PURPOSE

1. To introduce the concept of void functions (procedures)
2. To work with void functions (procedures) that have no parameters
3. To introduce and work with void functions (procedures) that have pass by value and pass by reference parameters

PROCEDURE

1. Students should read the Pre-lab Reading Assignment before coming to lab.
2. Students should complete the Pre-lab Writing Assignment before coming to lab.
3. In the lab, students should complete labs assigned to them by their instructor.

<table>
<thead>
<tr>
<th>Contents</th>
<th>Pre-requisites</th>
<th>Approximate completion time</th>
<th>Page number</th>
<th>Check when done</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-lab Reading Assignment</td>
<td></td>
<td>20 min.</td>
<td>76</td>
<td></td>
</tr>
<tr>
<td>Pre-lab Writing Assignment</td>
<td>Pre-lab reading</td>
<td>10 min.</td>
<td>83</td>
<td></td>
</tr>
<tr>
<td>LESSON 6.1A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lab 6.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Functions with No Parameters</td>
<td>Confident in use of the control structures</td>
<td>15 min.</td>
<td>84</td>
<td></td>
</tr>
<tr>
<td>Lab 6.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Introduction to Pass by Value</td>
<td>Basic understanding of pass by value.</td>
<td>35 min.</td>
<td>84</td>
<td></td>
</tr>
<tr>
<td>LESSON 6.1B</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lab 6.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Introduction to Pass by Reference</td>
<td>Basic understanding of pass by reference.</td>
<td>25 min.</td>
<td>86</td>
<td></td>
</tr>
<tr>
<td>Lab 6.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student Generated Code Assignments</td>
<td>Basic understanding of pass by reference and value.</td>
<td>30 min.</td>
<td>89</td>
<td></td>
</tr>
</tbody>
</table>
PRE-LAB READING ASSIGNMENT

Modules

A key element of structured (well organized and documented) programs is their modularity: the breaking of code into small units. These units, or modules, that do not return a value are called procedures in most languages and are called void functions in C++. Although procedures is the authors’ preferred term, this manual uses the word function to describe both void functions (discussed in this lesson set) and value returning functions (studied in the next lesson set), as this is the terminology used in C++.

The int main() section of our program is a function and, up until now, has been the only coded module used in our programs. We also have used pre-defined functions such as pow and sqrt which are defined in library routines and “imported” to our program with the #include <cmath> directive. We now explore the means of breaking our own code into modules. In fact, the main function should contain little more than “calls” to other functions. Think of the main function as a contractor who hires sub-contractors to perform certain duties: plumbers to do the plumbing, electricians to do the electrical work, etc. The contractor is in charge of the order in which these sub-contract jobs are issued.

The int main() function consists mostly of calls to functions just like a contractor issues commands to sub-contractors to come and do their jobs. A computer does many simple tasks (modules) that, when combined, produce a set of complex operations. How one determines what those separate tasks should be is one of the skills learned in software engineering, the science of developing quality software. A good computer program consists of several tasks, or units of code, called modules or functions.

In simple programs most functions are called, or invoked, by the main function. Calling a function basically means starting the execution of the instructions contained in that module. Sometimes a function may need information “passed” in order to perform designated tasks.

If a function is to find the square root of a number, then it needs that number passed to it by the calling function. Information is passed to or from a function through parameters. Parameters are the components of communication between functions. Some functions do very simple tasks such as printing basic output statements to the screen. These may be instructions to the user or just documentation on what the program will do. Such functions are often called parameter-less functions since they do not require anything passed by the calling procedure.

