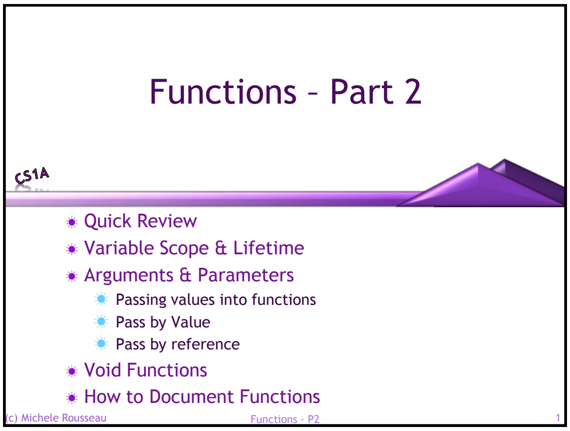
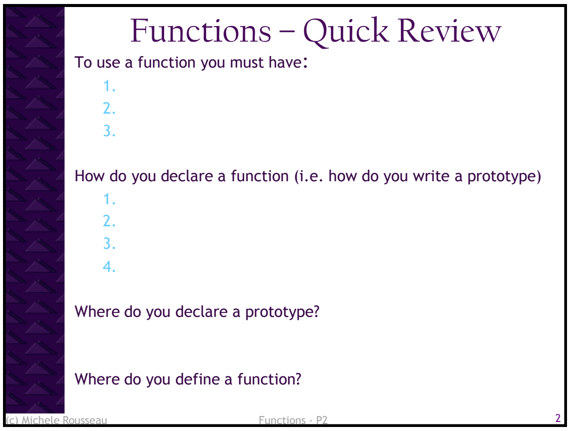


Functions – Part 2

CS1A

- Quick Review
- Variable Scope & Lifetime
- Arguments & Parameters
  - Passing values into functions
  - Pass by Value
  - Pass by reference
- Void Functions
- How to Document Functions

(c) Michele Rousseau Functions - P2 1



Functions – Quick Review

To use a function you must have:

1.
2.
3.

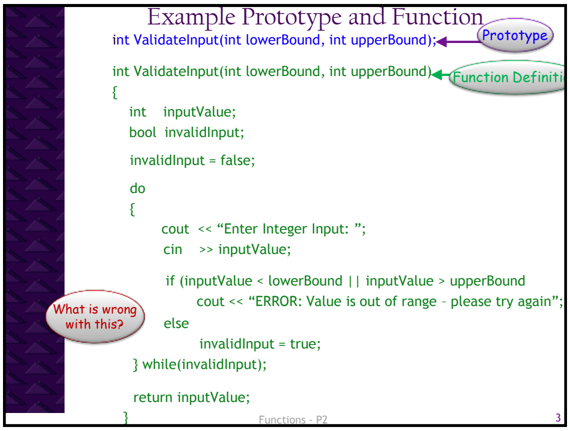
How do you declare a function (i.e. how do you write a prototype)

1.
2.
3.
4.

Where do you declare a prototype?

Where do you define a function?

(c) Michele Rousseau Functions - P2 2



Example Prototype and Function

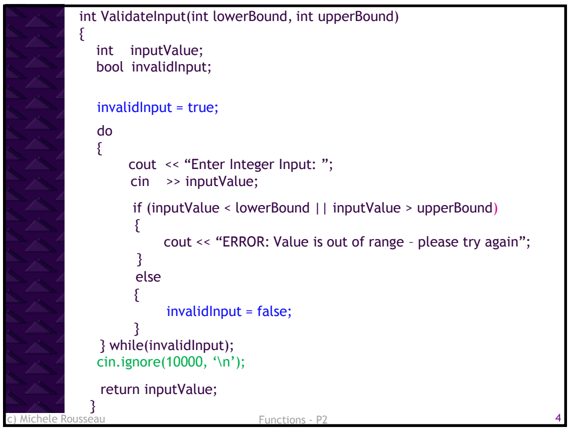
```
int ValidateInput(int lowerBound, int upperBound);

int ValidateInput(int lowerBound, int upperBound)
{
   int   inputValue;
   bool  invalidInput;

   invalidInput = false;

   do
   {
        cout  << “Enter Integer Input: ”;
        cin    >> inputValue;

        if (inputValue < lowerBound || inputValue > upperBound
              cout << “ERROR: Value is out of range - please try again”;
        else
              invalidInput = true;
   } while(invalidInput);

   return inputValue;
}
```

Prototype

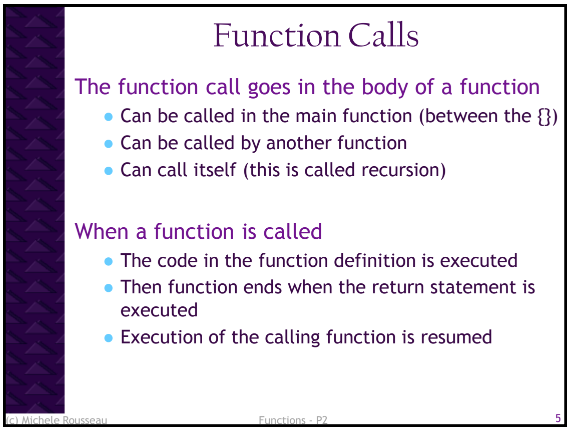
Function Definiti

What is wrong with this?

Functions - P2 3



```
int ValidateInput(int lowerBound, int upperBound)
{
    int    inputValue;
    bool  invalidInput;

    invalidInput = true;
    do
    {
           cout  << “Enter Integer Input: ”;
           cin    >> inputValue;

           if (inputValue < lowerBound || inputValue > upperBound)
           {
                  cout << “ERROR: Value is out of range - please try again”;
           }
           else
           {
                  invalidInput = false;
           }
     } while(invalidInput);
    cin.ignore(10000, ‘\n’);

     return inputValue;
  }
```



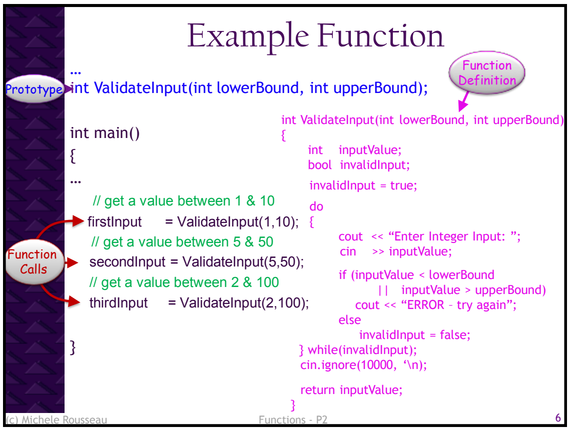
Function Calls

The function call goes in the body of a function

- Can be called in the main function (between the {})
- Can be called by another function
- Can call itself (this is called recursion)

When a function is called

- The code in the function definition is executed
- Then function ends when the return statement is executed
- Execution of the calling function is resumed



