

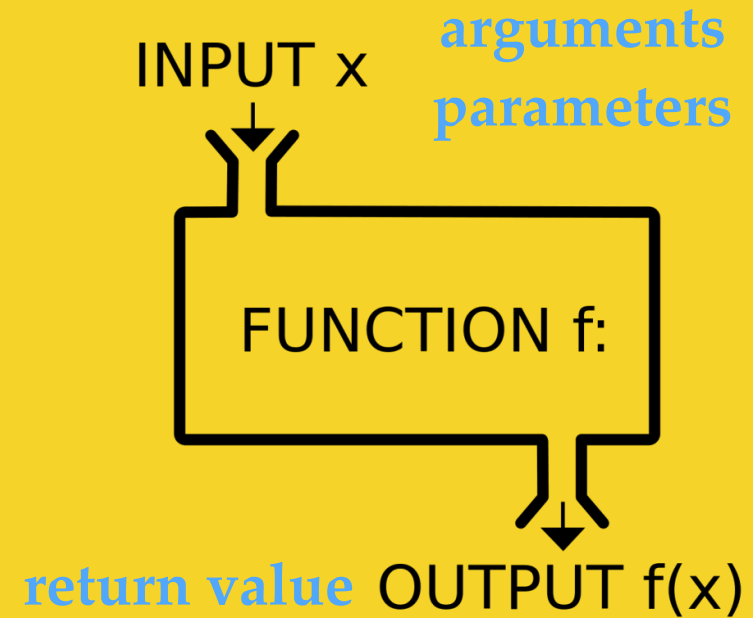
CSC 211: Computer Programming

Functions

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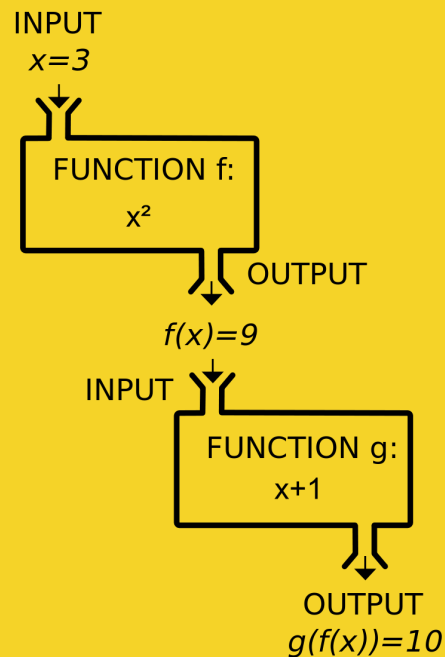
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<https://blogs.oracle.com/developers/the-power-of-functional-programming>

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Functions

- A function is a group of statements that together perform a task (packaged as a unit)
- **Top-down design**
 - ✓ break the algorithm into specific subtasks
 - ✓ break each subtask into smaller subtasks
- Smaller subtasks are generally trivial to implement in the programming language

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Functions

- Two major parts needed a function
 - ✓ **Function Definition**
 - ✓ **Function Call**

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Why functions?

- Improves code readability
- Improves code maintainability
- Allows easy code reuse

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Predefined functions

- Predefined functions are found in libraries
 - ✓ the library must be included in a program
 - ✓ e.g. `#include <cmath>`
- Predefined functions can be invoked after including the proper library headers

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Some <cmath> functions

Some Predefined Functions

Name	Description	Type of Arguments	Type of Value Returned	Example	Value	Library Header
sqrt	square root	double	double	sqrt(4.0)	2.0	cmath
pow	powers	double	double	pow(2.0, 3.0)	8.0	cmath
abs	absolute value for <i>int</i>	int	int	abs(-7) abs(7)	7 7	cstdlib
labs	absolute value for <i>long</i>	long	long	labs(-70000) labs(70000)	70000 70000	cstdlib
fabs	absolute value for <i>double</i>	double	double	fabs(-7.5) fabs(7.5)	7.5 7.5	cmath
ceil	ceiling (round up)	double	double	ceil(3.2) ceil(3.9)	4.0 4.0	cmath
floor	floor (round down)	double	double	floor(3.2) floor(3.9)	3.0 3.0	cmath

from: Problem Solving with C++, 10th Edition, Walter Savitch

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Programmer defined functions (syntax)

```
// comment describing what function does  
return_type function_name(parameters);
```

declaration

```
// ...  
// statements  
// ...
```

definition

```
return_type function_name(parameters) {  
    // body of the function  
}
```

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Function declaration

- Tells compiler the **function signature**
 - name, parameters, return type
- Declarations are required to appear prior to a function call
 - unless a definition has already appeared
- Declarations are normally placed before the main function

```
// comment describing what function does  
return_type function_name(parameters);
```

