C++ Jump Start

Data Structures
C++ for C Coders

한동대학교 김영섭교수
idebtor@gmail.com

C++ for C Coders

Getting Started

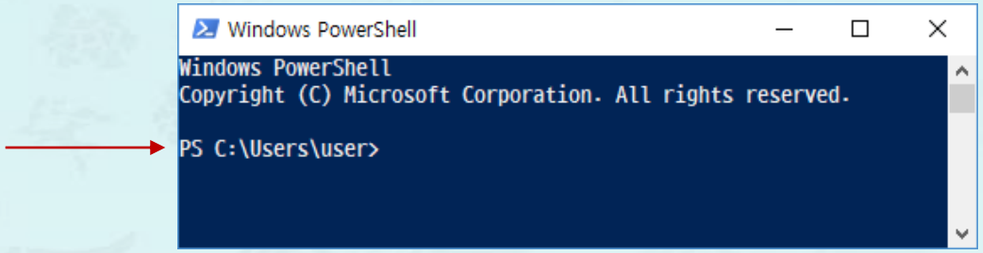
- Creating and using a console
  - cmd, PowerShell
  - bash (Borne-again) shell
  - Linux bash etc.
- Install GNU C/C++ compiler
- Install Atom
- Install Git and GitHub Desktop
- Read
  - github.com/idebtor/nowic/**README**
  - github.com/idebtor/nowic/**GettingStarted**

C++ for C Coders

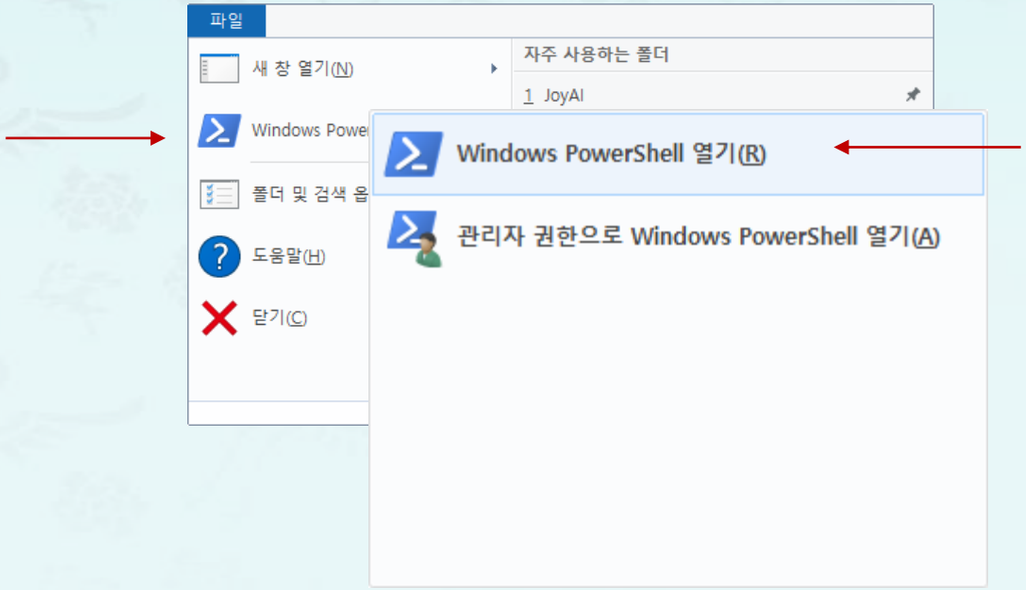
- C vs C++
- "Hello World!" program
- Scope resolution operator
- Call-by-value vs. Call-by-reference
- Overloading
- Input/Output
- Command line processing
- Labs and Quizzes