Example Function

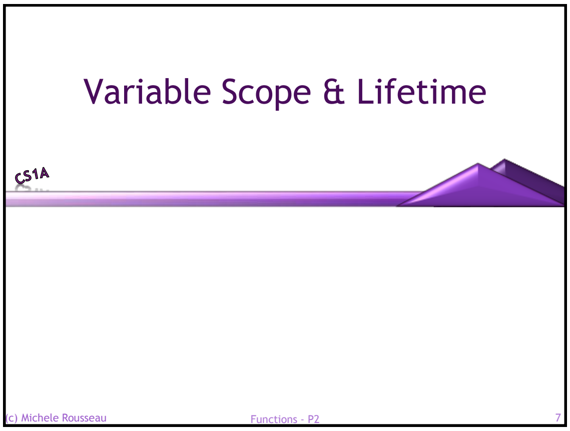
Prototype

Function Definition

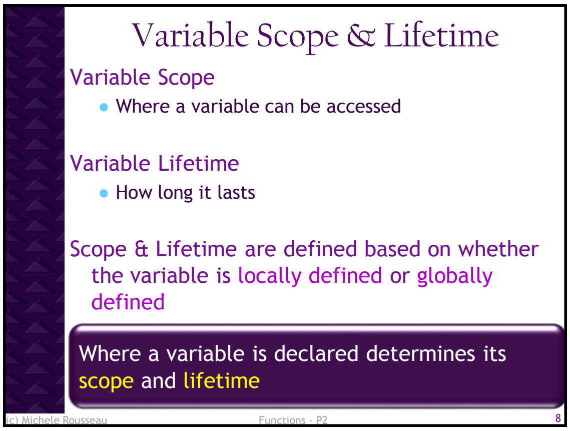
```
…
int ValidateInput(int lowerBound, int upperBound);

int main()
{
…
     // get a value between 1 & 10
    firstInput      = ValidateInput(1,10);
    // get a value between 5 & 50
    secondInput = ValidateInput(5,50);
    // get a value between 2 & 100
    thirdInput      = ValidateInput(2,100);

}
```

Function Calls

```
int ValidateInput(int lowerBound, int upperBound)
{
      int    inputValue;
      bool  invalidInput;
      invalidInput = true;
      do
      {
            cout  << “Enter Integer Input: ”;
            cin    >> inputValue;
            if (inputValue < lowerBound
                     ||   inputValue > upperBound)
               cout << “ERROR - try again”;
            else
                  invalidInput = false;
     } while(invalidInput);
     cin.ignore(10000, ‘\n);

     return inputValue;
   }
```



Variable Scope & Lifetime



Variable Scope & Lifetime

Variable Scope

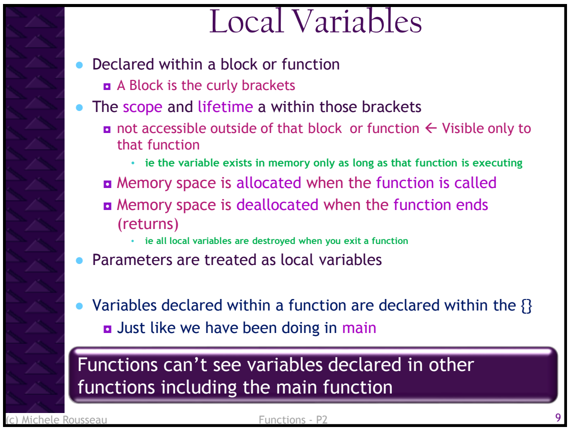
- Where a variable can be accessed

Variable Lifetime

- How long it lasts

Scope & Lifetime are defined based on whether the variable is locally defined or globally defined

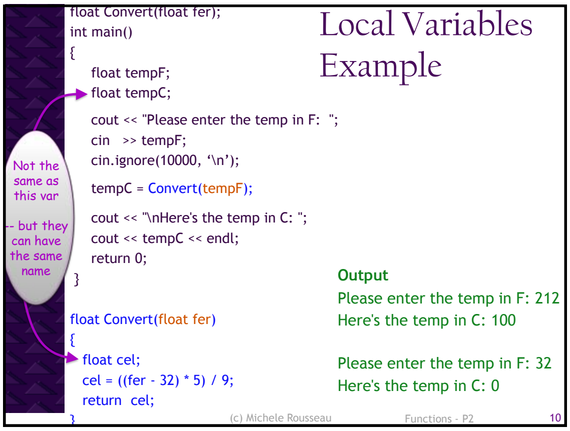
Where a variable is declared determines its scope and lifetime



Local Variables

- Declared within a block or function
  - A Block is the curly brackets
- The scope and lifetime a within those brackets
  - not accessible outside of that block or function ← Visible only to that function
    - ie the variable exists in memory only as long as that function is executing
  - Memory space is allocated when the function is called
  - Memory space is deallocated when the function ends (returns)
    - ie all local variables are destroyed when you exit a function
- Parameters are treated as local variables
- Variables declared within a function are declared within the {}
  - Just like we have been doing in main

Functions can’t see variables declared in other functions including the main function



Local Variables Example

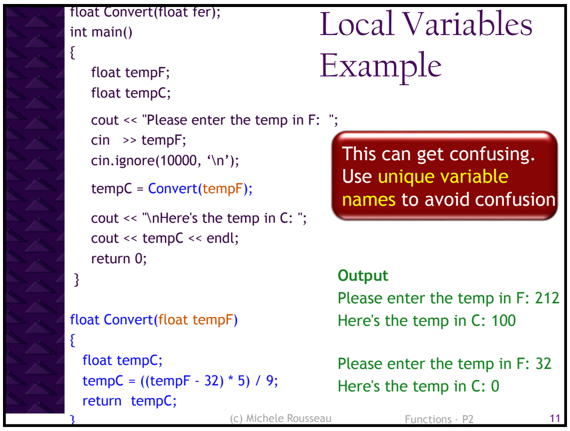
```
float Convert(float fer);
int main()
{
    float tempF;
    float tempC;

    cout << "Please enter the temp in F:  ";
    cin   >> tempF;
    cin.ignore(10000, ‘\n’);

    tempC = Convert(tempF);

    cout << "\nHere's the temp in C: ";
    cout << tempC << endl;
    return 0;
 }

float Convert(float fer)
{
  float cel;
  cel = ((fer - 32) * 5) / 9;
  return  cel;
}
```

Not the same as this var

-- but they can have the same name

Output

```
Please enter the temp in F: 212
Here's the temp in C: 100

Please enter the temp in F: 32
Here's the temp in C: 0
```



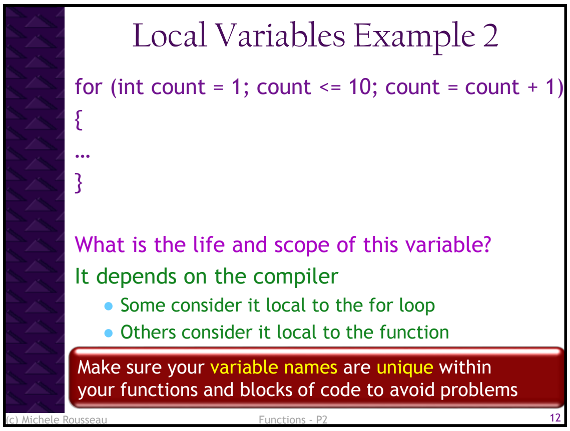
Local Variables Example

```
float Convert(float fer);
int main()
{
    float tempF;
    float tempC;

    cout << "Please enter the temp in F:  ";
    cin   >> tempF;
    cin.ignore(10000, ‘\n’);

    tempC = Convert(tempF);

    cout << "\nHere's the temp in C: ";
    cout << tempC << endl;
    return 0;
 }

float Convert(float tempF)
{
  float tempC;
  tempC = ((tempF - 32) * 5) / 9;
  return  tempC;
}
```