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Function definition

- Provides the all details of a function
 - includes the actual body of the function (block of statements)
- Can only return one value using the return statement
 - Trick to return multiple values

```
return_type function_name(parameters) {  
    // body of the function  
}
```

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Example

```
int function(int param);
```

```
int main() {  
    // ...  
    a = function(val);  
    // ...  
}
```

```
int function(int param) {  
    // body of the function  
    // must return an integer  
}
```

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A different style ...

```
int function(int param) {  
    // body of the function  
    // must return an integer  
}  
  
int main() {  
    // ...  
    a = function(val);  
    // ...  
}
```

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Parameter list

- Refers to the **type**, order, and number of parameters of a function
- Parameters are optional
 - ▾ can be empty
- When a function is invoked, arguments are passed accordingly (with respect to the parameter list)

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Parameter list (example)

- Refers to the **type**, order, and number of parameters of a function

```
1  int sum(int a, int b){  
2      return a + b;  
3  }  
4  
5  int main(){  
6      std::cout << sum(10, 20);  
7  }
```

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return statement

- Ends the function call
 - ▾ returns a value

return expression;

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return statement

return expression;

```
1  int sum(int a, int b){
2      return a + b;
3  }
4
5  int main(){
6      std::cout << sum(10, 20);
7  }
```

V.S

```
1  int sum(int a, int b){
2      return a + b;
3  }
4
5  int main(){
6      int mySum = sum(10, 20);
7  }
```

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Label all function parts

```
#include <iostream>
```

```
int abs(int n);
```

 declaration or prototype

```
int main() {
    std::cout << "|-5| = " << abs(-5) << std::endl;
    return 0;
}
```

 function call

```
int abs(int n) {
    if (n < 0) {
        return -n;
    } else {
        return n;
    }
}
```

 definition

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Functions are black boxes

DISPLAY 4.7 Definitions That Are Black-Box Equivalent

Function Declaration

```
1  double newBalance(double balancePar, double ratePar);
2  //Returns the balance in a bank account after
3  //posting simple interest. The formal parameter balancePar is
4  //the old balance. The formal parameter ratePar is the interest rate.
5  //For example, if ratePar is 5.0, then the interest rate is 5 percent
6  //and so newBalance(100, 5.0) returns 105.00.
```

Definition 1

```
double newBalance(double balancePar, double ratePar)
{
    double interestFraction, interest;

    interestFraction = ratePar/100;
    interest = interestFraction * balancePar;
    return (balancePar + interest);
}
```

Definition 2

```
double newBalance(double balancePar, double ratePar)
{
    double interestFraction, updatedBalance;

    interestFraction = ratePar/100;
    updatedBalance = balancePar * (1 + interestFraction);
    return updatedBalance;
}
```

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void functions

- A function might produce no returning value
 - e.g. sends IP packets to other machine, or sends data to the standard output, modifies elements in an array
- Void functions allow programmers to define functions (and some semantic behavior) with no returning values

```
void f_name(/* parameters */) {
    // statements
    return;
}
```

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DISPLAY 5.3 Use of return in a void Function

Function Declaration

```
1 void iceCreamDivision(int number, double totalWeight);
2 //Outputs instructions for dividing totalWeight ounces of
3 //ice cream among number customers.
4 //If number is 0, nothing is done.
```

Function Definition

```
1 //Definition uses iostream:
2 void iceCreamDivision(int number, double totalWeight)
3 {
4     using namespace std;
5     double portion;
6
7     if (number == 0)
8         return;
9     portion = totalWeight/Number;
10    cout.setf(ios::fixed);
11    cout.setf(ios::showpoint);
12    cout.precision(2);
13    cout << "Each one receives "
14         << portion << " ounces of ice cream." << endl;
15 }
```

If number is 0, then the function execution ends here.

