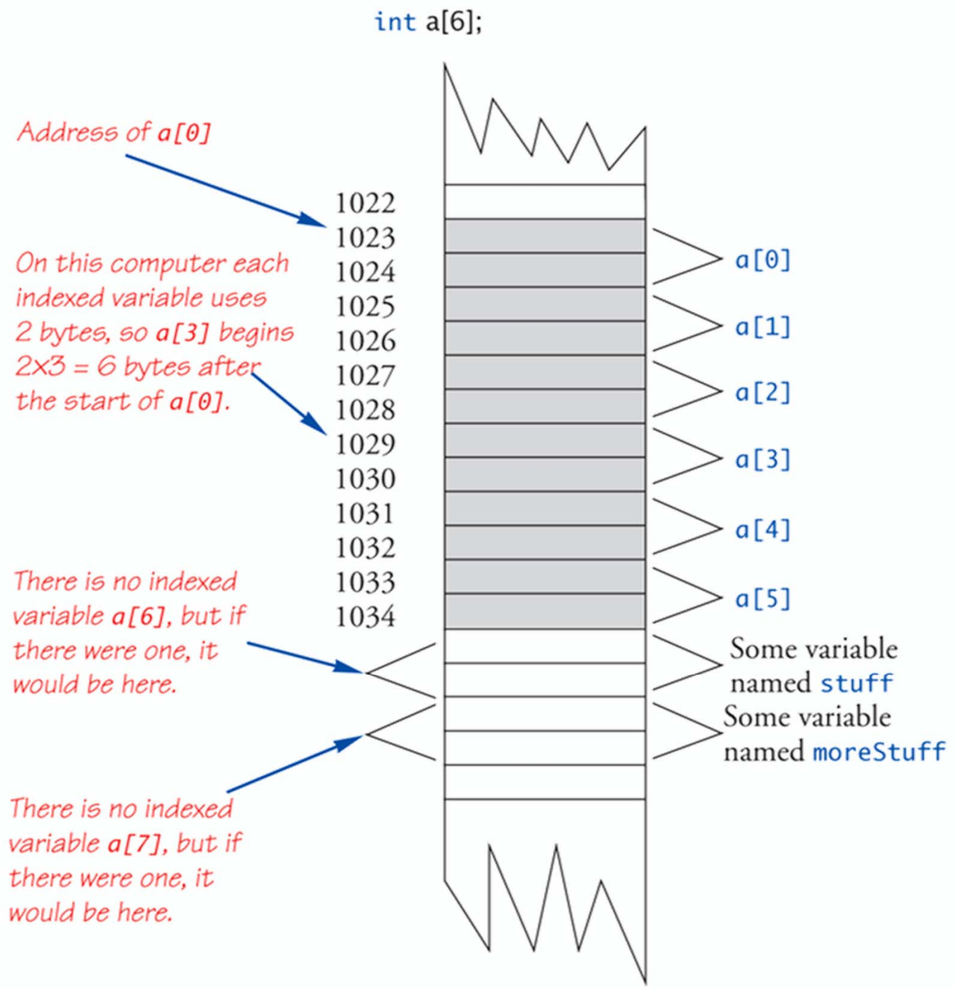
Array declarations allocate memory for entire array

- Sequential allocation

  Addresses allocated "back-to-back".

  Allows indexing calculations.

  Simple "addition" from array beginning (index 0).



Array Declaration

```
<type> <name> [size];
float  xArray [10];
```

This array now has memory to hold **`size=10`** floats.

0-based indexing (0 is our natural "first" number):

`xArray[9];` At **`size-1`** lies the final element of the array.

C++ pitfall:

The compiler will "let you go" beyond **`size-1.`**

Compiler will not detect this as an error.

```
xArray[10] = 1.0F;
```

Unpredictable results! Up to programmer to "stay in range".

Array Limitations

- Does not know how large it is – there is no C++ `size()` function for arrays.
- No bounds checking is performed.

Arrays are static

- Size must be known at compile time (cannot change once set).
  Can't do user input for array size: "How many numbers would you like to store?"

C / C++ Benefits:

- Efficiency.
- Backwards Compatibility.

Array Initialization

- A declaration does not initialize the data stored in the memory locations.
- They will contain "garbage" leftover data.

Declaration - initialization:

```
int numbers[5] = { 5, 2, 6, 9, 3 };
```

5	2	6	9	3

Auto – initialization (fewer values than the given size) :

- Fills values starting at the beginning.
- Remainder is filled with that data type's "zero".