Start a console

1. Start PowerShell through "Start" menu

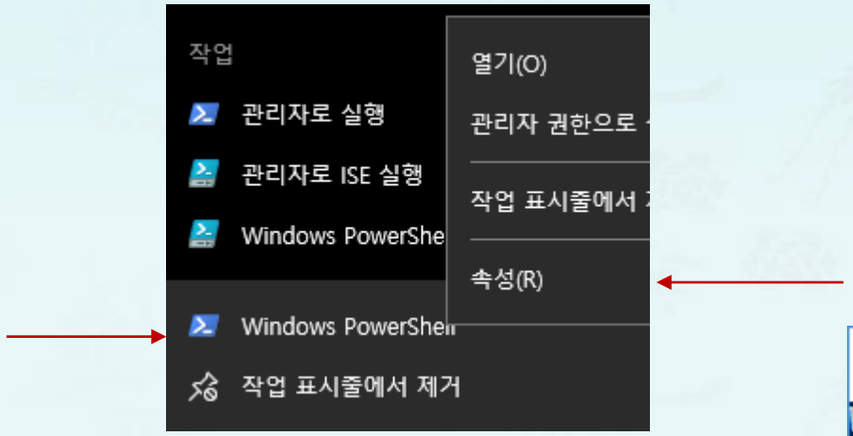


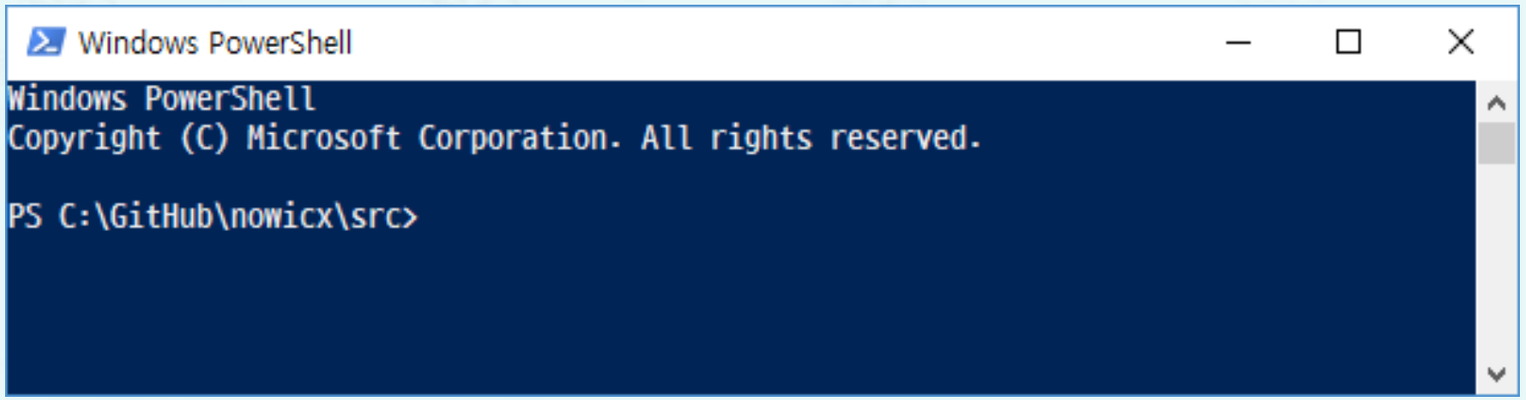
2. Move to the folder you want to start.
   - Click the "File" menu at the top left corner o
   - PowerShell or cmd windows
   - Enter a command at console. For example, **atom myfile.txt**



Start a console at your favorite folder

1. Start PowerShell if you don't have a PowerShell icon in Taskbar.
2. In the Taskbar right-click and pin to keep a link there.
3. **Again right click the icon in taskbar** and then right-click Windows PowerShell and choose Properties
4. Enter your preferred directory in the Start in: input field and press OK.
5. Start from the taskbar icon





PowerShell, Cmd, vs Bash (Borne-again shell), sh, ksh, csh

PowerShell (Cmdlet)	PowerShell (Alias)	Windows Cmd	Unix shell	Description
Get-ChildItem	gci, dir, ls	dir	ls	Lists all files and folders in the current or given folder
Get-Content	gc, type, cat	type	cat	Gets the content of a file
Get-Command	gcm	help	type, which	Lists available commands
Get-Help	help, man	help	man	Prints a command's documentation on the console
Clear-Host	cls, clear	cls	clear	Clears the screen
Copy-Item	cpi, copy, cp	copy, xcopy	cp	Copies files and folders to another location
Move-Item	mi, move, mv	move	mv	Moves files and folders to a new location
Remove-Item	ri, del, rmdir, rd, rm	del, rmdir, rd	rm, rmdir	Deletes files or folders
Rename-Item	rni, ren, mv	ren, rename	mv	Renames a single file, folder, hard link or symbolic link
Get-Location	gl, cd, pwd	cd	pwd	Displays the working path (current folder)
Pop-Location	popd	popd	popd	Changes the working path to the location most recently pushed onto the stack
Push-Location	pushd	pushd	pushd	Stores the working path onto the stack
Set-Location	sl, cd, chdir	cd, chdir	cd	Changes the working path, cd .. (move to parent folder), cd ~ (move to HOME folder)
Write-Output	echo, write	echo	echo	Prints strings or other objects to the standard output
Get-Process	gps, ps	tlist, tasklist	ps	Lists all running processes
Stop-Process	spps, kill	kill, taskkill	kill	Stops a running process
Select-String	sls	findstr	find, grep	Prints lines matching a pattern
Set-Variable	sv, set	set	env, export, set, setenv	Creates or alters the contents of an environment variable

Install GNU C/C++ Compiler

- MinGW = "Minimalist GNU for Windows“
  MSYS = "Minimal SYStem", is a Bourne Shell command line interpreter system

1. **MinGW/MSYS – stable, 32-bit systems, works fine everywhere**
2. **MinGW-w64, MSYS2 – hard to install in some computers**
3. **MinGW, MSYS2 – new trend**

Install GNU C/C++ Compiler (MinGW/MSYS)

- MinGW = "Minimalist GNU for Windows“
  MSYS = "Minimal SYStem", is a Bourne Shell command line interpreter system

- Install **mingw**
  - **http://holawang.blogspot.kr/2014/02/gcc-installing-gcc-at-windowsmingw-or.html**

- Add the following path to the PATH environment variable
  - **c:/MinGW/bin**
  - **c:/MinGW/msys/1.0/bin**

- Add .bash_profile
  - C:/MinGW/msys/1.0/home/user/.bash_profile

Install GNU C/C++ Compiler (MinGW-w64, MSYS2)

- MinGW = "Minimalist GNU for Windows“
  MSYS = "Minimal SYStem", is a Bourne Shell command line interpreter system

- Install **MinGW-w64**
  https://sourceforge.net/projects/mingw-w64/

- Install MSYS2
  http://www.msys2.org/

- Add the following path to the PATH environment variable
  - C:/msys64/user/bin

check your home folder

- Add .bash_profile
  - C:/msys64/home/user/.bash_profile

check your home folder

.bash_profile (an example)

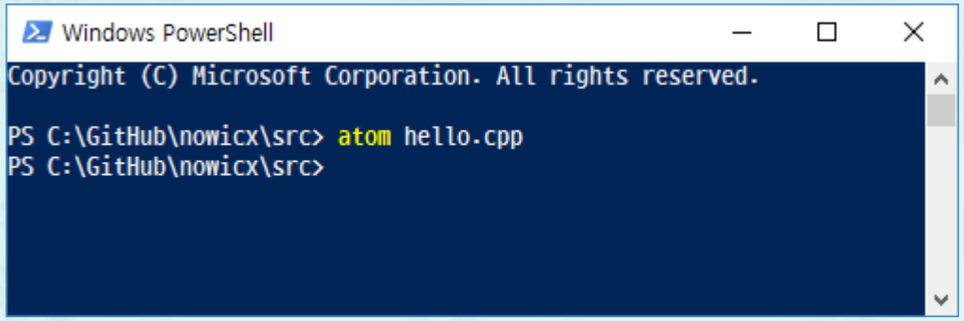
```
alias ls='ls -Gp --color=auto'
alias ll='ls –alkF'
alias rm='rm -i'
alias h='history‘
LS_COLORS=$LS_COLORS':no=00:di=36;01‘
LS_COLORS=$LS_COLORS':*.h=1;33:*.exe=31:*.o=1;32:*.md=1;33'
export LS_COLORS
export PATH=$PATH:"C:\Program Files\mingw-w64\x86_64-8.1.0-posix-seh-rt_v6-rev0\mingw64\bin"

### replace 'user' with your own user name in the following line:
export PATH=$PATH:"C:\Users\user\AppData\Local\atom\bin"
echo $PWD

# Setting my dev folder as a startup folder of msys.
HOME="/c/GitHub/nowic"
cd $HOME
echo $PWD

# @$(hostname) may be added, if necessary, after $(whoami)
GREEN="$(tput setaf 2)"
RESET="$(tput sgr0)"
PS1='${GREEN}$(pwd -W)> ${RESET}'
```