from: Problem Solving with C++, 10th Edition, Walter Savitch

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```
#include <iostream>
```

```
void foo(int a, int b) {
    std::cout << a + b;
    return;
}
```

```
int main() {
    std::cout << foo(10, 20);
}
```

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```
a.cc:9:15: error: invalid operands to binary expression ('std::__1::ostream' (aka 'basic_ostream<char>') and 'void')
    std::cout << foo(10, 20);
                ^
/Library/Developer/CommandLineTools/usr/include/c++/v1/
ostream:194:20: note: candidate function not viable: cannot convert argument of incomplete type 'void' to 'std::__1::ba
ic_ostream<char>' (&*) (std::__1::basic_ostream<char> &) for 1st argument
    basic_ostream& operator<<(basic_ostream& (*__pf)(basic_ostream&))
                        ^
/Library/Developer/CommandLineTools/usr/include/c++/v1/
ostream:198:20: note: candidate function not viable: cannot convert argument of incomplete type 'void' to 'basic_ios<st
d::__1::basic_ostream<char, std::__1::char_traits<char> >; char_type, std::__1::basic_ostream<char, std::__1::char_traits
<char> >; traits_type> &(*)' (aka 'basic_ios<char, std::__1::char_traits<char> > &(*)' for 1st argument
    basic_ios<char, std::__1::char_traits<char> > &(*)' (aka 'basic_ios<char, std::__1::char_traits<char> > &(*)' for 1st argument
    basic_ostream& operator<<(basic_ios<char_type, traits_type>&
                        ^
/Library/Developer/CommandLineTools/usr/include/c++/v1/
ostream:203:20: note: candidate function not viable: cannot convert argument of incomplete type 'void' to 'std::__1::ios
_base &(*) (std::__1::ios_base &)' for 1st argument
    basic_ostream& operator<<(ios_base& (*__pf)(ios_base&))
                        ^
.... 87 lines omitted
/Library/Developer/CommandLineTools/usr/include/c++/v1/
ostream:1081:1: note: candidate template ignored: could not match 'unique_ptr<type-parameter-0-2, type-
parameter-0-3>' against 'void'
operator<<(basic_ostream<CharT, _Traits& __os, unique_ptr<_Yp, _Dp> const& __p)
^
/Library/Developer/CommandLineTools/usr/include/c++/v1/
ostream:1088:1: note: candidate template ignored: could not match 'bitset<Size>' against 'void'
operator<<(basic_ostream<CharT, _Traits& __os, const bitset<Size>& __x)
^
1 error generated.
```

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```
#include <iostream>
```

```
void foo(int a, int b) {
    std::cout << a + b;
    return;
}
```

```
int main() {
    foo(10, 20);
}
```



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Tracing a function call

DISPLAY 4.3 A Function Definition

```
1 #include <iostream>
2 using namespace std;
3
4 double totalCost(int numberPar, double pricePar);
5 //Computes the total cost, including 5% sales tax,
6 //on numberPar items at a cost of pricePar each.
7
8 int main( )
9 {
10     double price, bill;
11     int number;
12
13     cout << "Enter the number of items purchased: ";
14     cin >> number;
15     cout << "Enter the price per item $";
16     cin >> price;
17
18     bill = totalCost(number, price);
19
20     cout.setf(ios::fixed);
21     cout.setf(ios::showpoint);
22     cout.precision(2);
23     cout << number << " items at "
24          << "$" << price << " each.\n"
25          << "Final bill, including tax, is $" << bill
26          << endl;
27
28     return 0;
29 }
30
31 double totalCost(int numberPar, double pricePar)
32 {
33     const double TAX_RATE = 0.05; //5% sales tax
34     double subtotal;
35
36     subtotal = pricePar * numberPar;
37     return (subtotal + subtotal * TAX_RATE);
38 }
```

function declaration/function prototype

function call

function heading

function body

function definition

from: Problem Solving with C++, 10th Edition, Walter Savitch

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DISPLAY 4.4 Details of a Function Call

```
int main()
{
    double price, bill;
    int number;
    cout << "Enter the number of items purchased: ";
    cin >> number;
    cout << "Enter the price per item $";
    cin >> price;

    bill = totalCost(number, price);

    cout.setf(ios::fixed);
    cout.setf(ios::showpoint);
    cout.precision(2);
    cout << number << " items at "
         << "$" << price << " each.\n"
         << "Final bill, including tax, is $" << bill
         << endl;
    return 0;
}

double totalCost (int numberPar, double pricePar)
{
    const double TAX_RATE = 0.05; //5% sales tax
    double subtotal;

    subtotal = pricePar * numberPar;
    return (subtotal + subtotal * TAX_RATE);
}
```

1. Before the function is called, values of the variables `number` and `price` are set to 2 and 10.10, by `cin` statements (as you can see the Sample Dialogue in Display 4.3)

2. The function call executes and the value of `number` (which is 2) plugged in for `numberPar` and value of `price` (which is 10.10) plugged in for `pricePar`.

3. The body of the function executes with `numberPar` set to 2 and `pricePar` set to 10.10, producing the value 20.20 in subtotal.

4. When the return statement is executed, the value of the expression after return is evaluated and returned by the function. In this case, $(\text{subtotal} + \text{subtotal} * \text{TAX_RATE})$ is $(20.20 + 20.20 * 0.05)$ or 21.21.

5. The value 21.21 is returned to where the function was invoked. The result is that `totalCost(number, price)` is replaced by the return value of 21.21. The value of `bill` (on the left-hand side of the equal sign) is set equal to 21.21 when the statement `bill = totalCost(number, price);` finally ends.

from: Problem Solving with C++, 10th Edition, Walter Savitch

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Question?

- Write a program that takes an integer $n > 1$ from `stdin` and outputs the largest prime number less than or equal than n to the `stdout`
- use an `is_prime` function to help find `highest_prime`

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