This can get confusing. Use unique variable names to avoid confusion

Output

```
Please enter the temp in F: 212
Here's the temp in C: 100

Please enter the temp in F: 32
Here's the temp in C: 0
```



Local Variables Example 2

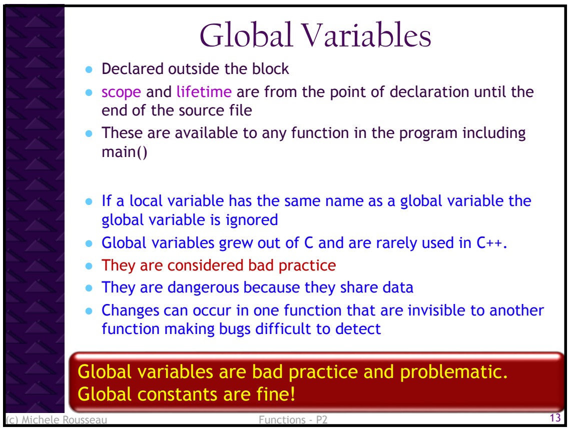
```
for (int count = 1; count <= 10; count = count + 1)
{
…
}
```

What is the life and scope of this variable?

It depends on the compiler

- Some consider it local to the for loop
- Others consider it local to the function

Make sure your variable names are unique within your functions and blocks of code to avoid problems

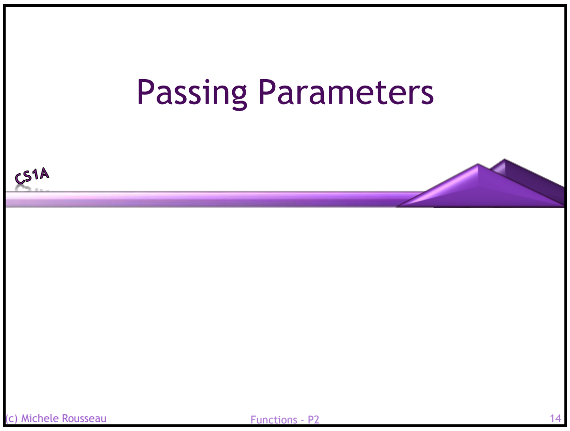


Global Variables

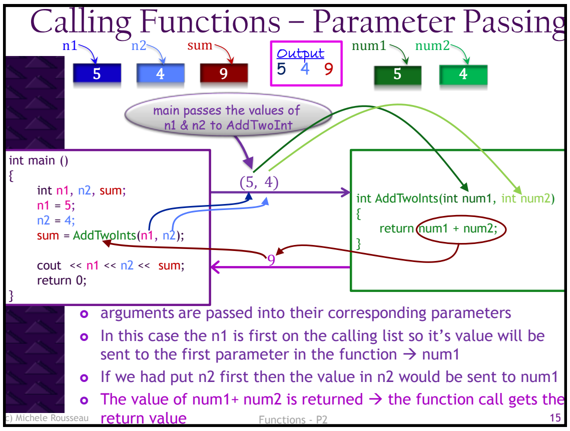
- Declared outside the block
- scope and lifetime are from the point of declaration until the end of the source file
- These are available to any function in the program including main()

- If a local variable has the same name as a global variable the global variable is ignored
- Global variables grew out of C and are rarely used in C++.
- They are considered bad practice
- They are dangerous because they share data
- Changes can occur in one function that are invisible to another function making bugs difficult to detect

Global variables are bad practice and problematic.
Global constants are fine!



Passing Parameters



Calling Functions – Parameter Passing

```
int main ()
{
        int n1, n2, sum;
        n1 = 5;
        n2 = 4;
        sum = AddTwoInts(n1, n2);

        cout  << n1 << n2 <<  sum;
        return 0;
}
```

```
int AddTwoInts(int num1, int num2)
{
      return num1 + num2;
}
```

- arguments are passed into their corresponding parameters
- In this case the n1 is first on the calling list so it's value will be sent to the first parameter in the function → num1
- If we had put n2 first then the value in n2 would be sent to num1
- The value of num1+ num2 is returned → the function call gets the return value

Parameters

There are two types of parameters

- Value Parameters
  - A formal parameter that receives a copy of the contents of the corresponding argument (actual parameter).
- Reference Parameter
  - A formal parameter that receives the address (location in memory) of the corresponding argument (actual parameter).

Passing by Value

What we have been doing so far is passing by value (ie using value parameters)

- A duplicate copy of each variable is created when the function is called
- The values of the parameters being passed from the calling function are copied into the parameters of the function
- If the called function changes these parameters it does not effect the calling functions values

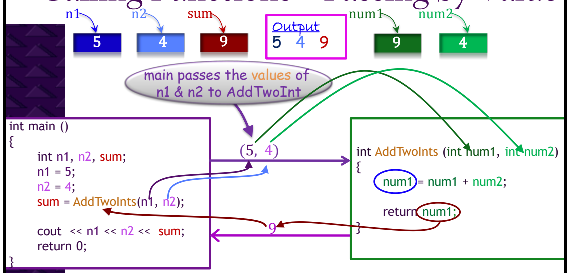
Advantage

- No accidental modifications of the arguments in the calling function

Disadvantage

- Passing large variables takes a lot of overhead
- The value of the passed variable has to be copied & initialized
- For small variables this is good
- Large variables time & space penalties become a problem

Calling Functions – Passing by Value



```
int main ()
{
      int n1, n2, sum;
      n1 = 5;
      n2 = 4;
      sum = AddTwoInts(n1, n2);

      cout  << n1 << n2 <<  sum;
      return 0;
}
```

```
int AddTwoInts (int num1, int num2)
{
      num1 = num1 + num2;

      return num1;
}
```

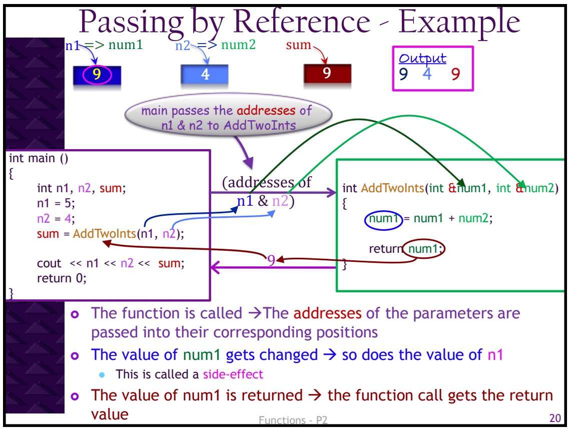
- The function is called → the values of n1 & n2 are passed into their respective positions (num1 & num2)
- The value of num1 is changed → it does not effect n1
- The value of num1 is returned → the function call gets the return value

Passing by Reference

- A reference is an alias
  - Basically a different name is used for the same variable
- When we use Reference parameters the addresses of the variables passed from the calling function to are called function
  - The actual memory location is being passed
  - This means that the value in these locations can be changed
- Because you are passing a reference you must pass a variable
  - You can't pass a literal or an expression by reference