Sample Program 6.1a:

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

void printDescription();  // Function prototype

int main()
{
    cout << "Welcome to the Payroll Program." << endl;
    printDescription();  // Call to the function
```
cout << "We hoped you enjoyed this program." << endl;

return 0;

/**
 * printDescription
 *
 * Task: This function prints a program description
 * Data in: none
 *
 */

void printDescription() // The function heading
{
    cout << "***************************************************"
    << endl << endl;
    cout << "This program takes two numbers (pay rate and hours)"
    << endl;
    cout << "and outputs gross pay. " << endl;
    cout << "***************************************************"
    << endl << endl;
}

In this example, three areas have been highlighted. Starting from the bottom we have the function itself which is often called the function definition.

The function heading `void printDescription()` consists of the name of the function preceded by the word `void`. The word `void` means that this function will not return a value to the module that called it. The function name is followed by a set of parentheses. Just like the `main` function, all functions begin with a left brace and end with a right brace. In between these braces are the instructions of the function. In this case they consist solely of `cout` statements that tell what the program does.

Notice that this function comes after the `main` function. How is this function activated? It must be called by either the `main` function or another function in the program. This function is called by `main` with the simple instruction `printDescription();`.

A call to a function can be classified as the sixth fundamental instruction (see Lesson Set 2). Notice the call consists only of the name of the function (not the word `void` preceding it) followed by the set of parentheses and a semicolon. By invoking its name in this way, the function is called. The program executes the body of instructions found in that function and then returns to the calling function (`main` in this case) where it executes the remaining instructions following the call. Let us examine the order in which the instructions are executed.

---

1 In the next lesson set we will see that the word preceding the name of a function can be the data type of the value that the function will return to the calling function.
The main function is invoked which then executes the following instruction:

```cpp
cout << "Welcome to the Pay Roll Program" << endl;
```

Next the call to the function printDescription is encountered which executes the following instructions:

```cpp
cout << "************************************************" << endl <<
    cout << "************************************************" << endl <<
    cout << "This program takes two numbers (pay rate & hours)" << endl;
    cout << "and outputs gross pay " << endl;
    cout << "************************************************" << endl <<
```

After all the instructions in printDescription are executed, control returns to main and the next instruction after the call is executed:

```cpp
cout << "We hoped you enjoyed this program" << endl;
```

The first highlighted section of the example is found before main() in what we call the global section of the program. It is called a prototype and looks just like the function heading except it has a semicolon at the end. Since our example has the “definition of the function” after the call to the function, the program will give us an error when we try to call it if we do not have some kind of signal to the computer that the definition will be forthcoming. That is the purpose of the prototype. It is a promise (contract if you will) to the compiler that a void function called printDescription will be defined after the main function. If the printDescription function is placed in the file before the main function which calls it, then the prototype is not necessary. However, most C++ programs are written with prototypes so that main() can be the first function.

**Pass by Value**

The following program, Sample Program 6.1b, is an extension of the code above. This program will take a pay rate and hours worked and produce the gross pay based on those numbers. This can be done in another function called calPaycheck.

**Sample Program 6.1b:**

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

// Function prototypes
void printDescription();
void calPaycheck(float, int);

int main()
{
    float payRate;
    int hours;

    cout << "Welcome to the Payroll Program." << endl;
```
printDescription(); // Call to the printDescription function

cout << endl << "Please input the pay per hour." << endl;
cin >> payRate;

cout << endl << "Please input the number of hours worked." << endl;
cin >> hours;
cout << endl << endl;

calPaycheck(payRate, hours); // Call to the calPaycheck function

cout << "We hope you enjoyed this program." << endl;

return 0;
}

//****************************************************************
//
// Task: This function prints a program description
// Data in: no parameters received from the function call
//
//****************************************************************

void printDescription() // The function heading
{
cout << "********************************************************************************" << endl << endl;
cout << "This program takes two numbers (pay rate and hours) " << endl;
cout << "and outputs gross pay. " << endl;
cout << "********************************************************************************" << endl << endl;
}