If no array size is given array is created only as big as is needed.

```
int yArray[] = { 5, 12, 11 };
```

Allocates array **`yArray`** to hold 3 integers

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Allocates array **yArray** to hold 3 integers

C-strings (as Arrays)

- They are **`char`** type arrays.

- Initialization (normal way):

```
char name[5] = {'J', 'o', 'h', 'n', 0};
```

- Initialization (string constant literal):

```
char name[5] = "John" ;
```

NULL-char delimited !

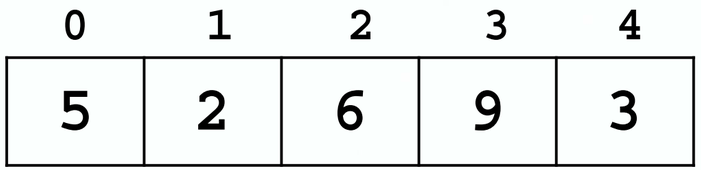
Note: Different quotes have different purposes !!!

- Double quotes are for strings
- Single quotes are for chars (characters)

Array Element Access

Bracket Operator ([•]):

- Access of a single element (when used on existing instance).




```
int numbers[5] = { 5, 2, 6, 9, 3 };
cout << " The third element is" << numbers[2] << endl;
```

Output:

```
The third element is 6
```

Array Element Access

- C++ also accepts any expression as a "subscript" (must evaluate to an integer, based on known values at compile-time).

```
int start = 0, end = 4;
double dNumbers[(start + end) / 2];
```

Note: Make sure you initialize these, otherwise you might never notice a problem until it's too late!

```
int start, end;
double dNumbers[(start + end) / 2];
dNumbers[0] = -1.0;
cout << (start+end)/2 << "," <<
 dNumbers[0] << "," << dNumbers[100];
```

Array Size using Constants

- Use defined/named constants for your size.

or

```
#define NUMBER_OF_STUDENTS 5
const int NUMBER_OF_STUDENTS = 5;

int score[NUMBER_OF_STUDENTS];
```

Readability, Versatility, Maintainability

Arrays (as Arguments in Functions)

- Indexed variables (individual element of an array is passed):

Function declaration:

```
void myFunction(double param1);
```

Variables:

```
double n, a[10];
```

Function calls:

```
myFunction( a[3] );
myFunction( n );
```

A `double` in both cases

Arrays (as Arguments in Functions)

- Entire arrays (passed by the array's name)
  Must pass **`size`** of array as well, done as second parameter of **`int`**-type.

SAMPLE DIALOGUEFUNCTION DECLARATION

```
void fillUp(int a[], int size);
```

SAMPLE DIALOGUEFUNCTION DEFINITION

```
void fillUp(int a[], int size)
{
    cout << "Enter " << size << " numbers:\n";
    for (int i = 0; i < size; i++)
        cin >> a[i];
    cout << "The last array index used is " << (size - 1) << endl;
}
```

Arrays (as Arguments in Functions)

- Entire arrays (passed by the array's name)
  Example code inside a program `main()`:

```
void fillUp( int a[], int size);

int score[5], numberOfScores = 5;
fillUp(score, numberOfScores);
```

Brackets in function definition.

Brackets in variable declaration.

No brackets when passing!

- How does this work? What's really passed?
  Address-Of first indexed variable (**`arrName[0]`**).

Multi-Dimensional Arrays

- Arrays with more than one index

```
char array2d [DIM2][DIM1];
char page [30][100];
```

- Two indices (it is an "*array of arrays*")

```
page[0][0],  page[0][1],  ..., page[0][99]
page[1][0],  page[1][1],  ..., page[1][99]
...
page[29][0], page[29][1], ..., page[29][99]
```

- C++ allows any number of indexes
  Typically no more than two or three

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```
char array2d [DIM2][DIM1];
char page [30][100];
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COLS

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```

Array of Arrays

- C++ allows any number of indexes
  - Typically no more than two or three

Multi-Dimensional Arrays

- Indexing with Bracket Operator ([•])

```
char a = array2d [j][i];
```

- Multi-Dimensional Arrays as Parameters (Similar to one-dimensional array)

  1st dimension size not given (#ROWS), provided as second parameter of function

  2nd dimension size is given (#COLS)

```
void DisplayPage(char page[][100], int numRows) {
    for ( int i = 0; i < numRows; i++ ) {
        for ( int j = 0; j < 100; j++ ) {
            cout << page[i][j];
        }
        cout << endl;
    }
}
```

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        cout << endl;
    }
}
```

CS-202

Time for Questions !