

Modern C++ for Computer Vision and Image Processing

Lecture 3: C++ Functions

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C-style strings are evil



Like everything else in C in general.

```
1 #include <cstring>
2 #include <iostream>
3
4 int main() {
5     const char source[] = "Copy this!";
6     char dest[5];           ← ↑ నీటి length కాదు?
7     std::cout << source << '\n';
8
9     std::strcpy(dest, source); ← దీనికండికా కావల్సినది.
10    std::cout << dest << '\n';
11
12    // source is const, no problem right? ← ఈంటి అంగొపిది. తో
13    std::cout << source << '\n';
14
15    return 0;
16 }
```

మరొక వేదికా కాదు. \n లేకుపోవచు.

శీర్షిక అంగొపిది. తో గాము.

Strings

- `#include <string>` to use `std::string`
- Concatenate strings with `+` ↪ దొండలిపు.
- Check if `str` is empty with `str.empty()` ↪ దొండలిపు.
- Works out of the box with I/O streams

```
1 #include <iostream>
2 #include <string>
3
4 int main() {
5     const std::string source{"Copy this!"};
6     std::string dest = source; // copy string
7
8     std::cout << source << '\n';
9     std::cout << dest << '\n';
10    return 0;
11 }
```

Function definition

*In programming, a named section of a program that performs a **specific** task. In this sense, a **function** is a type of procedure or routine. Some programming languages make a distinction between a **function**, which returns a value, and a **procedure**, which performs some operation but does not return a value.*

Bjarne Stroustrup

ଓঃ পুরুষ সন্দীপনী (1950)

*The main way of getting something done in a C++ program is to call a **function** to do it. Defining a **function** is the way you specify how an operation is to be done. A **function** cannot be called unless it has been previously declared. A **function** declaration gives the name of the **function**, the type of the value returned (if any), and the number and types of the arguments that must be supplied in a call.*

Danish Computer Scientist who invented C++

Extract from: Section 12 of "The C++ Programming Language Book by Bjarne Stroustrup"

Functions

```
1 ReturnType FuncName(ParamType1 in_1, ParamType2 in_2) {  
2     // Some awesome code here.  
3     return return_value;  
4 }
```

- Code can be organized into functions ✓
- Functions **create a scope** ✓
- **Single return value** from a function ✓
- Any number of input variables of any types ✓
- Should do **only one** thing and do it right ✓
- Name **must** show what the function does ✓
- GOOGLE-STYLE name functions in **CamelCase** ✓
- GOOGLE-STYLE **write small functions** ✓

Function Anatomy

```
1 [[attributes]] ReturnType FuncName(ArgumentList...) {  
2     // Some awesome code here  
3     return return_value;  
4 }
```



① ■ Body

② ■ Optional Attributes

③ ■ Return Type

④ ■ Name

⑤ ■ Argument List

Funtcion Body

L = g

- Where the **computation** happens.
- Defines a new scope, the **scope of the function**.
- Access outside world(scopes) through input arguments.
- Can not add information about the implementation outside this **scope**

Funtcion Body

```
1 // This is not part of the body of the function
2
3 void MyFunction() {
4     // This is the body of the function
5     // Whatever is inside here is part of
6     // the scope of the function
7 }
8
9 // This is not part of the body of the function
```

Return Type

Could be any of:

1. An **unique** type, eg: `int`, `std::string`, etc...
2. `void`, also called subroutine.

Rules:

- If has a return type, **must** return a value.
- If returns void, must **NOT** return any value.