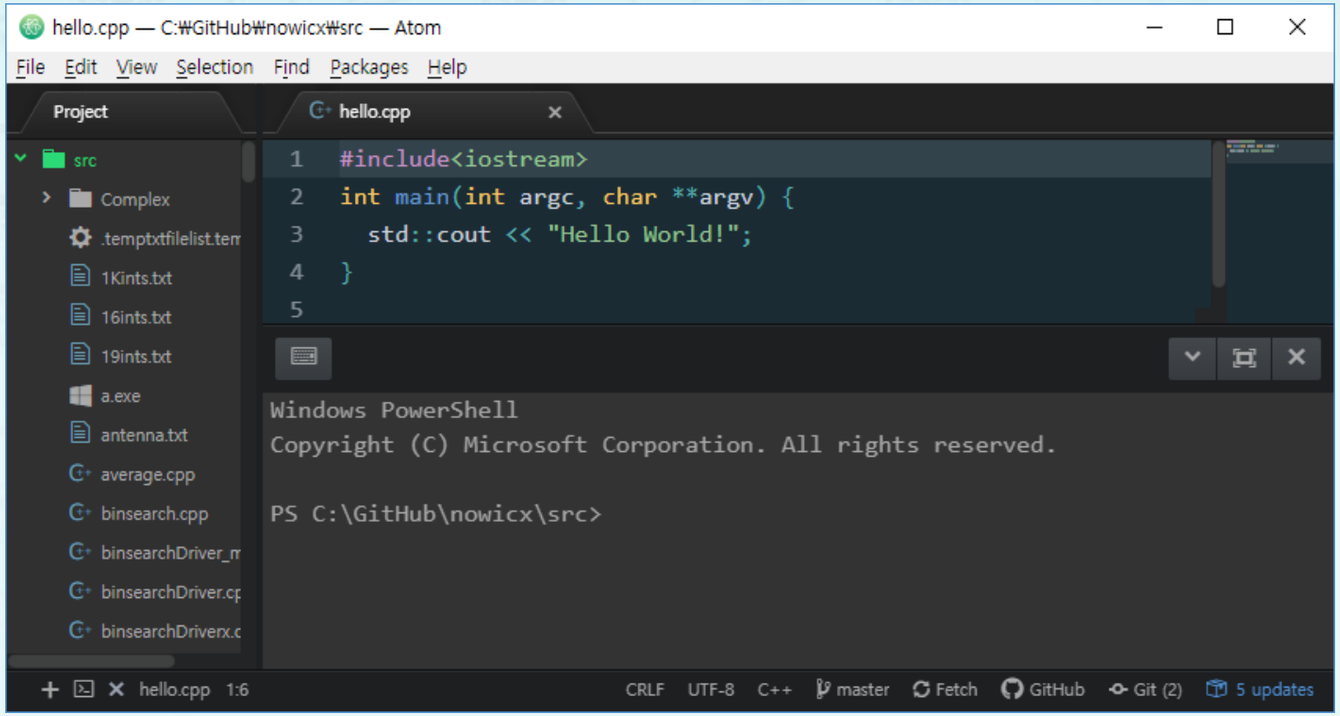
← This is the folder Atom is installed.

check your home folder

Install Atom

1. Install **Atom.**
2. Start Atom to edit a text file at a console.
   - start a console (or console window)
   - select Windows PowerShell
   - start the following command at console
     atom hello.cpp
3. Add the following packages
   - gpp-compiler
   - Platformio-ide-terminal
   - File-icons
   - Markdown-preview
   - Mini-maps