//****************************************************************
//
// Task: This function computes and outputs gross pay
// Data in: rate and time
//
//****************************************************************

void calPaycheck(float rate, int time)
{
float gross;

gross = rate * time;
cout << "The pay is " << gross << endl;
}

The bold sections of this program show the development of another function. This function is a bit different in that it has parameters inside the parentheses of the call, heading and prototype. Recall that parameters are the components of communication to and from a function and the call to that function. The
function calPaycheck needs information from the calling routine. In order to find the gross pay it needs the rate per hour and the number of hours worked to be passed to it. The call provides this information by having parameters inside the parentheses of the call calPaycheck(payRate,hours);. Both payRate and hours are called actual parameters. They match in a one-to-one correspondence with the parameters in the function heading which are called rate and time:

```c
void calPaycheck(float rate, int time)
```

The parameters in a function heading are called formal parameters. It is important to compare the call with the function heading.

- **Call**
  ```c
  calPaycheck(payRate,hours);
  ```

- **Function heading**
  ```c
  void calPaycheck(float rate, int time)
  ```

1. The call does not have any word preceding the name whereas the function heading has the word `void` preceding its name.
2. The call must NOT give the data type before its actual parameters whereas the heading MUST give the data type of its formal parameters.
3. Although the formal parameters may have the same name as their corresponding actual parameters, they do not have to be the same. The first actual parameter, payRate, is paired with rate, the first formal parameter. This means that the value of payRate is given to rate. The second actual parameter, hours, is paired with time, the second formal parameter, and gives time its value. Corresponding (paired) parameters must have the same data type. Notice that payRate is defined as float in the main function and thus it can legally match rate which is also defined as float in the function heading. hours is defined as int so it can be legally matched (paired) with time which is defined as int in the function heading.
4. The actual parameters (payRate and hours) pass their values to their corresponding formal parameters. Whatever value is read into payRate in the main function will be given to rate in the calPaycheck function. This is called pass by value. It means that payRate and rate are two distinct memory locations. Whatever value is in payRate at the time of the call will be placed in rate's memory location as its initial value. It should be noted that if the function calPaycheck were to alter the value of rate, it would not affect the value of payRate back in the main function. In essence, pass by value is like making a copy of the value in payRate and placing it in rate. Whatever is done to that copy in rate has no effect on the value in payRate. Recall that a formal parameter can have the same name as its corresponding actual parameter; however, they are still two different locations in memory.

How does the computer know which location to go to if there are two variables with the same name? The answer is found in a concept called scope. Scope refers to the location in a program where an identifier is accessible. All variables defined in the main function become inactive when another function is called and are reactivated when the control returns to main. By the same token, all formal parameters and variables defined inside a function are active only during the time the function is executing. What this means is that an actual parameter and its corresponding formal parameter are never active at the same time. Thus there is no confusion as to which memory location to access even if corresponding
parameters have the same name. More on scope will be presented in the next lesson set.

It is also important to compare the prototype with the heading.

**Prototype**

```c
void calPaycheck(float, int);
```

**Function heading**

```c
void calPaycheck(float rate, int time)
```

1. The prototype has a semicolon at the end and the heading does not.
2. The prototype lists only the data type of the parameters and not their name. However, the prototype can list both and thus be exactly like the heading except for the semicolon. Some instructors tell students to copy the prototype without the semicolon and paste it to form the function heading.

Let us look at all three parts—prototype, call and heading:

1. The heading MUST have both data type and name for all its formal parameters.
2. The prototype must have the data type and can have the name for its formal parameters.
3. The call MUST have the name but MUST NOT have the data type for its actual parameters.

### Pass by Reference

Suppose we want the `calPaycheck` function to only compute the gross pay and then pass this value back to the calling function rather than printing it. We need another parameter, not to get information from the call but to give information back to the call. This particular parameter can not be **passed by value** since any change made in a function to a **pass by value formal parameter** has no effect on its corresponding actual parameter. Instead, this parameter is **passed by reference**, which means that the calling function will give the called function the location of its actual parameter instead of a copy of the value that is stored in that location. This then allows the called function to go in and change the value of the actual parameter.