Return Type

```
1 int f1() {} // error
2 void f2() {} // OK
3
4 int f3() { return 1; } // OK
5 void f4() { return 1; } // Error
6
7 int f5() { return; } // Ok
8 void f6() { return; } // Error
```

Return Type

return

Automatic return type deduction C++14):

```
1 std::map<char, int> GetDictionary() {  
2     return std::map<char, int>{{'a', 27}, {'b', 3}};  
3 }
```

or

Can be expressed as:

```
1 auto GetDictionary() {  
2     return std::map<char, int>{{'a', 27}, {'b', 3}};  
3 }
```

return type

Return Type

Sadly you can use only one type for return values, so, no **Python** like:

```
1 #!/usr/bin/env python3
2 def foo():
3     return "Super Variable", 5
4
5     ↪ Python ရှင်းကြော်တွေများ
6 name, value = foo()
7 print(name + " has value: " + str(value))
```

ခုံနယ်
အပေါ် လိုအပ်သူများ - Data type များမှာ Container
ဖို့ပြီ: Python တော်ဝန်ဆောင်ရွက်ပါတယ်.

Return Type

Sadly you can use only one type for return values, so no Python like:

```
1 #!/usr/bin/env python3
2 def foo():
3     return "Super Variable", 5
4
5
6 name, value = foo()
7 print(name + " has value: " + str(value))
```

বেসিক প্রোগ্ৰাম



Let's write this in C++, and make it run **18** times faster, with a similar syntax.

Return Type

With the introduction of structured binding in C++17 you can now:

```
1 #include <iostream>
2 #include <tuple>
3 using namespace std;
4
5 auto Foo() {
6     return make_tuple("Super Variable", 5);
7 }
8
9 int main() {
10    auto [name, value] = Foo();
11    cout << name << " has value :" << value << endl;
12    return 0;
13 }
```

Return Type

WARNING:

Never return reference to locally variables!!!

```
1 #include <iostream>
2 using namespace std;
3
4 int& MultiplyBy10(int num) { // retval is created
5     int retval = 0;
6     retval = 10 * num;
7     return retval;
8 } // retval is destroyed, it's not accessible anymore
9
10 int main() {
11     int out = MultiplyBy10(10);
12     cout << "out is " << out << endl;
13     return 0;
14 }
```

Segmentation Fault

Return Type

```
1 #include <iostream>
2 using namespace std;
3
4 int& MultiplyBy10(int num) { // retval is created
5     int retval = 0;
6     retval = 10 * num;
7     cout << "retval is " << retval << endl;
8     return retval;
9 } // retval is destroyed, it's not accessible anymore
10
11 int main() {
12     int out = MultiplyBy10(10);
13     cout << "out      is " << out << endl;
14     return 0;
15 }
```

Return Type

Compiler got your back:

Return value optimization:

https://en.wikipedia.org/wiki/Copy_elision#Return_value_optimization

Compiler

Return of Optimize
நடவடிக்கை

```
1 Type DoSomething() {                                big object அடிக்கம்
2     Type huge_variable;                         ←
3
4     // ... do something
5
6     // don't worry, the compiler will optimize it
7     return huge_variable;           ← return வகுகிறது
8 }
9
10 // ...
11
12 Type out = DoSomething(); // does not copy      ← copy செய்யப்படுவதற்கு
```

Local Variables

Variables အကျဉ်းဆောင်ရန်

Definition စတင်တဲ့ Initialized မဖြစ်

- A local variable is initialized when the execution reaches its definition.

ထုတေသနပုဂ္ဂနယ်

အိမ်စွဲ

တစ်လျှောက် GDB

```
1 void f() {                                မျှေးစိန် random တွေဖြစ်နေမှတ်မည်
2     // Gets initialized when the execution reaches
3     // the defintion of f(), thus, this implementation
4     int local_variable = 50;
5 }
6
7 // at this point local_variable has not been intialized
8 // is not accessibly by any other part of the program
9
10 f(); //< When enter the function call, gets initialized
```

ရွှေ့နေရန် တို့ ပုံစံရှိ, ထောက် မှတ်စွာမှု ရေးလွှာ

တွေ့မှတ်ခြင်း၊ ပြီးပါတယ်

Local Variables

Fonction scope යුතු static වේ.

variable නැංවාම මෙයින් function තුළ variable
කුපාදෙනු යුතුවන් නො යුතුවන් නිස් යුතුයි. variables

- Unless declared **static**, each invocation has its own copy.