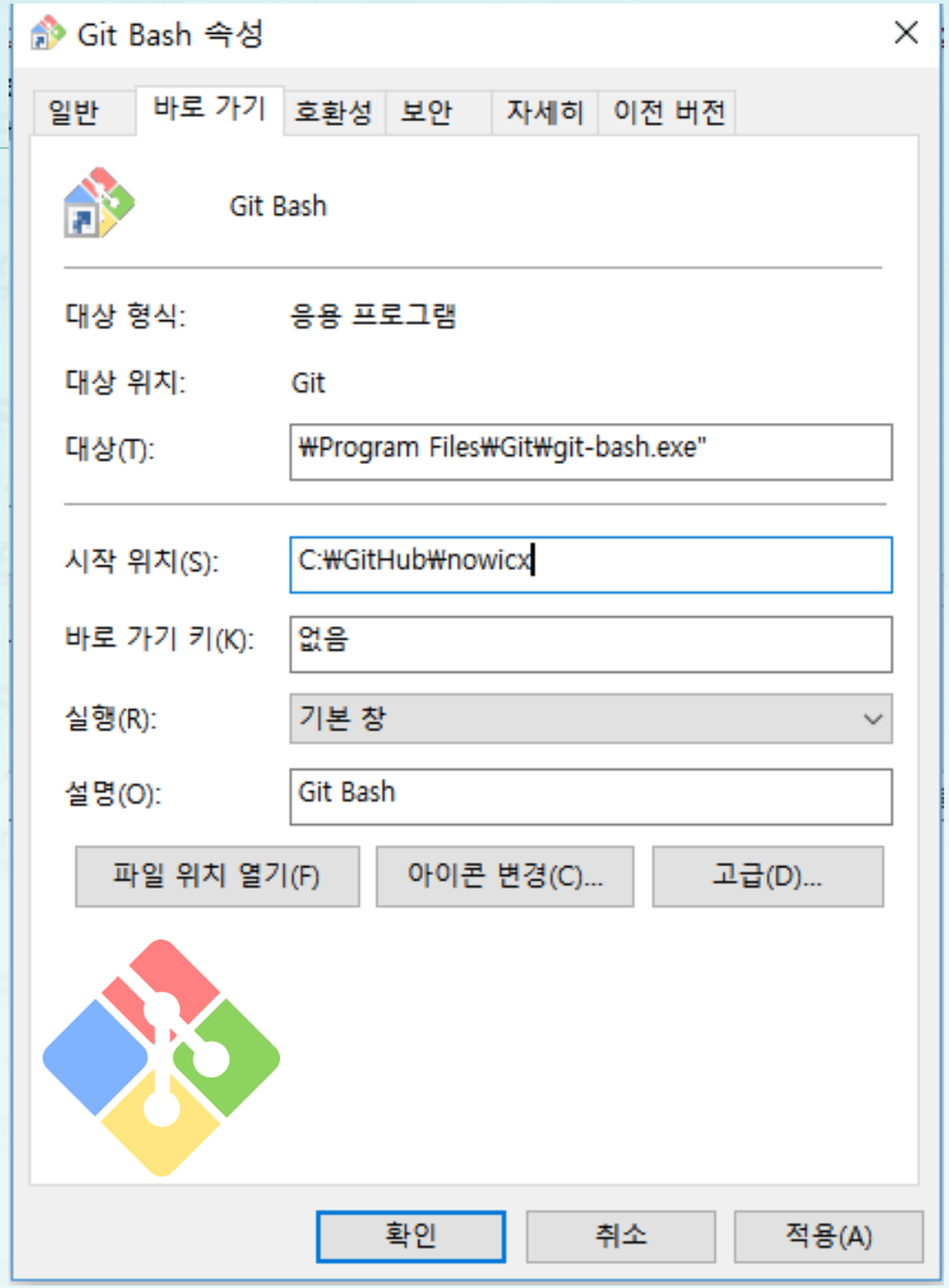




Install Git and GitHub Desktop

- **Git**
  - **a revision control system,**
  - **a tool to manage your source code history**
- **Github**
  - **a hosting service for Git repositories.**
- **Github Desktop**
  - **a Windows interface for Git/GitHub,**
  - **a subset of Git commands supported**

