CL-1002
Programming Fundamentals
Lab # 16

Objectives:

- Functions c++ programs

Note: Carefully read the following instructions (*Each instruction contains a weightage*)

1. There must be a block of comments at start of every question's code by students; the block should contain brief description about functionality of code.
2. Comment on every function about its functionality.
3. Use understandable name of variables.
4. Proper indentation of code is essential.
5. Write a C++ statement(s) for each of the following task one after the other, in the same order.
6. Make a Microsoft Word file and paste all of your C++ code with all possible screenshots of **every task output in MS word and submit .cpp file with word file**.
7. Make separate .cpp files for all tasks and use this format **23F-1234_Task1.cpp.**
8. First think about statement problems and then write/draw your logic on copy.
9. After copy pencil work, code the problem statement on MS Studio C++ compiler.
10. At the end when you done your tasks, attached C++ created files in MS word file and make your submission on Google classroom. (Make sure your submission is completed).
11. Please submit your word file in this format **23F-1234_L1.docx**
12. Do not submit your assignment **after the deadline**.
13. **Do not copy code from any source otherwise you will be penalized with negative marks.**

Problem: 1 | Pass by reference

Write a C++ program to swap two numbers using pass by reference. You should have the following function in your program.
Void swap(int &x, int &y)

Problem: 2 | Pass by reference

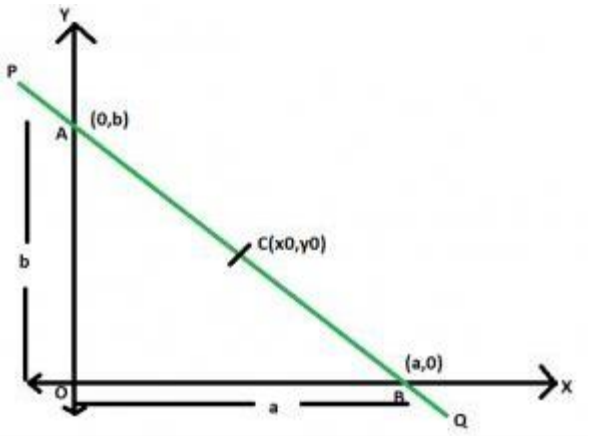
Given a straight line which passes through a given point (x0, y0) such that this point bisects the line segment in two equal line segments. The task is to find the equation of this straight line.

Examples:

Input: $x_0 = 4, y_0 = 3$
Output: $3x + 4y = 24$

Input: $x_0 = 7, y_0 = 12$
Output: $12x + 7y = 168$

Approach:



Let **PQ** be the line and **AB** be the line segment between the axes. The x-intercept and y- intercept are **a** & **b** respectively.
Now, as **C(x0, y0)** bisects **AB**
so, $x_0 = (a + 0) / 2$ **i.e.** $a = 2x_0$
Similarly, $y_0 = (0 + b) / 2$ i.e. $b = 2y_0$
We know that the equation of a straight line in intercept form is,

$x / a + y / b = 1$
Here, $a = 2x0 \ \& \ b = 2y0$
So, $x / 2x0 + y / 2y0 = 1$
or, $x / x0 + y / y0 = 2$
Therefore, $x * y0 + y * x0 = 2 * x0 * y0$

Make a void function which takes two double parameter and finds the equation of straight line i.e.

Void line(double &x0, double &y0)

Also, write why passing by reference is not the state-of-the-art approach here.

Problem: 3 | Max distance covered by N bikes

There are n bikes, and each can cover 100 km when fully fueled. What is the maximum amount of distance you can go using n bikes? You may assume that all bikes are similar, and a bike takes 1 liter to cover 1 km.

You have n bikes and using one bike you can only cover 100 km. so if n bikes start from the same point and run simultaneously you can go only 100 km. Let's think a bit differently, the trick is when you want to cover maximum distance, you should always try to waste minimum fuel. Minimum wastage of fuel means to run minimum number of bikes. Instead of parallel running of n bikes, you can think of serially running them. That means if you transfer some amount of fuel from last bike to other bikes and throw the last bike i.e., don't run the last bike after certain point. But the question is, after what distance the fuel transfer has to be done so that the maximum distance is covered, and fuel tank of remaining bikes do not overflow.

Let us take following base cases and then generalize the solution.

- **Base Case 1: There is one bike:** This is simple, we can cover 100 kms only.
- **Base Case 2: There are two bikes:** What is the maximum distance we can cover when there are 2 bikes? To maximize the distance, we must drop the second bike at some point and transfer its fuel to first bike. Let we do the transfer after x kms.
  - Total distance covered = Distance covered by 100 liter in first bike + Distance covered by fuel transferred from first bike.

Remaining fuel in second bike is 100 – x. If we transfer this much fuel to first bike, then the total distance would become 100 + 100 – x which is 200 – x. So, our task is to maximize 200-x. The constraint is, 100 – x must be less than or equal to the space created in first bike after x kms, i.e., 100 – x <= x. The value of 200-x becomes maximum when x is minimum. The minimum possible value of x is 50. So, we are able to travel 150 kms.