**Example:** Assume that I have a set of lockers each containing a sheet of paper with a number on it. Making a copy of a sheet from a particular locker and giving that sheet to you will ensure that you will not change my original copy. This is pass by value. On the other hand, if I give you a spare key to a particular locker, you could go to that locker and change the number on the sheet of paper located there. This is pass by reference.

How does the program know whether a parameter is passed by value or by reference? All parameters are passed by value unless they have the character `&` listed after the data type, which indicates a pass by reference.

### Sample Program 6.1C:

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

// Function prototypes
```
void printDescription(); // prototype for a parameter-less function
void calPaycheck(float, int, float&); // prototype for a function with 3
// parameters. The first two are passed
// by value. The third is passed by
// reference

int main()
{
    float payRate;
    float grossPay;
    float netPay;
    int hours;

    cout << "Welcome to the Payroll Program." << endl;
    printDescription(); // Call to the description function
    cout << endl << "Please input the pay per hour." << endl;
    cin >> payRate;
    cout << endl << "Please input the number of hours worked." << endl;
    cin >> hours;
    cout << endl;
    calPaycheck(payRate, hours, grossPay); // Call to the calPaycheck function
    etPay = grossPay - (grossPay * .20);

    cout << "The net pay is \"" << netPay << endl;
    cout "We hoped you enjoyed this program." << endl;

    return 0;
}

//***************************************************************
// printDescription
// Task: This function prints a program description
// Data in: none
// Data out: no actual parameters altered
//***************************************************************

void printDescription() // The function heading
{  
    cout "***************************" << endl << endl;
    cout "This program takes two numbers (pay rate and hours) " << endl;
    cout "and outputs gross pay. " << endl;
    cout "***************************" << endl << endl;
}
//*****************************************************************************
// calPaycheck
//
// Task: This function computes gross pay
// Data in: rate and time
// Data out: gross (alters the corresponding actual parameter)
//*****************************************************************************

void calPaycheck(float rate, int time, float& gross)
{
    gross = rate * time;
}

Notice that the function calPaycheck now has three parameters. The first two, rate and time, are passed by value while the third has an & after its data type indicating that it is pass by reference. The actual parameter grossPay is paired with gross since they both are the third parameter in their respective lists. But since this pairing is pass by reference, these two names refer to the SAME memory location. Thus what the function does to its formal parameter gross changes the value of grossPay. After the calPaycheck function finds gross, control goes back to the main function that has this value in grossPay. main proceeds to find the net pay, by taking 20% off the gross pay, and printing it. Study this latest revision of the program very carefully. One of the lab exercises asks you to alter it.

**PRE-LAB WRITING ASSIGNMENT**

**Fill-in-the-Blank Questions**

1. The word _____________ precedes the name of every function prototype and heading that does not return a value back to the calling routine.
2. Pass by _____________ indicates that a copy of the actual parameter is placed in the memory location of its corresponding formal parameter.
3. _____________ parameters are found in the call to a function.
4. A prototype must give the ________________ of its formal parameters and may give their _____________.
5. A _____________ after a data type in the function heading and in the prototype indicates that the parameter will be passed by reference.
6. Functions that do not return a value are often called _____________ in other programming languages.
7. Pass by _____________ indicates that the location of an actual parameter, rather than just a copy of its value, is passed to the called function.
8. A call must have the _____________ of its actual parameters and must NOT have the _____________ of those parameters.
9. _____________ refers to the region of a program where a variable is “active.”
10. _____________ parameters are found in the function heading.
LAB 6.1  Functions with No Parameters

Retrieve program proverb.cpp from the Lab 6.1 folder. The code is as follows:

```cpp
// This program prints the proverb
// "Now is the time for all good men to come to the aid of their party"
// in a function (procedure) called writeProverb that is called by the main function