1. Install Git.
2. Install Github Desktop
3. Clone the following repository
   - github.com/idebtor/nowic

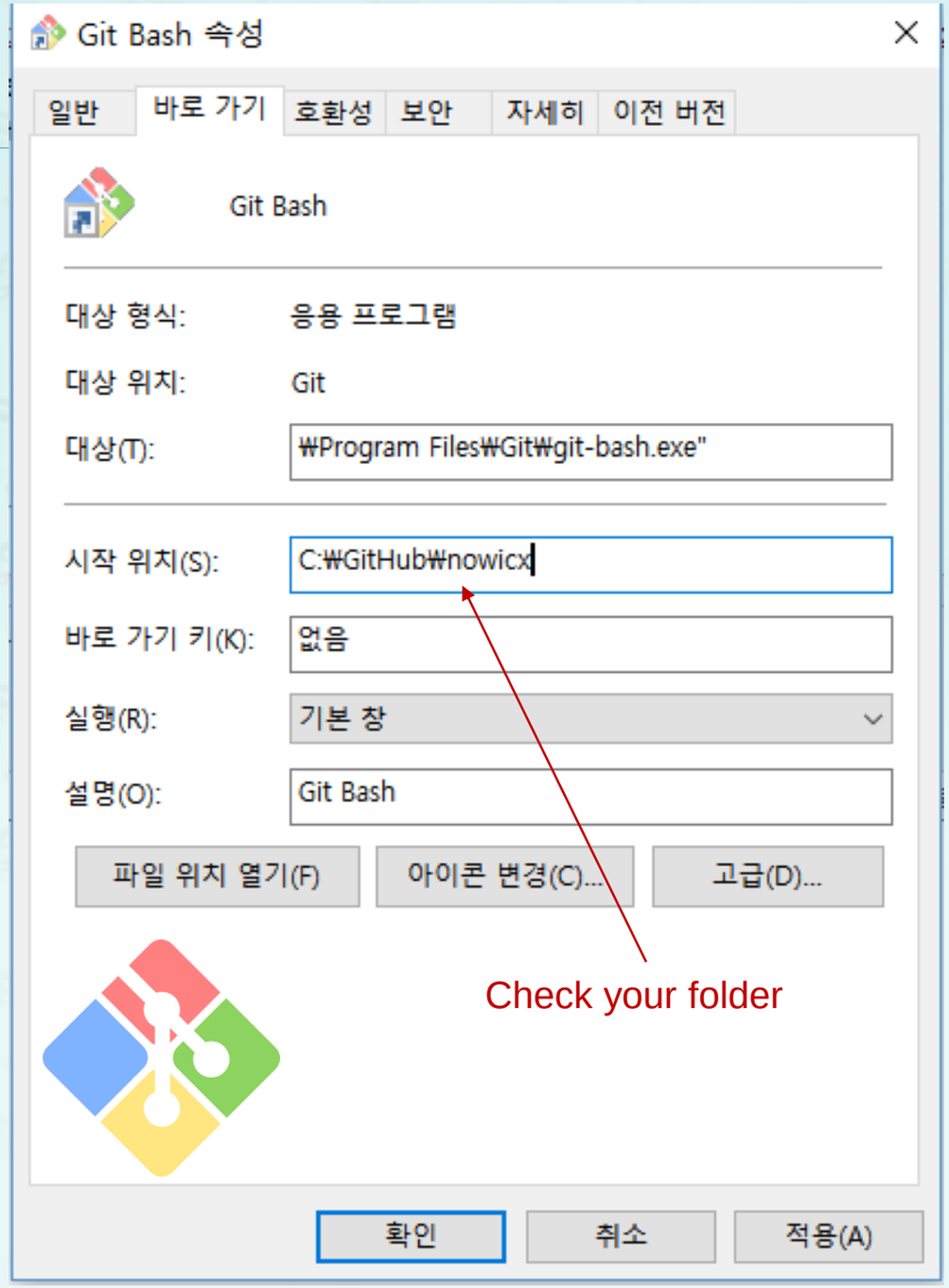


Install Git and GitHub Desktop

Setting the starting folder of Git

1. Right click on the Git Bash shortcut icon
   → *Start in:* → C:\github\nowic
2. Remove the **`--cd-to-home`** part from the Target box
3. **Add .bash_profile**
   - cd $HOME
     C:/users/user
   - C:/users/user/.bash_profile

Check your home folder



Check your folder

C++ for C Coders

- C
- Dennis Ritchie
- 1972
- 29 Keywords
  - Imperative programming
  - Procedural programming

- C++
- Stroustrup
- 1985
- 63 Keywords by 1996
- C++ as a better C
  - Imperative programming
  - Object-oriented programming
  - Generic programming

"Swiss Army Knife"

Declarative programming

명령형(C,C++,Java) vs 선언형(Prolog, Haskell)

C++ as a better C

- Comment Lines

```
/* This is a comment */
// This is a comment
```

- Declarations and definitions can be placed anywhere.
- A variable lives only in the block, in which it was defined. This block is called the **scope** of this variable.

```
int a = 0;
for (int i = 0; i < 100; i++){ // i is declared in for loop
  a++;
  int p = 12;                  // declaration of p ...
  ...                          // scope of p
} // end of scope for i and p
```

Write "Hello World" program in C++

- Open Atom editor
- Open a new file
  - Filename: **`hello.cpp`**
- Add the source code.
- Save the file.
- Compile and Execute

```
$ atom hello.cpp
$ g++ hello.cpp
$ ./a.exe
$ ./a
$ a
```

PowerShell

OSX

cmd

```
// file: hello.cpp
#include <iostream>

int main() {
  std::cout << "Hello World!" << std::endl;
}
```

Write "Hello World" program in C++

- Open Atom editor
- Open a new file
  - Filename: **`hello.cpp`**
- Add the source code.
- Save the file.
- Compile and Execute

```
$ atom hello.cpp
$ g++ hello.cpp
$ ./a.exe
$ ./a
$ a
```

PowerShell

OSX

cmd

```
// file: hello.cpp
#include <iostream>

int main() {
  std::cout << "Hello World!" << std::endl;
}
```

```
// file: hello.cpp
#include <iostream>
using namespace std;

int main() {
  cout << "Hello World!" << endl;
}
```

Write "Hello World" program in C++

- Open Atom editor
- Open a new file
  - Filename: **`hello.cpp`**
- Add the source code.
- Save the file.
- Compile and Execute

```
$ g++ hello.cpp
$ ./a.exe
$ ./a
```

- Compile and Execute

```
$ g++ hello.cpp -o hello
$ ./hello.exe
$ ./hello
```

```
// file: hello.cpp
#include <iostream>

int main() {
  std::cout << "Hello World!" << std::endl;
}
```

```
// file: hello.cpp
#include <iostream>
using namespace std;

int main() {
  cout << "Hello World!" << endl;
}
```

namespaces

- Global identifiers in a header file used in a program become global
  - Syntax error occurs if an identifier in a program has the same name as a global identifier in the header file
- Same problem can occur with third-party libraries
  - Common solution: third-party vendors begin their global identifiers with _ (underscore)
  - Do not begin identifiers in your program with _
- ANSI/ISO Standard C++ attempts to solve this problem with the namespace mechanism
- Syntax:
  - A member is usually a variable declaration, a named constant, a function, or another namespace.

```
namespace namespace_name {
    members
}
```

namespaces

Briefly, it's a fence!

```
namespace namespace_name {
    members
}
```

namespaces

Example

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

namespace first  { int var = 5; }
namespace second { int var = 3; }

int main(int argc, char **argv} {
  std::cout << first::var << std::endl << second::var << endl;
  return 0;
}
```

namespaces

Example

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

namespace first  { int var = 5; }
namespace second { int var = 3; }

int main(int argc, char **argv} {
  std::cout << first::var << std::endl << second::var << endl;
  return 0;
}
```

```
5
3
```

namespaces

Example

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

namespace first  { int var = 5; }
namespace second { int var = 3; }

int main(int argc, char **argv} {
  std::cout << first::var << std::endl << second::var << endl;
  return 0;
}
```

```
5
3
```

Scope resolution operator ::

The scope resolution operator :: is used for following purposes.

1. To access a global variable when there is a local variable with same name.
2. To define a function outside a class.
3. To access a class's static variables.
4. In case of multiple Inheritance.

Scope Operator ::

- A definition in a block can hide a definition in an enclosing block or a global name. It is possible to use a hidden global name by using the **scope resolution operator ::**

```
int y = 0;          // Global y
int x = 1;          // Global x
void f(){           // Function is a new block
  int x = 5;        // Local  x=5, it hides global x
  ::x++;            // Global x=2
  x++;              // Local x=6
  y++;              // Global y=1
}
```

Scope Operator ::

- **Lab**

```
int i = 1;
int main(){
  int i = 2; {
    int n = i;
    int i = 3;
    cout << i << " " << ::i << endl;
    cout << n << "\n" ;
  }
  cout << i << " " << ::i << endl;
  return 0;
}
```

Scope Operator ::

- **Lab**

```
int i = 1;
int main(){
  int i = 2; {
    int n = i;
    int i = 3;
    cout << i << " " << ::i << endl;
    cout << n << "\n" ;
  }
  cout << i << " " << ::i << endl;
  return 0;
}
```

```
3 1
2
2 1
```

Multiple Source Files

- Open Atom editor
- Open two new files
  - Filename: **greet.cpp**
  - Filename: **greet_func.cpp**
- Add the source code.
- Save files.