කුළු ලෙස පෙන්වනුයි

```
1 void f() {  
2     float var1 = 5.5F;  
3     float var2 = 1.5F;  
4     // do something with var1, var2  
5 }  
6  
7 f(); //< First call, var1, var2 are created ≠  
8 f(); //< Second call, NEW var1, var2 are created
```

Local Variables

static local variables
oxygen memory പോതുന്നത് ഫോറ്റോ
ഈ പ്രൗഢിയും തുറന്നേണ്ടിക്കാം
അപ്പേണ്ടിക്സിൽ access ചെയ്യിവാൻ

- static variable, a single, statically allocated object represent that variable in **all** calls.

```
1 void f() {  
2     // same variable for all function calls  
3     static int counter = 0;  
4  
5     // Increment counter on each function call  
6     counter++;  
7 }  
8  
9 // at this point, f::counter has been statically  
10 // allocated and accessible by any function call to f()  
11  
12 f(); //< Acess counter, counter == 1  
13 f(); //< Acess same counter, counter ==2
```

Local Variables

```
1 #include <iostream>
2 using namespace std;
3 void Counter() {
4     static int counter = 0;
5     cout << "counter state = " << ++counter << endl;
6 }
7 int main() {
8     for (size_t i = 0; i < 5; i++) {
9         Counter();
10    }
11    return 0;
12 }
```

Class പേരിൽ static വർക്കൾ
അടങ്കിയതാണ്.
Object എന്ന് അംഗീകാരം ചെയ്യുന്നത്.
static എന്ന വർക്ക് തിരുന്നേരം

ഒരു

NACHO-STYLE Avoid if possible, read more at:

<https://isocpp.org/wiki/faq/ctors#static-init-order>

സ്റ്റാറ്റിക്ക് ഓർഡർ

Local Variables



- Any local variable will be destroyed when the execution exit the `scope` of the function.

```
1 void f() {  
2     // Gets initialized when the execution reaches  
3     // the defintion of f(), thus, this implementation  
4     int local_variable = 50;  
5 }
```

`local_variable` has been destroyed at this point, RIP.

Argument List

```
void setup(int num) { }  
pass by copy
```

- **How** the function interact with external world
- They all have a **type**, and a **name** as well.
- They are also called **parameters**.
- Unless is declared as reference, a **copy** of the actual argument is passed to the function.

pass නැංවා data type හා & reference
ප්‍රාග්ධනයේද තමයි variable න් copy නොමැති
තු: යහුණු අපිල්

Argument List

```
1 void f(type arg1, type arg2) {          pass by copy
2   // f holds a copy of arg1 and arg2
3 }
4
5 void f(type& arg1, type& arg2) {          pass by reference
6   // f holds a reference of arg1 and arg2
7   // f could possibly change the content
8   // of arg1 or arg2
9 }
10
11 void f(const type& arg1, const type& arg2) {    pass by const reference
12   // f can't change the content of arg1 nor arg2
13 }                                              This means const & data type of arguments.
14
15 void f(type arg1, type& arg2, const type& arg3);
```

Default arguments

myearn.com తెలుగులో

- Functions can accept default arguments
- Only **set in declaration** not in definition
- **Pro:** simplify function calls ✓
- **Cons:**
 - Evaluated upon every call ✗
 - Values are hidden in declaration
 - Can lead to unexpected behavior when overused
- **GOOGLE-STYLE** Only use them when readability gets much better
- **NACHO-STYLE** Never use them

Example: default arguments

```
1 #include <iostream>
2 using namespace std;
3
4 string SayHello(const string& to_whom = "world") {
5     return "Hello " + to_whom + "!";
6 }
7
8 int main() {
9     // Will call SayHello using the default argument
10    cout << SayHello() << endl;
11
12    // This will override the default argument
13    cout << SayHello("students") << endl;
14    return 0;
15 }
```

default value

Passing big objects

- By default in C++, objects are copied when passed into functions *pass by copy*
- If objects are big it might be slow
- **Pass by reference** to avoid copy

Object size കുറയ്ക്കാൻ reference കുറച്ച് pass ആവശ്യം

```
1 void DoSmth(std::string huge_string); // Slow.  
2 void DoSmth(std::string& huge_string); // Faster.
```



Is the string still the same?

```
1 string hello = "some_important_long_string";  
2 DoSmth(hello);
```

Unknown without looking into `DoSmth()`!