- **Base Case 3: There are three bikes:** Let the first transfer is done after x kms. After x distance all bikes contain 100-x amount of fuel. If we take 100-x amount of fuel from 3rd bike and distribute it among 1st and 2nd bike so that fuel tanks of 1st and 2nd bikes get full. So 100-x <= 2*x; or, x=33.333 so we should transfer the remaining fuel of third bike and distribute that amount of fuel among 1st and 2nd bike after exactly 33.33 km.

Let us generalize it. If we take a closer look at above cases, we can observe that if there are n bikes, then the first transfer is done (or a bike is dropped) after 100/n kms. To generalize it more, when we have x litre remaining fuel in every bike and n remaining bikes, we drop a bike after x/n kms.

Your program must have the following functions.

- Input function for taking input (input is number of bikes, and amount of fuel (let's say 100 initially))
- Output function (display the max distance covered)
- Double MaxDistance(int &n, int fuel)

Problem: 4 | Legendre's Formula (Given p and n, find largest x such that p^x divides n!)

Given an integer n and a prime number p, find the largest x such that px (p raised to power x) divides n! (factorial)

Examples:

Input: n = 7, p = 3 Output:

x = 2

3^2 divides 7! and 2 is the largest such power of 3.
Input: n = 10, p = 3 Output:
x = 4
3^4 divides 10! and 4 is the largest such power of 3.

n! is multiplication of {1, 2, 3, 4, …n}.
How many numbers in {1, 2, 3, 4, … n} are divisible by p?
Every p'th number is divisible by p in {1, 2, 3, 4, … n}. Therefore in n!, there are n/p numbers divisible by p. So we know that the value of x (largest power of p that divides n!) is at-least n/p.
Can x be larger than n/p?
Yes, there may be numbers which are divisible by p2, p3, …
How many numbers in {1, 2, 3, 4, … n} are divisible by p2, p3, …?
There are n/(p2) numbers divisible by p2 (Every p2'th number would be divisible). Similarly, there are n/(p3) numbers divisible by p3 and so on.
What is the largest possible value of x?
So the largest possible power is n/p +n/(p2) + n/(p3) +…
Note that we add only n/(p2)? only once (not twice) as one p is already considered by expression n/p. Similarly, we consider n/(p3) (not thrice).

Use pass by reference only in the functions that you make.

Problem: 5 |(Computer-Assisted Instruction)

1. The use of computers in education is referred to as computer- assisted instruction (CAI). Write a program that will help an elementary school student learn multiplication. Use the rand function to produce two positive one-digit integers. The program should then prompt the user with a question, such as

How much is 6 times 7?

The student then inputs the answer. Next, the program checks the student's answer. If it's correct,

display the message "Very good!" and ask another multiplication question. If the answer is wrong, display the message "No. Please try again." and let the student try the same question repeatedly until the student finally gets it right. A separate function should be used to generate each new question.

This function should be called once when the application begins execution and each time the user answers the question correctly.

2. One problem in CAI environments is student fatigue. This can be reduced by varying the computer's responses to hold the student's attention. Modify the program of Exercise 6.1 so that various comments are displayed for each answer as follows:

Possible responses to a correct answer:
Very good!
Excellent!
Nice work!
Keep up the good work!

Possible responses to an incorrect answer:
No. Please try again.
Wrong. Try once more.
Don't give up!
No. Keep trying.

Use random-number generation to choose a number from 1 to 4 that will be used to select one of the four appropriate responses to each correct or incorrect answer. Use a switch statement to issue the responses.

3. More sophisticated computer-assisted instruction systems monitor the student's performance over a period of time. The decision to begin a new topic is often based on the student's success with previous topics. Modify the program of Exercise 6.2 to count the number of correct and incorrect responses typed by the student. After the student types 10 answers, your program should calculate the percentage that are correct. If the percentage is lower than 75%, display "Please ask your teacher for extra help.", then reset the program so another student can try it. If the percentage is 75% or higher, display "Congratulations, you are ready to go to the next level!", then reset the program so another student can try it.

4. Exercises 6.1–6.3 developed a computer- assisted instruction program to help teach an elementary school student multiplication. Modify the program to allow the user to enter a difficulty level. At a difficulty level of 1, the program should use only single-digit numbers in the problems; at a difficulty level of 2, numbers as large as two digits, and so on.

5. Modify the program of Exercise 6.4 to allow the user to pick a type of arithmetic problem to study. An option of 1 means addition problems only, 2 means subtraction problems only, 3

means multiplication problems only, 4 means division problems only and 5 means a random mixture of all these types.

Problem: 6 |

Write a C++ program with a function that takes two int parameters, adds them together, and takes a third, pass by reference parameter then puts the sum in that. The program should ask the user for two numbers, then call the function with the numbers as arguments, and tell the user the sum.

Problem: 7 | Built in Function

Determine the value of each of the following expressions.

1. abs(-4)
2. fabs(10.8)
3. fabs(-2.5)
4. pow(3.2, 2)
5. pow(2.5, 3)
6. sqrt(25.0)
7. sqrt(6.25)
8. pow(3.0, 4.0) / abs(-9)
9. floor(28.95)
10. ceil(35.2)

Problem: 8 | Pre-defined function

Write a function qualityPoints that inputs a student's average and returns 4 if a student's average is 90–100, 3 if the average is 80–89, 2 if the average is 70–79, 1 if the average is 60–69 and 0 if the average is lower than 60.