```
// file: greet_func.cpp
#include <iostream>
void greet_func() {
    std::cout << "Hello World!";
}
```

```
// file: greet.cpp
#include <iostream>
extern greet_func();
int main() {
    greet_func();
}
```

- Compile and Execute

```
$ g++ greet.cpp greet_func.cpp -o greet
$ ./great
```

More GCC Compiler Options

- There are some flags available for compiler options:

```
$ $g++ -std=c++11 -Wall -g file1.cpp file2.cpp -o prog
```

  - **-o** : specifies the output executable filename.
  - **-std=c++11** : to specify the C++ standard version
    c++11, c++14, c++17, c++2a
  - **-Wall** : enables most warning messages
  - **-g** : for use with gdb debugger.
  - **-DDEBUG** : define "DEBUG" as a macro

Command line processing

- Open Atom editor
- Open a new file
  - Filename: **`argcargv.cpp`**
- Add the source code.
- Save the file.
- Compile and Execute

```
$ g++ argcargv.cpp -o arg
$ ./arg command line args
```

```
// Name of program argcargv.cpp
#include <iostream>
using namespace std;

int main(int argc, char** argv) {
  cout << "You entered: "
       << argc << " arguments:" << endl;

  for (int i = 0; i < argc; ++i)
    cout << argv[i] << endl;

    return 0;
}
```

Input/Output

- When a C++ program includes the iostream header, four objects are created and initialized:
  - **cin** handles input from the standard input, **the keyboard**.
  - **cout** handles output to the standard output, **the screen**.
  - **cerr** handles unbuffered output to the standard error device, the screen.
  - **clog** handles buffered error messages to the standard error device.

Input/Output – Using cin object

- cin is used with >> to gather input

```
cin >> variable;
```

- The stream extraction operator is >>

- For example, if miles is a **double** variable

```
cin >> miles;
```

  - Causes computer to get a value of type **double**
  - Places it in the variable miles

Input/Output – Using cin object

- The predefined **cin** stream object is used to read data from the standard input device, usually the keyboard.
- The **cin** stream uses the >> operator, usually called the "get from" operator.

```
#include<iostream>
using namespace std;                    // we don't need std:: anymore

int main() {
  int i, j;                             // Two integers are defined
  cout << "Give two numbers \n";        // cursor to the new line

  cin >> i >> j;                        // Read i and j from the keyboard
  cout << "Sum= " << i + j << "\n";
  return 0;
}
```

Input/Output – Avoid using cin >> if you can

- Using `cin` to get user input is convenient sometimes since we can specify a primitive data type. However, it is notorious at causing input issues because it doesn't remove the newline character from the stream or do type-checking. So anyone using `cin >> var;` and following it up with another `cin >> stringtype;` or `std::getline();` will receive empty inputs. It's the best practice not to mix the different types of input methods from `cin`.

- Another disadvantage of using `cin >> stringvar;` is that `cin` has no checks for length, and it will break on a space. So you enter something that is more than one word, only the first word is going to be loaded. Leaving the space, and following word still in the input stream.

- JoyNote: A more elegant solution, much easier to use, is the `std::getline()`.
- Reference https://github.com/idebtor/nowic/blob/master/02GettingInput.md

Input/Output – Using cout object

- The syntax of **cout** and **<<** is:

```
cout << expression or manipulator << ··· ;
```

- Called an output statement
- The stream insertion operator is **<<**
- Expression evaluated and its value is printed at the current cursor position on the screen

Input/Output

TABLE 2-4 Commonly Used Escape Sequences

	Escape Sequence	Description
`\n`	Newline	Cursor moves to the beginning of the next line
`\t`	Tab	Cursor moves to the next tab stop
`\b`	Backspace	Cursor moves one space to the left
`\r`	Return	Cursor moves to the beginning of the current line (not the next line)
`\\`	Backslash	Backslash is printed
`\'`	Single quotation	Single quotation mark is printed
`\"`	Double quotation	Double quotation mark is printed

inline functions

- In C, macros are defined by using the #define directive of the preprocessor.

```
#define sq(x) ((x)*(x))
#define max(x, y) (y < x ? x : y)
```

- In C++, macros are defined as normal functions.
  Here the keyword **inline** is inserted before the declaration of the function.

```
inline int sq(int x) { return x * x; }
inline int max(int x, int y) { return y < x ? x : y); }
```

inline functions

- An inline function is defined using almost the same syntax as an ordinary function. However, instead of placing the function's machine-language code in a separate location, the compiler simply inserts it into the location of the function call.
- It's appropriate to inline a function when it is short, but not otherwise. If a long or complex function is inlined, too much memory will be used and not much time will be saved.
- Advantages
  - Debugging
  - Type checking
  - Readable

Default Function Arguments

- In calling of the function, if the arguments are not given, default values are used.

```
int exp(int n, int k = 2) {
  if (k == 2) return (n * n);
  return (exp(n, k - 1) * n);
}
```

Default Function Arguments

- In calling a function argument must be given from left to right without skipping any parameter

```
void foo(int i, int j=7);       // right
void goo(int i=3, int j);       // wrong
void hoo(int i, int j=3, int k=7); // right
void moo(int i=1, int j=2, int k=3);  // right
void noo(int i=2, int j, int k=3); // right? wrong
```

Reference Operator &

- A reference allows to declare an alias to another variable.
- As long as the aliased variable lives, you can use indifferently the variable or the alias.

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

int main() {
  int x;
  int& foo = x;
  foo = 49;
  cout << x << endl;
  retrn 0
}
```

Reference Operator &

- A reference allows to declare an alias to another variable.
- References are extremely useful when used with function arguments since it saves the cost of copying parameters into the stack when calling the function.