ചീരുന്ന കേസിൽ, മുൻ പരീക്ഷയിൽ ഫലം അഭ്യന്തരാജ്ഞം.

Solution: use const references

- Pass **const** reference to the function
- Great speed as we pass a reference
- Passed object stays intact

→ speed
ହରାନ୍ତିର
ବିଲା

```
1 void DoSmth(const std::string& huge_string);
```

- Use **snake_case** for all function arguments
- Non-const refs are mostly used in older code written before C++ 11
- They can be useful but destroy readability
- **GOOGLE-STYLE** Avoid using non-const refs

Cost of passing by value

```
1 void pass_by_value(std::string huge_string) {  
2     (void) huge_string;  
3 }  
4  
5 // Pay attention to the -> "&" <- symbol  
6 void pass_by_ref(std::string& huge_string) {  
7     (void) huge_string;  
8 }  
9  
10 static void PassByValue(benchmark::State& state) {  
11     // Code inside this loop is measured repeatedly  
12     std::string created_string("hello");  
13     for (auto _ : state) {  
14         pass_by_value(created_string);  
15     }  
16 }  
17 BENCHMARK(PassByValue);  
18  
19 static void PassByRef(benchmark::State& state) {  
20     // Code inside this loop is measured repeatedly  
21     std::string created_string("hello");  
22     for (auto _ : state) {  
23         pass_by_ref(created_string);  
24     }  
25 }  
26 BENCHMARK(PassByRef);
```

This function receive a copy of the value of the input string. Is the input string is big, this operation might cost a lot of time

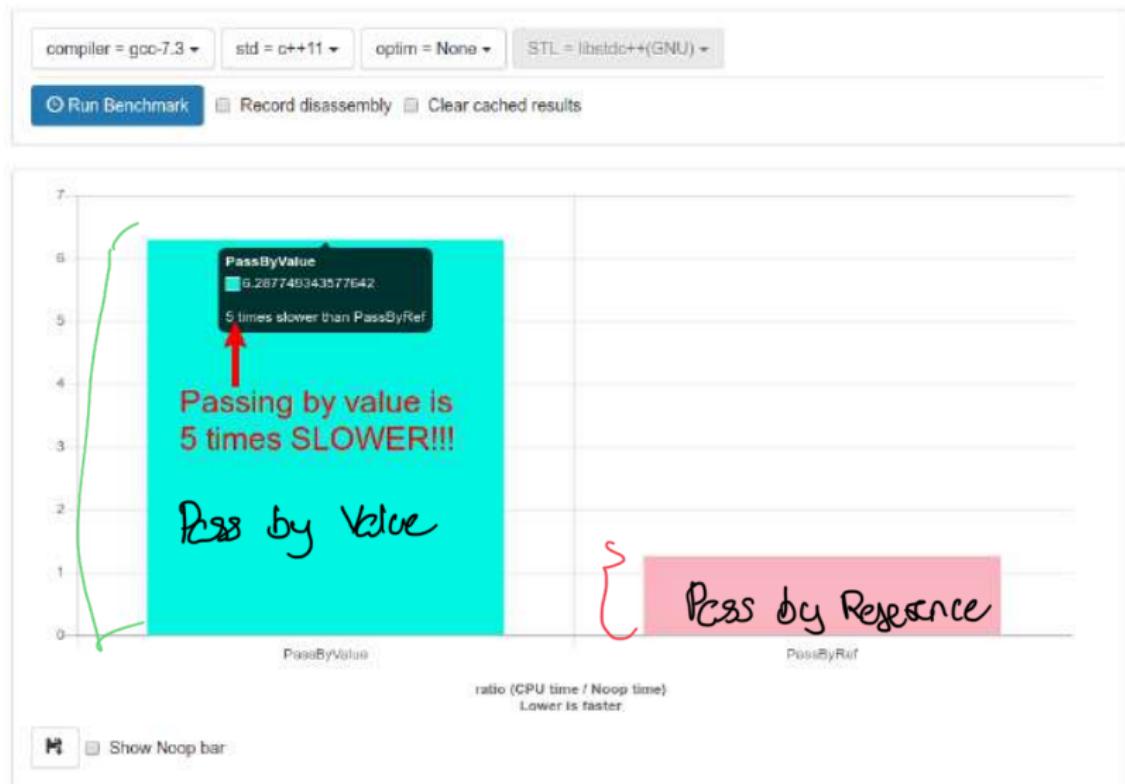
This function receive a reference to the input_string. We will access the memory location where the input string is located