Syntax
returnType functionName(*parameterType &parameterName*)

Example: int AddTwoInts(int &num1, int &num2)



Passing by Reference - Example

n1 => num1 n2 => num2 sum

9 4 9

Output
9 4 9

main passes the addresses of n1 & n2 to AddTwoInts

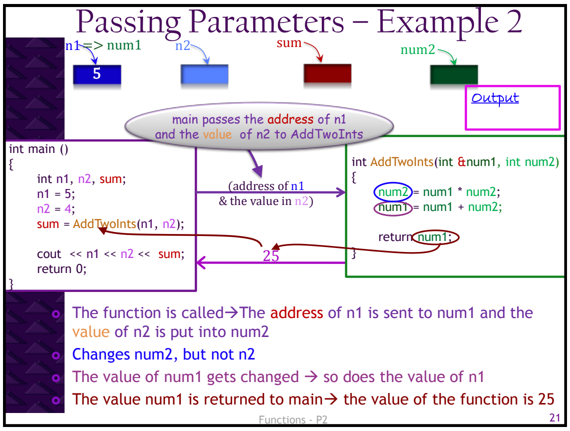
```
int main ()
{
      int n1, n2, sum;
      n1 = 5;
      n2 = 4;
      sum = AddTwoInts(n1, n2);

      cout  << n1 << n2 <<  sum;
      return 0;
}
```

(addresses of n1 & n2)

```
int AddTwoInts(int &num1, int &num2)
{
      num1 = num1 + num2;

      return num1;
}
```

9

- The function is called →The addresses of the parameters are passed into their corresponding positions
- The value of num1 gets changed → so does the value of n1
  - This is called a side-effect
- The value of num1 is returned → the function call gets the return value



Passing Parameters – Example 2

n1 => num1 n2 sum num2

5

Output

main passes the address of n1 and the value of n2 to AddTwoInts

```
int main ()
{
      int n1, n2, sum;
      n1 = 5;
      n2 = 4;
      sum = AddTwoInts(n1, n2);

      cout  << n1 << n2 <<  sum;
      return 0;
}
```

(address of n1 & the value in n2)

```
int AddTwoInts(int &num1, int num2)
{
      num2 = num1 * num2;
      num1 = num1 + num2;

      return num1;
}
```

25

- The function is called→The address of n1 is sent to num1 and the value of n2 is put into num2
- Changes num2, but not n2
- The value of num1 gets changed → so does the value of n1
- The value num1 is returned to main→ the value of the function is 25

Side-Effects

- when a parameter passed by reference is changed in the function that is called
- This can lead to trouble
  - It becomes to hard to determine how values are changed
- Can't happen with pass by value
  - All variables passed by value are treated like constants by the called function

Solution ➔ Pass by constant reference

Constant Reference

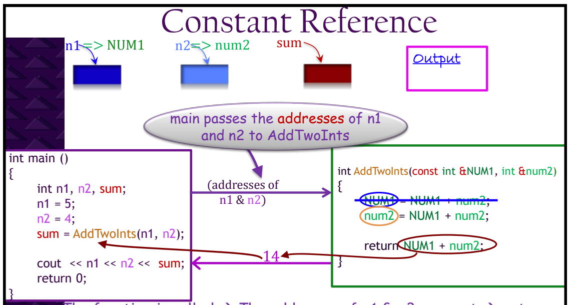
- A reference that does not allow the variable being referenced to be changed
- The called function can use the value but can't change it

Syntax
returnType functionName(const *parameterType &parameterName*)

Example:

```
int AddTwoInts(const int &num1, const int &num2)
```

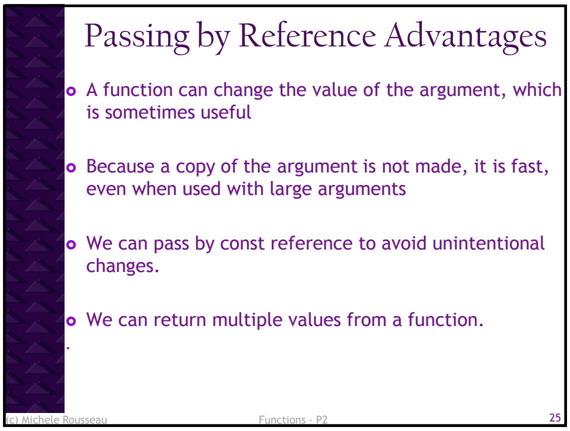
Constant Reference



```
int main ()
{
     int n1, n2, sum;
     n1 = 5;
     n2 = 4;
     sum = AddTwoInts(n1, n2);

     cout  << n1 << n2 <<  sum;
     return 0;
}
```

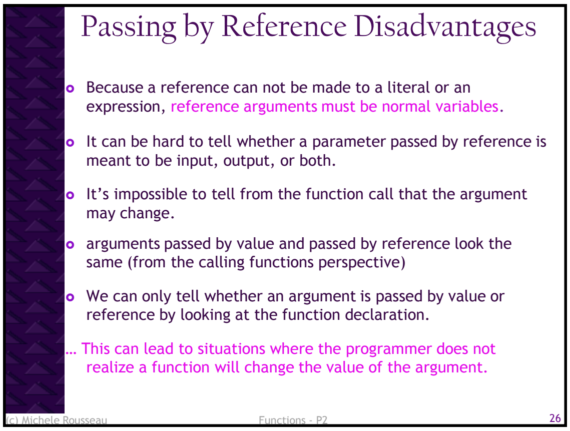
```
int AddTwoInts(const int &NUM1, int &num2)
{
     ~~NUM1 = NUM1 + num2;~~
     num2 = NUM1 + num2;

     return NUM1 + num2;
}
```

- The function is called → The addresses of n1 & n2 are sent → note that num1 is a constant now
- Can't do this! → num1 is a constant now
- The value of num2 gets changed → so does the value of n2
- The value of the expression num1 + num2 is returned to main→ the value of the function is 14



Passing by Reference Advantages

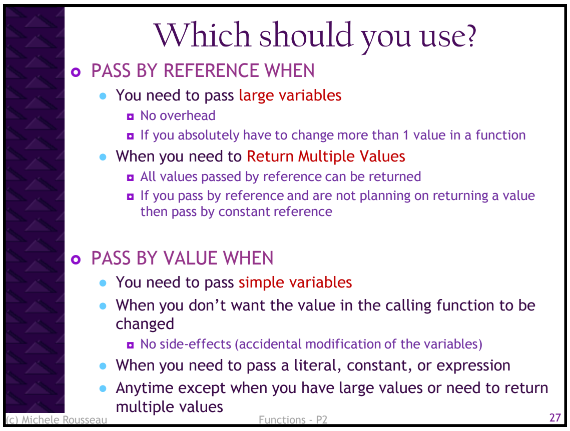
- A function can change the value of the argument, which is sometimes useful
- Because a copy of the argument is not made, it is fast, even when used with large arguments
- We can pass by const reference to avoid unintentional changes.
- We can return multiple values from a function.