Reference Operator &

- Swap() example in C/C++

```
void swap(int *a, int *b) {
  int temp = *a;
  *a = *b;
  *b = temp;
}
```

```
int main() {
  int i = 3, j = 5;
  swap(&i, &j);
  cout << i << " " << j << endl;
}
```

5 3

Reference Operator &

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

void whatIsOutput(int& x, int y, int& z) {
    cout << x << " " y << " " << z << endl;
    x = 1;
    y = 2;
    z = 3;
    cout << x << " " y << " " << z << endl;
}

int main() {
    int a = 10, b = 20, c = 30;
    whatIsOutput(a, b, c);
    cout << a << " " << b << " " << c << endl;
    return 0;
}
```

What is the output?

Swap in C

```
int main() {
  int a = 5, b = 6;
  double x = 6.7, y = 8.9;

  printf("in: %d, %d\n", a, b);
  swap(&a, &b);
  printf("out: %d, %d\n, a, b);

                  & is an address operator.



}
```

Swap in C

```
int main() {
  int a = 5, b = 6;
  double x = 6.7, y = 8.9;

  printf("in: %d, %d\n", a, b);
  swap(&a, &b);
  printf("out: %d, %d\n, a, b);

}
```

& is an address operator.

```
void swap(int *i, int *j) {
  int temp = *i;
  *i = *j;
  *j = temp;
}
```

i is a pointer (or memory address) to an int.
*i is the memory contents that i points.

Swap in C

```
int main() {
  int a = 5, b = 6;
  double x = 6.7, y = 8.9;

  printf("in: %d, %d\n", a, b);
  swap(&a, &b);
  printf("out: %d, %d\n, a, b);

  printf("in: %lf, %lf\n", a, b);
  swap(&x, &y);
  printf("out: %lf, %lf\n, x, y);
}
```

& is an address operator.

```
void swap(int *i, int *j) {
  int temp = *i;
  *i = *j;
  *j = temp;
}
```

Any problem here?

No overloading in C

```
void swap(int *i, int *j) {
  int temp = *i;
  *i = *j;
  *j = temp;
}

void swap_double(double *i, double *j) {
  double temp = *i;
  *i = *j;
  *j = temp;
}
```

No overloading in C

```
int main() {
  int a = 5, b = 6;
  double x = 6.7, y = 8.9;

  printf("in: %d, %d\n", a, b);
  swap(&a, &b);
  printf("out: %d, %d\n, a, b);



  printf("in: %lf, %lf\n", a, b);
  swap(&x, &y);
  printf("out: %lf, %lf\n, x, y);
}
```

```
void swap(int *i, int *j) {
  int temp = *i;
  *i = *j;
  *j = temp;
}

void swap_double(double *i, double *j) {
  double temp = *i;
  *i = *j;
  *j = temp;
}
```

Swap in C++

& is a reference to int

```
int main() {
  int a = 5, b = 6;
  double x = 6.7, y = 8.9;

  cout << "in:" << a << ", " << b << endl;
  swap(a, b);
  cout << "out:" << a << ", " << b << endl;



}
```

call by reference

```
void swap(int& i, int& j) {
  int temp = i;
  i = j;
  j = temp;
}
```

Swap in C++

& is a reference to int

```
int main() {
  int a = 5, b = 6;
  double x = 6.7, y = 8.9;

  cout << "in:" << a << ", " << b << endl;
  swap(a, b);
  cout << "out:" << a << ", " << b << endl;



  cout << "in:" << x << ", " << y << endl;
  swap(x, y);
  cout << "out:" << x << ", " << y << endl;
}
```

```
void swap(int& i, int& j) {
  int temp = i;
  i = j;
  j = temp;
}
```

C++ has both overloading and call by reference.

Swap in C++

```
int main() {
  int a = 5, b = 6;
  double x = 6.7, y = 8.9;

  cout << "in:" << a << ", " << b << endl;
  swap(a, b);
  cout << "out:" << a << ", " << b << endl;

  cout << "in:" << x << ", " << y << endl;
  swap(x, y);
  cout << "out:" << x << ", " << y << endl;
}
```

call by reference

```
void swap(int& i, int& j) {
  int temp = i;
  i = j;
  j = temp;
}

void swap(double& i, double& j) {
  double temp = i;
  i = j;
  j = temp;
}
```

& is a reference to int

function overloading

C++ has both overloading and call by reference.

Reference Operator &

- Summary: swap() example in C/C++

C

```
void swap(int *a, int *b) {
  int temp = *a;
  *a = *b;
  *b = temp;
}
```

```
int main() {
  int i = 3, j = 5;
  swap(&i, &j);
  cout << i << " " << j << endl;
}
```

C++

```
void swap(int& a, int& b) {
  int temp = a;
  a = b;
  b = temp;
}
```

```
int main() {
  int i = 3, j = 5;
  swap(i, j);
  cout << i << " " << j << endl;
}
```

Reference Operator &

- Lab

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

int main(){
  int x = 2, y = 3, z = 4;
  squareByPointer(&x);
  cout<< x << endl;

  squareByReference(y);
  cout<< y << endl;

  z = squareByValue(z);
  cout<< z << endl;
}
```

Overloading

- Function overloading refers to the possibility of creating multiple functions with the same name as long as they have different parameters (type and/or number) which is called a signature of function.

C

```
int main() {
  int i = 3, j = 5;
  swap(&i, &j);
  cout << i << " " << j << endl;
}
```

C++

```
int main() {
  int i = 3, j = 5;
  swap(i, j);
  cout << i << " " << j << endl;
}
```

const Reference

- To prevent the function from changing the parameter accidentally, we pass the argument as **constant reference** to the function.

```
struct Person {
  char name[40];
  int age;
};
void print(const Person& k) {
  cout << "Name: " << k.name << endl;
  cout << "Age: " << k.age << endl;
}

int main(){
  Person man{"Adam", 316};
  print(man);
  return 0;
}
```

C style coding in C++

k is constant reference parameter

Instead of 44 bytes, only 4 bytes (address) are sent to the function.

const Reference

- To prevent the function from changing the parameter accidentally, we pass the argument as **constant reference** to the function.

```
struct Person {
  string name;
  int age;
};
void print(const Person& k) {
  cout << "Name: " << k.name << endl;
  cout << "Age: " << k.age << endl;
}

int main(){
  Person man{"Adam", 316};
  print(man);
  return 0;
}
```

k is constant reference parameter

Return by reference

- By default in C++, when a function returns a value, it is copied into stack. The calling function reads this value from stack and copies it into its variables.
- An alternative to “return by value ”is “return by reference”, in which the value returned is not copied into stack.
- One result of using “return by reference” is that the function which returns a parameter by reference **can be used on the left side** of an assignment statement.