//PLACE YOUR NAME HERE

#include <iostream>
using namespace std;

void writeProverb(); //This is the prototype for the writeProverb function

int main()
{
    // Fill in the code to call the writeProverb function
    return 0;
}

// **********************************************
// writeProverb
//
// task:  This function prints a proverb
// data in: none
// data out: no actual parameter altered
//
// **********************************************

// Fill in the function heading and the body of the function that will print
// to the screen the proverb listed in the comments at the beginning of the
// program

Exercise 1: Fill in the code (places in bold) so that the program will print out the proverb listed in the comments at the beginning of the program. The proverb will be printed by the function which is called by the main function.

LAB 6.2  Introduction to Pass by Value

Retrieve program newproverb.cpp from the Lab 6.1 folder. The code is as follows:

// This program will allow the user to input from the keyboard
// whether the last word to the following proverb should be party or country:
// "Now is the time for all good men to come to the aid of their _________"
// Inputting a 1 will use the word party. Any other number will use the word country.

// PLACE YOUR NAME HERE

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

// Fill in the prototype of the function writeProverb.

int main ()
{

    int wordCode;

cout << "Given the phrase:" << endl;
cout << "Now is the time for all good men to come to the aid of their ___" << endl;
cout << "Input a 1 if you want the sentence to be finished with party" << endl;
cout << "Input any other number for the word country" << endl;
cout << "Please input your choice now" << endl;
cin >> wordCode; cout << endl;
writeProverb(wordCode);

    return 0;
}

//******************************************************************************
//******************************************************************************

void writeProverb (int number)

Exercise 1: Some people know this proverb as “Now is the time for all good men to come to the aid of their country” while others heard it as “Now is the time for all good men to come to the aid of their party.” This program will allow the user to choose which way they want it printed. Fill in the blanks of the program to accomplish what is described in the program comments. What happens if you inadvertently enter a float such as -3.97?

Exercise 2: Change the program so that an input of 1 from the user will print “party” at the end, a 2 will print “country” and any other number will be invalid so that the user will need to enter a new choice.

Sample Run:
Given the phrase:
Now is the time for all good men to come to the aid of their ___
Input a 1 if you want the sentence to be finished with party
Input a 2 if you want the sentence to be finished with country
Please input your choice now
4
I'm sorry but that is an incorrect choice; Please input a 1 or 2
2
Now is the time for all good men to come to the aid of their country

Exercise 3: Change the previous program so the user may input the word to end the phrase. The string holding the user's input word will be passed to the proverb function instead of passing a number to it. Notice that this change requires you to change the proverb function heading and the prototype as well as the call to the function.

Sample Run:
Given the phrase:
Now is the time for all good men to come to the aid of their ____
Please input the word you would like to have finish the proverb family
Now is the time for all good men to come to the aid of their family

LESSON 6.1B

Lab 6.3 Introduction to Pass by Reference

Retrieve program paycheck.cpp from the Lab 6.1 folder. This program is similar to Sample Program 6.1C that was given in the Pre-lab Reading Assignment. The code is as follows:

// This program takes two numbers (payRate & hours)
// and multiplies them to get grosspay.
// It then calculates net pay by subtracting 15%

// PLACE YOUR NAME HERE
#include <iostream>
#include <iomanip>
using namespace std;

// Function prototypes
void printDescription();
void computePaycheck(float, int, float&, float&);

int main()
{
    float payRate;
    float grossPay;
    float netPay;
    int hours;

    cout << setprecision(2) << fixed;
    cout << "Welcome to the Pay Roll Program" << endl;
    printDescription(); // Call to Description function
    cout << "Please input the pay per hour" << endl;
    cin >> payRate;
    cout << endl << "Please input the number of hours worked" << endl;
    cin >> hours;
    cout << endl << endl;
    computePaycheck(payRate, hours, grossPay, netPay);