Passing by Reference Disadvantages

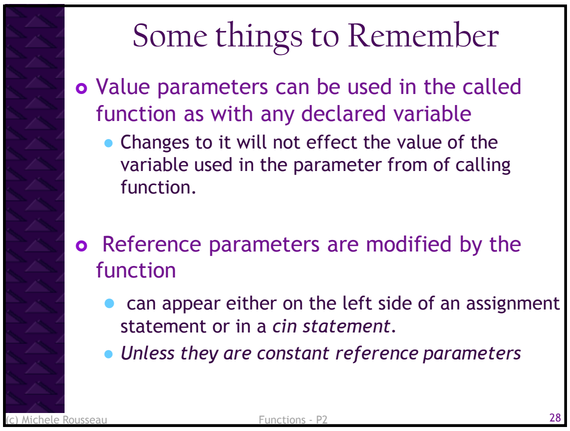
- Because a reference can not be made to a literal or an expression, reference arguments must be normal variables.
- It can be hard to tell whether a parameter passed by reference is meant to be input, output, or both.
- It's impossible to tell from the function call that the argument may change.
- arguments passed by value and passed by reference look the same (from the calling functions perspective)
- We can only tell whether an argument is passed by value or reference by looking at the function declaration.

… This can lead to situations where the programmer does not realize a function will change the value of the argument.



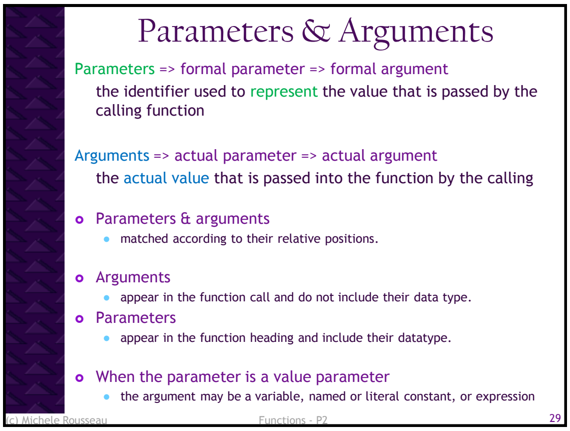
Which should you use?

- PASS BY REFERENCE WHEN
  - You need to pass large variables
    - No overhead
    - If you absolutely have to change more than 1 value in a function
  - When you need to Return Multiple Values
    - All values passed by reference can be returned
    - If you pass by reference and are not planning on returning a value then pass by constant reference
- PASS BY VALUE WHEN
  - You need to pass simple variables
  - When you don't want the value in the calling function to be changed
    - No side-effects (accidental modification of the variables)
  - When you need to pass a literal, constant, or expression
  - Anytime except when you have large values or need to return multiple values



Some things to Remember

- Value parameters can be used in the called function as with any declared variable
  - Changes to it will not effect the value of the variable used in the parameter from of calling function.
- Reference parameters are modified by the function
  - can appear either on the left side of an assignment statement or in a *cin statement*.
  - *Unless they are constant reference parameters*



Parameters & Arguments

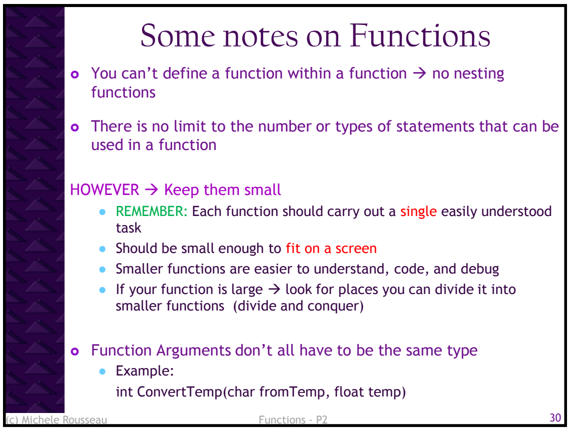
Parameters => formal parameter => formal argument

the identifier used to represent the value that is passed by the calling function

Arguments => actual parameter => actual argument

the actual value that is passed into the function by the calling

- Parameters & arguments
  - matched according to their relative positions.
- Arguments
  - appear in the function call and do not include their data type.
- Parameters
  - appear in the function heading and include their datatype.
- When the parameter is a value parameter
  - the argument may be a variable, named or literal constant, or expression



Some notes on Functions

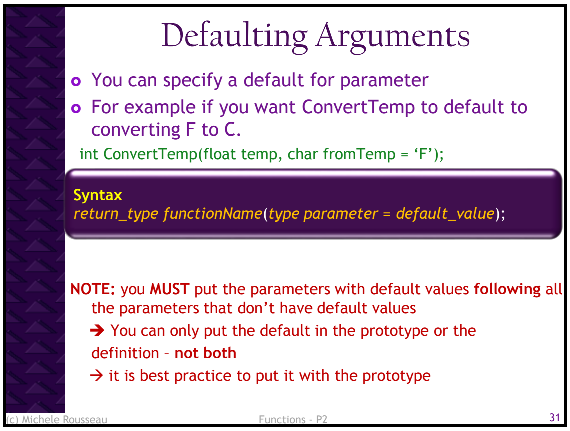
- You can't define a function within a function → no nesting functions
- There is no limit to the number or types of statements that can be used in a function

HOWEVER → Keep them small

- REMEMBER: Each function should carry out a single easily understood task
- Should be small enough to fit on a screen
- Smaller functions are easier to understand, code, and debug
- If your function is large → look for places you can divide it into smaller functions (divide and conquer)

- Function Arguments don't all have to be the same type
  - Example:

    int ConvertTemp(char fromTemp, float temp)



Defaulting Arguments

- You can specify a default for parameter
- For example if you want ConvertTemp to default to converting F to C.

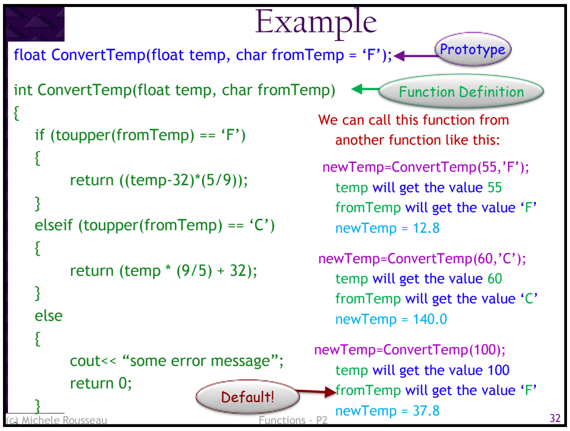
```
int ConvertTemp(float temp, char fromTemp = ‘F’);
```

Syntax
return_type functionName(*type parameter = default_value*);

NOTE: you **MUST** put the parameters with default values **following** all the parameters that don’t have default values

➔ You can only put the default in the prototype or the definition - **not both**

→ it is best practice to put it with the prototype



Example

```
float ConvertTemp(float temp, char fromTemp = ‘F’);

int ConvertTemp(float temp, char fromTemp)
{
    if (toupper(fromTemp) == ‘F’)
    {
        return ((temp-32)*(5/9));
    }
    elseif (toupper(fromTemp) == ‘C’)
    {
        return (temp * (9/5) + 32);
    }
    else
    {
        cout<< “some error message”;
        return 0;
    }
```

Prototype

Function Definition

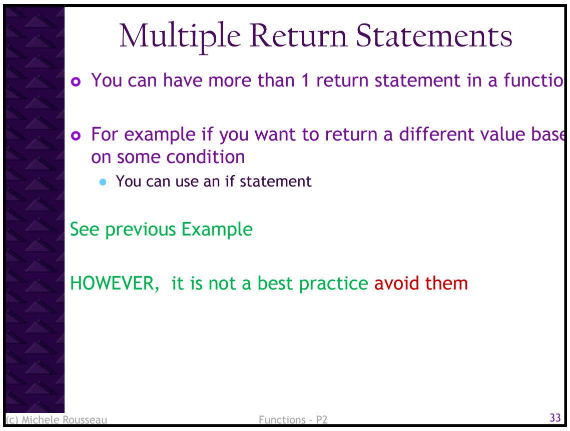
Default!