This function call will be evaluated in the benchmark

Pay attention to the benchmark names

<http://quick-bench.com/LqwBICOM3KrQE4tqupBtzqJmCdw>

Cost of passing by value



inline

generate code

Function
CALL

```
void foo() {  
    ;  
}  
void bar() { foo(); }  
  
int main()  
{  
    ;  
    bar();  
}
```



- **function calls are expensive...**
- Well, not **THAT** expensive though.
- If the function is rather small, you could help the compiler.
- inline is a **hint** to the compiler
 - should attempt to generate code for a call
 - rather than a function call.
- Sometimes the compiler do it anyways.

Stack ઉચ્ચિતોની કોડ ના પરિપૂર્ણતા

inline

```
1 inline int fac(int n) {  
2     if (n < 2) {  
3         return 2;  
4     }  
5     return n * fac(n - 1);  
6 }  
7  
8 int main() { return fac(10); }
```

$$2! = 2 \times 1$$

$$2! = 1 \times 2$$

$$1! = 1$$

Cehck it out:

<https://godbolt.org/z/amkfH4>

```

1 inline int fac(int n) {
2     if (n < 2) {
3         return 2;
4     }
5     return n * fac(n - 1);
6 }
7
8 int main() {
9     int fac0 = fac(0);
10    int fac1 = fac(1);
11    int fac2 = fac(2);
12    int fac3 = fac(3);
13    int fac4 = fac(4);
14    int fac5 = fac(5);
15    return fac0 + fac1 + fac2 + fac3 + fac4 + fac5;
16 }
```

inline സൂചിപ്പിക്കുന്നത്. അതാവി
inline ഫൂ. തരംഗി ഏഴ്.പൈ

ശൈലി Compiler Explorer
എന്ന്.

എന്നുമെന്തിലും

<https://godbolt.org>

Check it out:

<https://godbolt.org/z/EGd6aG>

സൗജ്യം compiler explorer നു Compiler Options

-O3 ഫൂ. ഏഴ്.
fac ഫൂ. എഴുന്നു.പൈ

C-style overloading

cosine

```
1 #include <math.h>
2
3 double cos(double x);
4 float cosf(float x);
5 long double cosl(long double x);
```

function Overloading

3 variants

arctan

```
1 #include <math.h>
2
3 double atan(double x);
4 float atanf(float x);
5 long double atanl(long double x);
```

What is arctan?

What is atan?

3 variants

C-style overloading

usage

```
1 #include <math.h>
2 #include <stdio.h>
3
4 int main() {
5     double x_double = 0.0;
6     float x_float = 0.0;
7     long double x_long_double = 0.0;
8
9     printf("cos(0) = %f\n", cos(x_double));
10    printf("cos(0) = %f\n", cosf(x_float));
11    printf("cos(0) = %Lf\n", cosl(x_long_double));
12
13    return 0;
14 }
```



Function overloading

return type
နေပတ်များ

- Compiler infers a function from arguments
- Cannot overload based on return type
- Return type plays no role at all
- GOOGLE-STYLE** Avoid non-obvious overloads

```
1 #include <iostream>
2 #include <string>
3 using namespace std;
4 string TypeOf(int) { return "int"; }
5 string TypeOf(const string&) { return "string"; }
6 int main() {
7     cout << TypeOf(1) << endl;
8     cout << TypeOf("hello") << endl;
9     return 0;
10 }
```