Return by reference

- Example: Modify the following programs such that it sets the maximum element to zero.

```
int max(int a[], int N) {
  int i=0;
  for (int j=0 ; j<N; j++)
    if (a[j] > a[i]) i = j;
  return a[i];
}
int main() {
  int array[] = {12, 42 , 33 , 99, 63};
  int n = 5;


  for (int i = 0; i < n; i++)
    cout << a[i] << " ";
}
```

```
12  42  33  0  63
```

Return by reference

- Example: Modify the following programs such that it sets the maximum element to zero.

```
int& max(int a[], int N) {    // returns an integer reference of the max element
  int i=0;
  for (int j=0 ; j<N; j++)
    if (a[j] > a[i]) i = j;
  return a[i];
}
int main() {
  int array[] = {12, 42 , 33 , 99, 63};
  int n = 5;

  max(array,5) = 0;           // overwrite the max element with 0
  for (int i = 0; i < n; i++)
    cout << a[i] << " ";
}
```

```
12 42 33 0 63
```

const return value

- **To prevent** the calling function from changing the return parameter accidentally, **const** qualifier can be used.

```
const int& max(const int a[], int N){
  int i=0;
  for (int j=0 ; j<N ; j++) {
    if (a[j] > a[i]) i = j;
  return a[i];
}

int main(){
  int array[ ] = {12, 42 , 33 , 99, 63};
  int largest = max(array,5);
  cout << "The largest is " << largest << endl;
  return 0;
}
```

Never return a local variable by reference

- Since a function that uses "return by reference" returns an actual memory address, it is important that the variable in this memory location remain in existence after the function returns.

```
int& foo() {
  int i;
  ...
  return i;                    // ERROR! does not exist anymore
```

- Local variables can be return by their values

```
int foo() {
  int i;                       // Local variable, created in stack
  ...
  return i;                    // OK! does not exist anymore
```

malloc & free vs new & delete

- In C, dynamic memory allocation is done with malloc() and free().
- The C++ new and delete operators perfroms dynamic memory allocation.

```
int *p = (int *)malloc(sizeof(int) * N);

for (int i = 0; i < N; i++)
  p[i] = i;

free(p);
```

```
int *p = new int[N];

for (int i = 0; i < N; i++)
  p[i] = i;

delete[] p;
```

Using new & delete

- The **new** operator allocates memory, and **delete** frees memory allocated by **new**.

```
int *pi = new int;                  // pi points to uninitialized int
int *pi = new int(7);               // which pi points has value 7
string *ps = new string;            // empty string
```

Using new & delete

- The **new** operator allocates memory, and **delete** frees memory allocated by **new**.

```
int *pi = new int;                  // pi points to uninitialized int
int *pi = new int(7);               // which pi points has value 7
string *ps = new string;            // empty string

int *pia = new int[7];              // block of seven uninitialized ints
int *pia = new int[7]();            // block of seven ints values initialized to 0
```

Using new & delete

- The **new** operator allocates memory, and **delete** frees memory allocated by **new**.

```
int *pi = new int;                      // pi points to uninitialized int
int *pi = new int(7);                   // which pi points has value 7
string *ps = new string;                // empty string

int *pia = new int[7];                  // block of seven uninitialized ints
int *pia = new int[7]();                // block of seven ints values initialized to 0

string *psa = new string[5];                // block of 5 empty strings
string *psa = new string[5]();              // block of 5 empty strings
int    *pia = new int[5]{0, 1, 2, 3, 4};    // block of 5 ints initialized
string *psa = new string[2]{"a", "the"};    // block of 2 strings initialized
delete   pi;
delete[] pia;
```

Lab 1: Convert a C program to C++

```c
#include <stdio.h>
#define N 40
void sum(int d[], int n, int* p) {
  *p = 0;
  for(int i = 0; i < n; ++i) *p = *p + d[i];
}

int main() {
  int total = 0;
  int data[N];
  for(int i = 0; i < N; ++i) data[i] = i;
  sum(data, N, &total);
  printf("total is %d\n", total);
  return 0;
}
```

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

Lab 1: Convert a C program to C++

```c
#include <stdio.h>
#define N 40
void sum(int d[], int n, int* p) {
  *p = 0;
  for(int i = 0; i < n; ++i) *p = *p + d[i];
}

int main() {
  int total = 0;
  int data[N];
  for(int i = 0; i < N; ++i) data[i] = i;
  sum(data, N, &total);
  printf("total is %d\n", total);
  return 0;
}
```

```c
#include <iostream>
using namespace std;
void sum(int d[], int n, int& p) {
  p = 0;
  for(int i = 0; i < n; ++i) p = p + d[i];
}

int main() {
  const int N = 40;
  int total = 0;
  int *data = new int[N];
  for(int i = 0; i < N; ++i) data[i] = i;
  sum(data, N, total);
  cout << "total is " << total << endl;
  return 0;
}
```

Command line processing

- Open Atom editor
- Open a new file
  - Filename: **argcargv.cpp**
- Add the source code.
- Save the file.
- Compile and Execute

```
$ g++ argcargv.cpp -o arg
$ ./arg command line args
```

```
// Name of program argcargv.cpp
#include <iostream>
using namespace std;

int main(int argc, char** argv) {
  cout << "You entered: "
       << argc << " arguments:" << endl;

  for (int i = 0; i < argc; ++i)
    cout << argv[i] << endl;
  return 0;
}
```