Problem: 9 | Functions

Explain line by line in comments what happened in this program

```
#include <iostream>
using namespace std;
void addFirst(int& first, int& second);
void doubleFirst(int one, int two);
void squareFirst(int& ref, int val);
int main()
{
	int num = 5;
	cout << "Line 1: Inside main: num = " << num
		<< endl; //Line 1
	addFirst(num, num); //Line 2
	cout << "Line 3: Inside main after addFirst:"
		<< " num = " << num << endl; //Line 3
	doubleFirst(num, num); //Line 4
	cout << "Line 5: Inside main after "
		<< "doubleFirst: num = " << num << endl; //Line 5
```

```
	squareFirst(num, num); //Line 6
	cout << "Line 7: Inside main after "
		<< "squareFirst: num = " << num << endl; //Line 7
	return 0;
}
void addFirst(int& first, int& second)
{
	cout << "Line 8: Inside addFirst: first = "
		<< first << ", second = " << second << endl; //Line 8
	first = first + 2; //Line 9
	cout << "Line 10: Inside addFirst: first = "

		<< first << ", second = " << second << endl; //Line 10
	second = second * 2; //Line 11
	cout << "Line 12: Inside addFirst: first = "
		<< first << ", second = " << second << endl; //Line 12
}
void doubleFirst(int one, int two)
{
	cout << "Line 13: Inside doubleFirst: one = "
		<< one << ", two = " << two << endl; //Line 13
	one = one * 2; //Line 14
	cout << "Line 15: Inside doubleFirst: one = "
		<< one << ", two = " << two << endl; //Line 15
	two = two + 2; //Line 16
	cout << "Line 17: Inside doubleFirst: one = "
		<< one << ", two = " << two << endl; //Line 17
}
void squareFirst(int& ref, int val)
{
	cout << "Line 18: Inside squareFirst: ref = "
		<< ref << ", val = " << val << endl; //Line 18
	ref = ref * ref; //Line 19
	cout << "Line 20: Inside squareFirst: ref = "
		<< ref << ", val = " << val << endl; //Line 20
	val = val + 2; //Line 21
	cout << "Line 22: Inside squareFirst: ref = "
		<< ref << ", val = " << val << endl; //Line 22
}
```

Problem: 10 | Function overloading

Write a program with three functions having the same name “sum”

- The first function takes two int parameters, adds them together, and then returns an int sum
- The second function takes two float parameters, adds them together, and then returns a float sum
- The third function takes three int parameters, adds them together, and then returns an int sum.

The program should ask the user to choose any of these functions, then call the function with the numbers as arguments, and tell the user the sum.

Problem: 11 | Function overloading

Modify Problem 1 remove the "sum" functions and add a single "sum" function which can take up to four integer arguments, but also works if the number of arguments are 2 or 3. For example:
sum(10, 15)
sum(10, 15, 25)
sum(10, 15, 25, 30

Problem: 12 | C string and function

Write a program that prompts the user to input a string and outputs the string in uppercase letters. (Use a character array to store the string.). Use function uppercase(). Pass character array with size as a parameter. Then display the word in uppercase. Make uppercase logic in function.

Problem: 13 | C string and function

Write a function CountDigit which receives two arguments: a char array and the size of the array (of type int). This function counts the number of digit letters in the char array, and returns the count (of type int)

Problem: 14 | Default parameter User-defined function

Run this program and correct mistake is function calls. Specify that why call function is correct, incorrect, legal or illegal with proper explanation on lines having "?"

```
#include <iostream>
#include <iomanip>
using namespace std;
int volume(int l = 1, int w = 1, int h = 1);
void funcOne(int& x, double y = 12.34, char z = 'B');
int main()
{
int a = 23;
double b = 48.78;
char ch = 'M';
cout << fixed << showpoint;
cout << setprecision(2);
cout << "Line 1: a = " << a << ", b = "
<< b << ", ch = " << ch << endl; //Line 1
cout << "Line 2: Volume = " << volume()//?
```



```
<< endl; //Line 2
cout << "Line 3: Volume = " << volume(5.4, 4)//?
<< endl; //Line 3
cout << "Line 4: Volume = " << volume('A')//?
<< endl; //Line 4
```

```
cout << "Line 5: Volume = "
<< volume(6, 4, 5) << endl; //?
funcOne(a); //?
funcOne(a, 42.68,1); //?
funcOne(a, 34.65, 'Q'); //?

cout << "Line 9: a = " << a << ", b = "
<< b << ", ch = " << ch << endl; //Line 9
return 0;
}
int volume(int l, int w, int h)
{
return l * w * h; //Line 10
}
void funcOne(int& x, double y, char z)
{
x = 2 * x; //Line 11
cout << "Line 12: x = " << x << ", y = "
<< y << ", z = " << z << endl; //Line 12
}
```

Best of luck

You are done with your exercise, submit on classroom at given time.