We can call this function from another function like this:

newTemp=ConvertTemp(55,’F’);
temp will get the value 55
fromTemp will get the value ‘F’
newTemp = 12.8

newTemp=ConvertTemp(60,’C’);
temp will get the value 60
fromTemp will get the value ‘C’
newTemp = 140.0

newTemp=ConvertTemp(100);
temp will get the value 100
fromTemp will get the value ‘F’
newTemp = 37.8

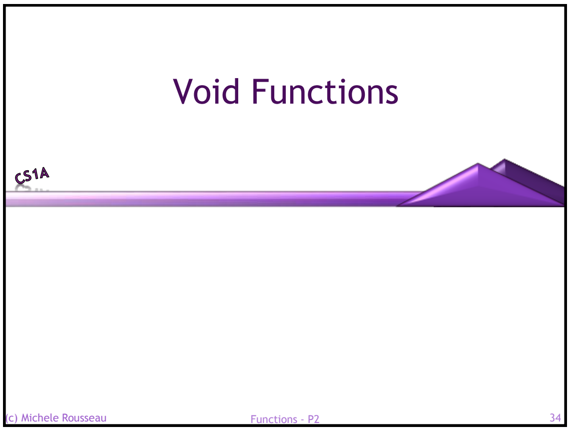


Multiple Return Statements

- You can have more than 1 return statement in a functio
- For example if you want to return a different value base on some condition
  - You can use an if statement

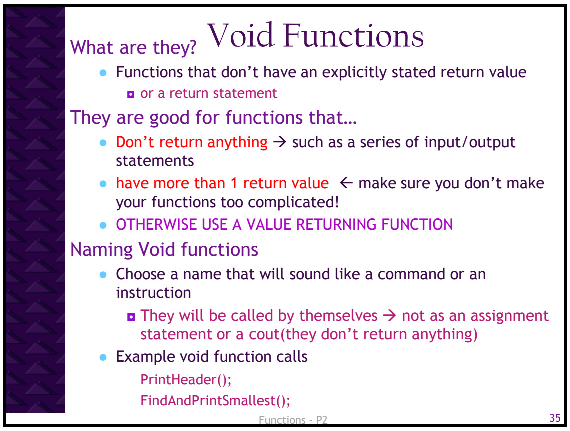
See previous Example

HOWEVER, it is not a best practice avoid them



Void Functions

CS1A



Void Functions

What are they?

- Functions that don't have an explicitly stated return value
  - or a return statement

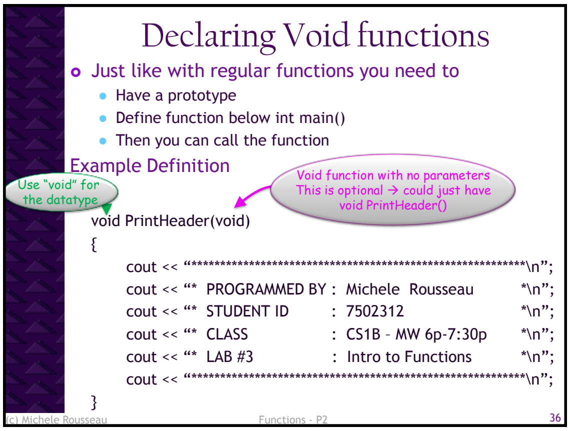
They are good for functions that…

- Don't return anything → such as a series of input/output statements
- have more than 1 return value ← make sure you don't make your functions too complicated!
- OTHERWISE USE A VALUE RETURNING FUNCTION

Naming Void functions

- Choose a name that will sound like a command or an instruction
  - They will be called by themselves → not as an assignment statement or a cout(they don't return anything)
- Example void function calls

```
PrintHeader();
FindAndPrintSmallest();
```



Declaring Void functions

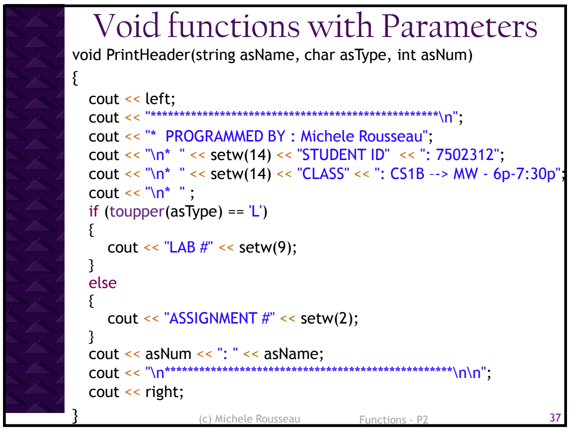
- Just like with regular functions you need to
  - Have a prototype
  - Define function below int main()
  - Then you can call the function

Example Definition

Use "void" for the datatype

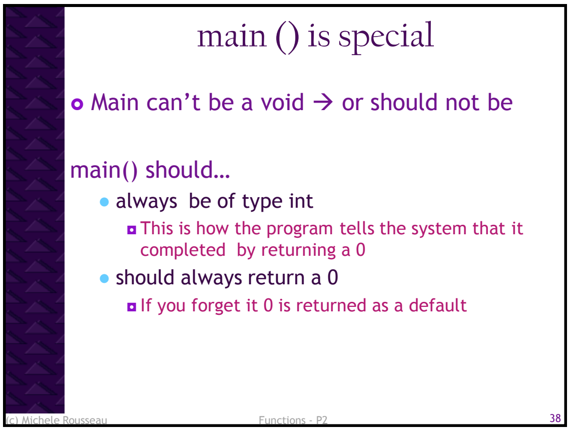
Void function with no parameters
This is optional → could just have
void PrintHeader()

```
void PrintHeader(void)
{
      cout << “************************************************************\n”;
      cout << “*  PROGRAMMED BY :  Michele  Rousseau        *\n”;
      cout << “*  STUDENT ID        :  7502312                    *\n”;
      cout << “*  CLASS                 :  CS1B – MW 6p-7:30p      *\n”;
      cout << “*  LAB #3                :  Intro to Functions        *\n”;
      cout << “************************************************************\n”;
}
```



Void functions with Parameters

```
void PrintHeader(string asName, char asType, int asNum)
{
   cout << left;
   cout << "**************************************************\n";
   cout << "*  PROGRAMMED BY : Michele Rousseau";
   cout << "\n*  " << setw(14) << "STUDENT ID"  << ": 7502312";
   cout << "\n*  " << setw(14) << "CLASS" << ": CS1B --> MW - 6p-7:30p";
   cout << "\n*  " ;
   if (toupper(asType) == 'L')
   {
      cout << "LAB #" << setw(9);
   }
   else
   {
      cout << "ASSIGNMENT #" << setw(2);
   }
   cout << asNum << ": " << asName;
   cout << "\n**************************************************\n\n";
   cout << right;
}
```