Good Practices

- Break up complicated computations into meaningful chunks and name them.
- Keep the length of functions small enough.
- Avoid **unnecessary** comments.
- One function should achieve ONE task.
- If you can't pick a short name, then split functionality.
- Avoid **macros**.
 - If you must use it, use ugly names with lots of capital letters.

macro යොමු කිරීමේ, Function සංස්කරණය සඳහා task
සංවේද කිරීමේදී මෙයින් භාවිත කිරීම් නො තැබුණු ඇත

Good function example

```
1 #include <vector>
2 using namespace std;
3
4 vector<int> CreateVectorOfZeros(int size) {
5     vector<int> null_vector(size);
6     for (int i = 0; i < size; ++i) {
7         null_vector[i] = 0;
8     }
9     return null_vector;
10}
11
12 int main() {
13     vector<int> zeros = CreateVectorOfZeros(10);
14     return 0;
15}
```



Bad function example #1

```
1 #include <vector>
2 using namespace std;
3 vector<int> Func(int a, bool b) {
4     if (b) { return vector<int>(10, a); }
5     vector<int> vec(a);
6     for (int i = 0; i < a; ++i) { vec[i] = a * i; }
7     if (vec.size() > a * 2) { vec[a] /= 2.0f; }
8     return vec;
9 }
```



- Name of the function means nothing
- Names of variables mean nothing
- Function does not have a single purpose

గැනුමෙන්ම එය, තක්සි මගින් ගැනුම්පාඩුවායි.

Bad function example #2

+

```
1 #include <iostream>
2 #include <vector>
3 using namespace std;
4
5 vector<int> CreateVectorAndPrintContent(int size) {
6     vector<int> vec(size);
7     for (size_t i = 0; i < size; i++) {
8         vec[i] = 0;
9         cout << vec[i] << endl;
10    }
11    return vec;
12 }
13
14 int main() {
15     vector<int> zeros = CreateVectorAndPrintContent(5);
16     return 0;
17 }
```

Bad function example #2 fix

```
1 #include <iostream>
2 #include <vector>
3 using namespace std;
4
5 vector<int> CreateVector(int size) {
6     vector<int> vec(size);
7     for (size_t i = 0; i < size; i++) {
8         vec[i] = 0;
9     }
10    return vec;
11 }
12
13 void PrintVector(std::vector<int> vec) {
14     for (auto element : vec) {
15         cout << element << endl;
16     }
17 }
```



Bad function example #3

Comment for function

```
1 // function user will only see the declaration  
2 // and NOT the definition.  
3 // It's impossible to know at this point any  
4 // additional information about this function.  
5 int SquareNumber(int num);
```



Bad function example #3



Bad function example #3

```
1 // function user will only see the declaration
2 // and NOT the definition.
3 // It's impossible to know at this point any
4 // additional information about this function.
5 int SquareNumber(int num);
```



```
1 int SquareNumber(int num) {
2     // by the way, you need to call your aunt
3     // at this point. otherwise the program will
4     // fail with error code 314.
5     CallYourAunt();
6
7     return num * num;
8 }
```



Namespaces

module1

```
namespace module_1 {  
    int SomeFunc() {}  
}
```

module2

```
namespace module_2 {  
    int SomeFunc() {}  
}
```

- Helps avoiding name conflicts
- Group the project into logical modules

Function හෝ, Class හෝ, variables නොමැත්තුව වෙයි ප්‍රතිඵලියා යොමු කළ ඇත.