    // Fill in the code to output grossPay
    cout << "The net pay is $" << netPay << endl;
    cout << "We hope you enjoyed this program" << endl;
    return 0;
}

// ************************************************************
// printDescription
//
// task: This function prints a program description
// data in: none
// data out: no actual parameter altered
//
// ************************************************************
continues
void printDescription() // The function heading
{
    cout << "*****************************************************************************" << endl << endl;
    cout << "This program takes two numbers (payRate & hours)" " << endl;
    cout << "and multiplies them to get gross pay " " << endl;
    cout << "it then calculates net pay by subtracting 15%" " << endl;
    cout << "*****************************************************************************" << endl << endl;
}

// **************************************************************************
// computePaycheck
//
// task: This function takes rate and time and multiplies them to
// get gross pay and then finds net pay by subtracting 15%.
//
// data in: pay rate and time in hours worked
// data out: the gross and net pay
//
// **************************************************************************

void computePaycheck(float rate, int time, float& gross, float& net)
{
    // Fill in the code to find gross pay and net pay
}

Exercise 1: Fill in the code (places in bold) and note that the function
computePaycheck determines the net pay by subtracting 15% from the gross
pay. Both gross and net are returned to the main() function where those
values are printed.

Exercise 2: Compile and run your program with the following data and make
sure you get the output shown.

Please input the pay per hour
9.50
Please input the number of hours worked
40

The gross pay is $380
The net pay is $323
We hoped you enjoyed this program
Exercise 3: Are the parameters gross and net, in the modified calPaycheck function you created in Exercise 1 above, pass by value or pass by reference?

Exercise 4: Alter the program so that gross and net are printed in the function computePaycheck instead of in main(). The main() function executes the statement

    cout << "We hoped you enjoyed this program" << endl;

after the return from the function calPaycheck.

Exercise 5: Run the program again using the data from Exercise 2. You should get the same results. All parameters should now be passed by value.

LAB 6.4 Student Generated Code Assignments

Option 1: Write a program that will read two floating point numbers (the first read into a variable called first and the second read into a variable called second) and then calls the function swap with the actual parameters first and second. The swap function having formal parameters number1 and number2 should swap the value of the two variables. Note: This is similar to a program you did in Lesson Set 1; however, now you are required to use a function. You may want to look at logicprob.cpp from Lesson Set 1.

Sample Run:

Enter the first number
Then hit enter
80
Enter the second number
Then hit enter
70

You input the numbers as 80 and 70.
After swapping, the first number has the value of 70 which was the value of the second number
The second number has the value of 80 which was the value of the first number

Exercise 1: Compile the program and correct it if necessary until you get no syntax errors.

Exercise 2: Run the program with the sample data above and see if you get the same results.

Exercise 3: The swap parameters must be passed by ________________.
(assume that main produces the output) Why?

Option 2: Write a program that will input miles traveled and hours spent in travel. The program will determine miles per hour. This calculation must be done in a function other than main; however, main will print the calculation. The function will thus have 3 parameters: miles, hours, and milesPerHour. Which parameter(s) are pass by value and which are passed by reference? Output is fixed with 2 decimal point precision.
LESSON SET 6.1 Introduction to Void Functions (Procedures)

*Sample Run:*

Please input the miles traveled
475
Please input the hours traveled
8
Your speed is 59.38 miles per hour

*Option 3*: Write a program that will read in grades, the number of which is also input by the user. The program will find the sum of those grades and pass it, along with the number of grades, to a function which has a “pass by reference” parameter that will contain the numeric average of those grades as processed by the function. The main function will then determine the letter grade of that average based on a 10-point scale.

- 90–100 A
- 80–89 B
- 70–79 C
- 60–69 D
- 0–59 F

*Sample Run:*

Enter the number of grades
3
Enter a numeric grade between 0-100
90
Enter a numeric grade between 0-100
80
Enter a numeric grade between 0-100
50
The grade is C