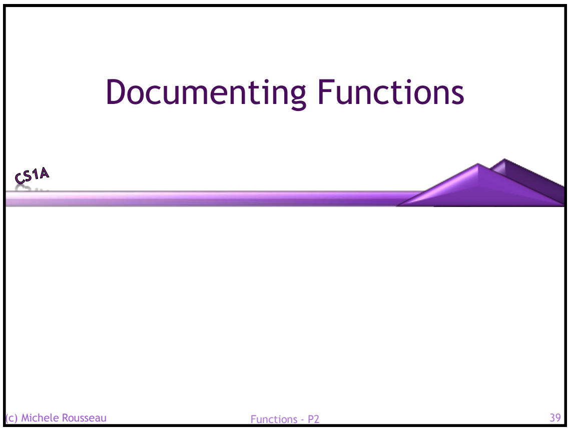


main () is special

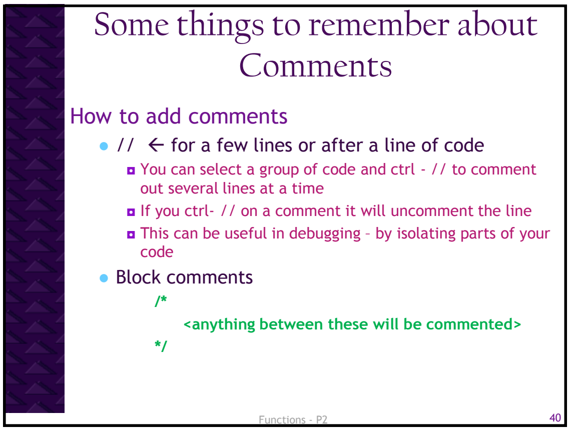
- Main can't be a void → or should not be

main() should…

- always be of type int
  - This is how the program tells the system that it completed by returning a 0
- should always return a 0
  - If you forget it 0 is returned as a default



Documenting Functions

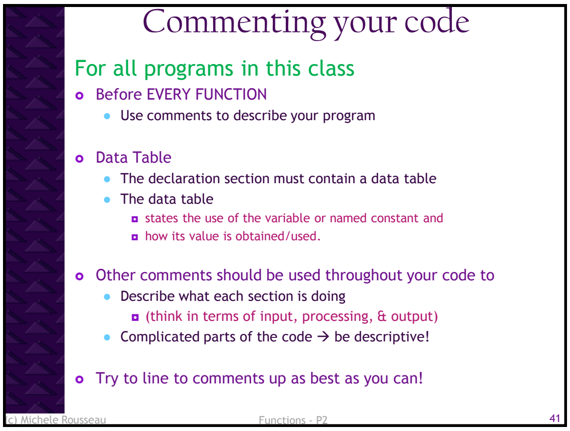


Some things to remember about Comments

How to add comments

- // ← for a few lines or after a line of code
  - You can select a group of code and ctrl - // to comment out several lines at a time
  - If you ctrl- // on a comment it will uncomment the line
  - This can be useful in debugging – by isolating parts of your code
- Block comments

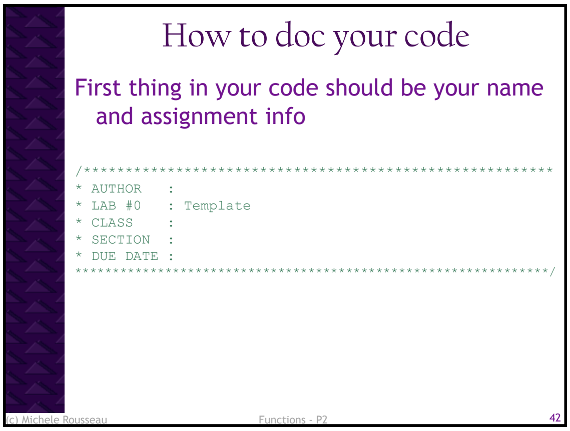
```
/*
    <anything between these will be commented>
*/
```



Commenting your code

For all programs in this class

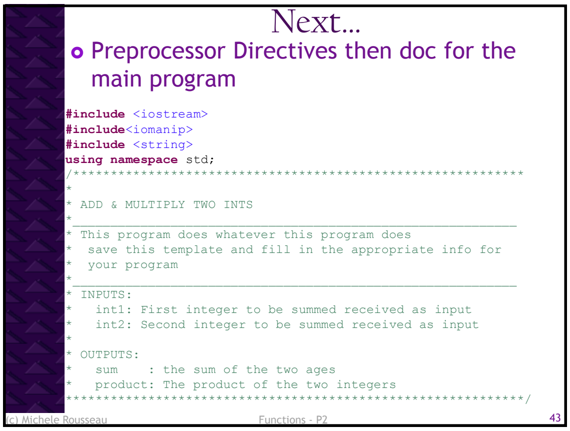
- Before EVERY FUNCTION
  - Use comments to describe your program
- Data Table
  - The declaration section must contain a data table
  - The data table
    - states the use of the variable or named constant and
    - how its value is obtained/used.
- Other comments should be used throughout your code to
  - Describe what each section is doing
    - (think in terms of input, processing, & output)
  - Complicated parts of the code → be descriptive!
- Try to line to comments up as best as you can!



How to doc your code

First thing in your code should be your name and assignment info

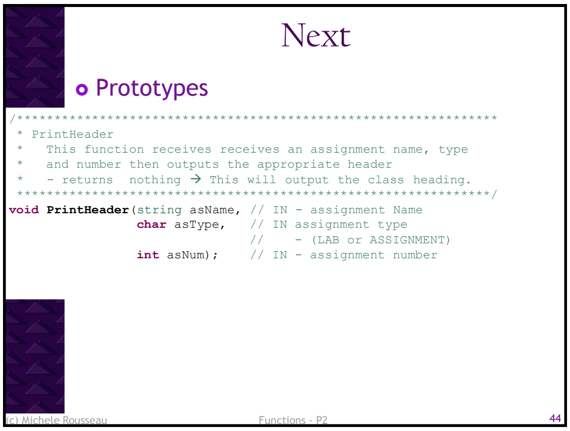
```
/********************************************************
* AUTHOR   :
* LAB #0   : Template
* CLASS    :
* SECTION  :
* DUE DATE :
*********************************************************/
```



Next…

- Preprocessor Directives then doc for the main program

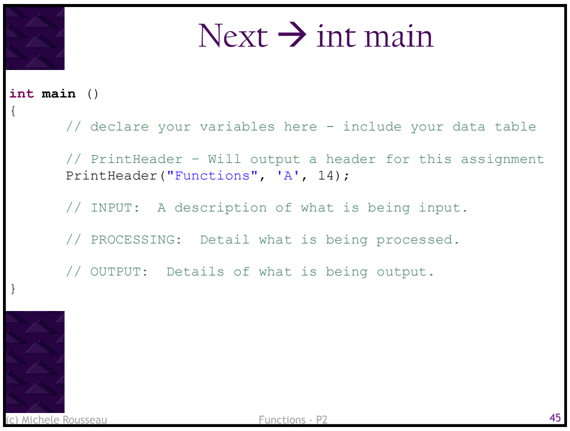
```
#include <iostream>
#include<iomanip>
#include <string>
using namespace std;
/*************************************************************
*
* ADD & MULTIPLY TWO INTS
*____________________________________________________________
* This program does whatever this program does
*  save this template and fill in the appropriate info for
*  your program
*____________________________________________________________
* INPUTS:
*   int1: First integer to be summed received as input
*   int2: Second integer to be summed received as input
*
* OUTPUTS:
*   sum    : the sum of the two ages
*   product: The product of the two integers
*************************************************************/
```