Namespaces example

```
1 #include <iostream>
2
3 namespace fun {
4     int GetMeaningOfLife(void) { return 42; }
5 } // namespace fun
6
7 namespace boring {
8     int GetMeaningOfLife(void) { return 0; }
9 } // namespace boring
10
11 int main() {
12     std::cout << boring::GetMeaningOfLife() << std::endl
13             << fun::GetMeaningOfLife() << std::endl;
14     return 0;
15 }
```



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Namespaces example 2

- We don't like `std::vector` at all
- Let's define our own vector Class

```
1 // @file: my_vector.hpp
2 namespace my_vec {
3     template <typename T>
4     class vector {
5         // ...
6     };
7 } // namespace my_vec
```

my_vector.hpp

Namespaces example 2

```
1 #include <vector>
2 #include "my_vecor.hpp"
3 int main() {
4     std::vector<int> v1;      // Standard vector. ✓
5     vec::vector<int> v2;      // User defined vector. ✓
6
7     {
8         using std::vector;
9         vector<int> v3;      // Same as std::vector ✓
10        v1 = v3;             // OK ✓
11    }
12
13    {
14        using vec::vector;           // using vector = vec::vector<int>;
15        vector<int> v4;      // Same as vec::vector ✓
16        v2 = v4;             // OK ✓
17    }
18 }
```

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Avoid using namespace <name>

```
1 #include <cmath>
2 #include <iostream>
3 using namespace std; // std namespace is used
4
5 // Self-defined function power shadows std::pow
6 double pow(double x, int exp) {
7     double res = 1.0;
8     for (int i = 0; i < exp; i++) {
9         res *= x;
10    }
11    return res;
12 }
13
14 int main() {
15     cout << "2.0^2 = " << pow(2.0, 2) << endl;
16     return 0;
17 }
```

3 , 2

ഡോൾ സ്റ്റാറ്റിക് പാവ്
അംഗീകാരിക്കുന്ന ലോക് പാവ്

അംഗീകാരിക്കുന്ന ലോക് പാവ്

അംഗീകാരിക്കുന്ന ലോക് പാവ്

Namespace error

Error നാമം.

Error output:

```
1 /home/ivizzo/.../namespaces_error.cpp:13:26:  
2 error: call of overloaded ‘pow(double&, int&)’ is  
      ambiguous  
3 double res = pow(x, exp);  
4  
5 ...
```

Only use what you need

```
1 #include <cmath>
2 #include <iostream>
3 using std::cout; // Explicitly use cout. } නිවාස
4 using std::endl; // Explicitly use endl. } using සඳහා
5
6 // Self-defined function power shadows std::pow
7 double pow(double x, int exp) {
8     double res = 1.0;
9     for (int i = 0; i < exp; i++) { ← ප්‍රතිඵලිය,
10         res *= x;
11     }
12     return res;
13 }
14
15 int main() {
16     cout << "2.0^2 = " << pow(2.0, 2) << endl;
17     return 0;
18 }
```

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Namespaces Wrap Up

Use namespaces to avoid name conflicts

```
1 namespace some_name {  
2     <your_code>  
3 } // namespace some_name
```

Use using correctly

- [good]

- ✓ using my_namespace::myFunc;
- ✓ my_namespace::myFunc(...);

ଶଫ୍ଟ୍‌କୌଣସି: ଆ

- **Never** use using namespace name in *.hpp files

* using namespace ନେଇ Header ଫିଲ୍ୟୁଳା ହୁଏ: ପାଇଁ

- Prefer using explicit using even in *.cpp files

* CPP ଫିଲ୍ୟୁଳା ହୁଏ: ଏହା ଯଦି କାମ କରିବାକୁ ପାଇଁ

Nameless namespaces

- GOOGLE-STYLE for namespaces:

<https://google.github.io/styleguide/cppguide.html#Namespaces>

- GOOGLE-STYLE If you find yourself relying on some constants in a file and these constants should not be seen in any other file, put them into a **nameless namespace** on the top of this file

```
1 namespace {  
2     const int kLocalImportantInt = 13;  
3     const float kLocalImportantFloat = 13.0f;  
4 } // namespace
```

nameless namespace සිංහ පොන්නේ හැඳුවා ඇත

https://google.github.io/styleguide/cppguide.html#Unused_namespaces_and_variables