Next

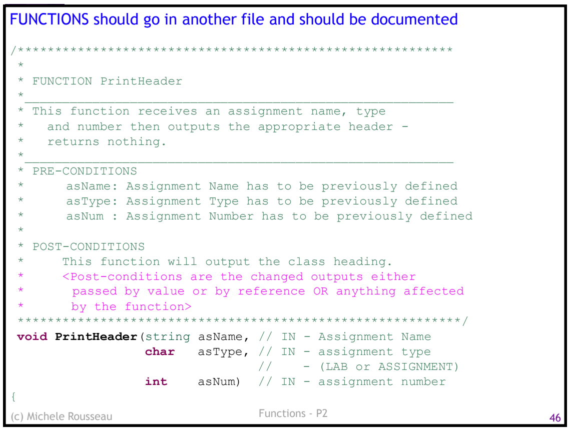
- Prototypes

```
/*****************************************************************
 * PrintHeader
 *   This function receives receives an assignment name, type
 *   and number then outputs the appropriate header
 *   - returns  nothing → This will output the class heading.
 *****************************************************************/
void PrintHeader(string asName, // IN - assignment Name
                 char asType,   // IN assignment type
                                //    - (LAB or ASSIGNMENT)
                 int asNum);    // IN - assignment number
```



Next → int main

```
int main ()
{
       // declare your variables here - include your data table

       // PrintHeader - Will output a header for this assignment
       PrintHeader("Functions", 'A', 14);

       // INPUT:  A description of what is being input.

       // PROCESSING:  Detail what is being processed.

       // OUTPUT:  Details of what is being output.
}
```



FUNCTIONS should go in another file and should be documented

```
/**********************************************************
 *
 * FUNCTION PrintHeader
 *_________________________________________________________
 * This function receives an assignment name, type
 *   and number then outputs the appropriate header -
 *   returns nothing.
 *_________________________________________________________
 * PRE-CONDITIONS
 *      asName: Assignment Name has to be previously defined
 *      asType: Assignment Type has to be previously defined
 *      asNum : Assignment Number has to be previously defined
 *
 * POST-CONDITIONS
 *     This function will output the class heading.
 *     <Post-conditions are the changed outputs either
 *      passed by value or by reference OR anything affected
 *      by the function>
 **********************************************************/
 void PrintHeader(string asName, // IN - Assignment Name
                  char   asType, // IN - assignment type
                                 //    - (LAB or ASSIGNMENT)
                  int    asNum)  // IN - assignment number
{
```

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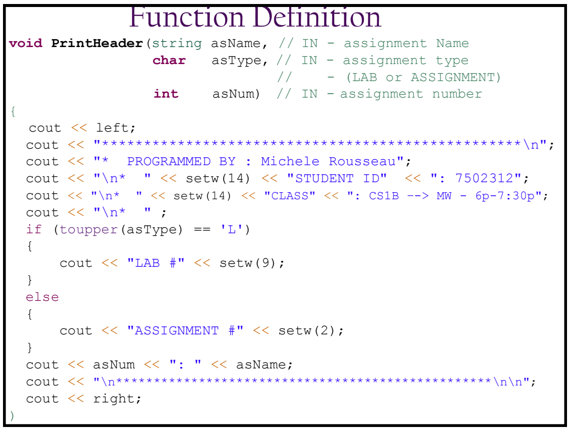
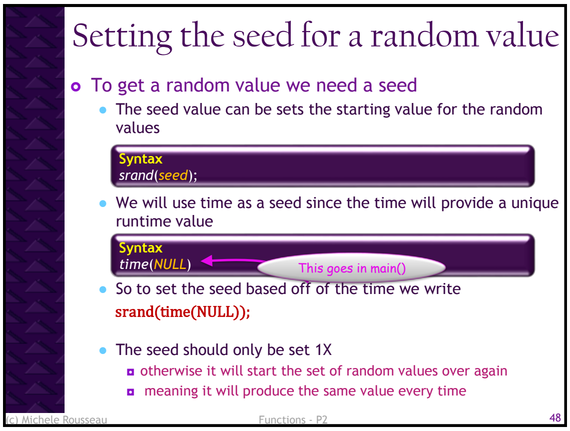


Function Definition

```
void PrintHeader(string asName, // IN - assignment Name
                 char   asType, // IN - assignment type
                                //    - (LAB or ASSIGNMENT)
                 int    asNum)  // IN - assignment number
{
   cout << left;
  cout << "***************************************************\n";
  cout << "*  PROGRAMMED BY : Michele Rousseau";
  cout << "\n*  " << setw(14) << "STUDENT ID"  << ": 7502312";
  cout << "\n*  " << setw(14) << "CLASS" << ": CS1B --> MW - 6p-7:30p";
  cout << "\n*  " ;
  if (toupper(asType) == 'L')
  {
      cout << "LAB #" << setw(9);
  }
  else
  {
      cout << "ASSIGNMENT #" << setw(2);
  }
  cout << asNum << ": " << asName;
  cout << "\n**********************************************\n\n";
  cout << right;
)
```



Setting the seed for a random value

- To get a random value we need a seed
  - The seed value can be sets the starting value for the random values

    Syntax
    srand(seed);
  - We will use time as a seed since the time will provide a unique runtime value

    Syntax
    time(NULL)

    This goes in main()
  - So to set the seed based off of the time we write
    srand(time(NULL));
  - The seed should only be set 1X
    - otherwise it will start the set of random values over again
    - meaning it will produce the same value every time

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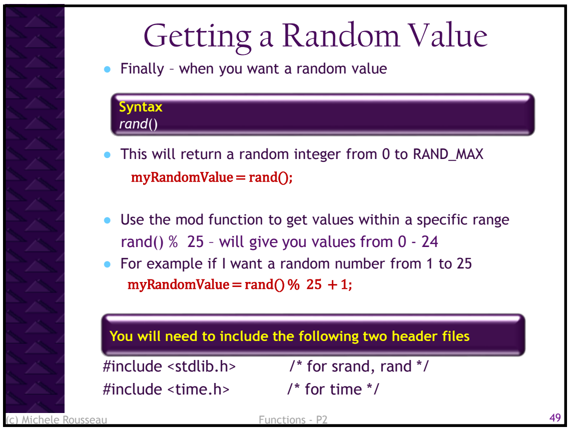

Getting a Random Value

- Finally – when you want a random value

Syntax
rand()

- This will return a random integer from 0 to RAND_MAX

```
myRandomValue = rand();
```

- Use the mod function to get values within a specific range
  rand() % 25 – will give you values from 0 - 24
- For example if I want a random number from 1 to 25

```
myRandomValue = rand() % 25 + 1;
```

You will need to include the following two header files

```
#include <stdlib.h>        /* for srand, rand */
#include <time.h>          /* for time */
```

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