CL103 COMPUTER PROGRAMMING

LAB 11

Operator Overloading (Compile time Polymorphism)

NATIONAL UNIVERSITY OF COMPUTER AND EMERGING SCIENCES

POLYMORPHISM

Polymorphism refers to the ability of a method to be used in different ways, that is, it can take different forms at different times (poly + morphos).

TYPES OF POLYMORPHISM

There are two types of polymorphism:

- Compile time polymorphism
- Run time polymorphism.

COMPILE TIME POLYMORPHISM

Compile time (static) polymorphism occurs when a method is overloaded.
EXAMPLE: An example of this would be suggesting different names for being the President of a country, which would get you different results each time – but they would still be called the President.

TYPES OF OVERLOADING:

- Constructor Overloading – Already discussed in previous labs.
- Function Overloading - Already discussed in previous labs.
- Operator Overloading - Is discussed below.

OPERATOR OVERLOADING

An operator is said to be overloaded if it is defined for multiple types. In other words, overloading an operator means making the operator significant for a new type.

BUILT IN OVERLOADS

Most operators are already overloaded for fundamental types.

Example:

1) In the case of the expression:

   a / b

   the operand type determines the machine code created by the compiler for the division operator. If both operands are integral types, an integral division is performed; in all other cases floating-point division occurs. Thus, different actions are performed depending on the operand types involved.

2) <<, which is used both as the stream insertion operator and as the bitwise left-shift operator.

OVERLOADS FOR USER DEFIND TYPES

Operators can be used with user-defined types as well. Although C++ does not allow new operators to be created, it does allow most existing operators to be overloaded so that, when they're used with objects, they have meaning appropriate to those objects.

Example:
The effect of + operator can be stipulated for the objects of a particular class.

OPERATOR FUNCTION SYNTAX

To overload an operator, an appropriate *operator function is required.*

```
returntype operator op (arg_list)
{
    function body   //  task defined
}
```

- **returntype** is the type of value returned by the specified operation.
- **op** is the operator being overloaded. (+,- etc)
- **op** is preceded by the keyword **operator**.

LIST OF OPERATORS THAT CAN BE OVERLOADED IN C++

new	delete		new[]		delete[]			
+	-	*	/	%	^	&	|	~
!	=	<	>	+=	-=	*=	/=	%=
^=	&=	|=	<<	>>	>>=	<<=	==	!=
<=	>=	&&	||	++	--	,	->*	->
()	[]							

LIST OF OPERATORS THAT CAN'T BE OVERLOADED

- **?:** (conditional)
- **.** (member selection)
- **.*** (member selection with pointer-to-member)
- **::** (scope resolution)
- **sizeof** (object size information)
- **typeid** (object type information)

OPERATOR OVERLOADING AS MEMBER FUNCTIONS

If the operator function of a binary operator is defined as a method inside the class, the left operand must always be an object of the class. The operator function is called for this object. The second, right operand is passed as an argument to the method. The method thus has a single parameter.

EXAMPLE

```
//Rupee.h
#include <sstream>      // The class stringstream
#include <iomanip>
#include <iostream>
using namespace std;

class Rupee
{
        private:
                long data;
        public:
                Rupee( int rupee = 0)
                        {
                                data = rupee;
                        }
```

```
                    Rupee operator-() const                       // Negation (unary minus)
                              {
                                        Rupee temp;
                                        temp.data = -data;
                                        return temp;
                              }

                    Rupee operator+( const Rupee& obj) const        // addition.
                              {
                                        Rupee temp;
                                        temp.data = data + obj.data;
                                        return temp;
                              }

                    Rupee operator-( const Rupee& obj) const        // Subtraction.
                              {
                                        Rupee temp;
                                        temp.data = data - obj.data;
                                        return temp;
                              }

                    Rupee& operator+=( const Rupee& obj)            // Add Rupees.
                              {
                                        data += obj.data;
                                        return *this;
                              }

                    Rupee& operator-=( const Rupee& obj)            // Subtract Rupees.
                              {
                                        data -= obj.data;
                                        return *this;
                              }

                    friend ostream &operator<<( ostream &os, const Rupee &e );
};

                    ostream& operator<<(ostream& os, const Rupee& e)  //Overloading << operator
                              {
                                        os << e.data;
                                        return os;
                              }
```

```
//TestRupee.cpp
#include "Rupee.h"
#include <iostream>
using namespace std;

int main()
{
          Rupee wholesale(20), retail;
          retail = wholesale;                   // Standard assignment

          cout << "Wholesale price: "<<wholesale;
```

```
        cout << "\nRetail price: "<<retail;

        Rupee discount(2);
        retail -= discount;
        cout << "\nRetail price including discount: "<<retail;

        wholesale = 34.10;
        cout << "\nNew wholesale price: "<<wholesale;

        retail = wholesale + 10;
        cout << "\nNew retail price: "<<retail;

        Rupee profit( retail - wholesale);
        cout << "\nThe profit: "<<profit;

        profit = -profit;
        cout << "\nThe profit after unary minus: "<<profit;

        return 0;
}
```

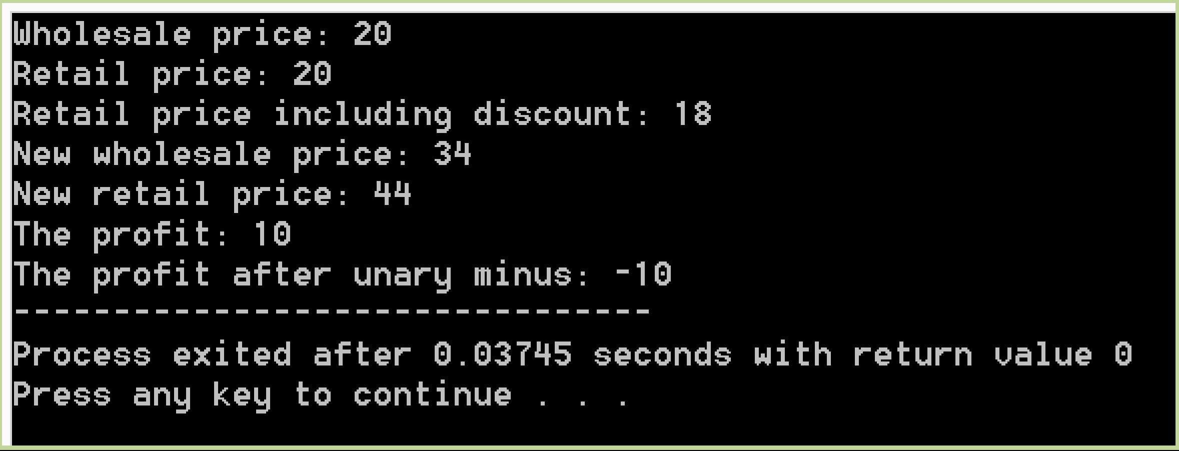
This statement means:

retail = wholesale.operator+(Rupee(10));

The binary operator is always called with reference to the left hand argument and here, it must be a class object because the operator function has been defined as a class method. So, the operator function doesn't handle the following situation:

retail = 10 + wholesale;

However, if we want to convert both operands, we will need global definitions for the operator functions.



```
Wholesale price: 20
Retail price: 20
Retail price including discount: 18
New wholesale price: 34
New retail price: 44
The profit: 10
The profit after unary minus: -10
--------------------------------
Process exited after 0.03745 seconds with return value 0
Press any key to continue . . .
```

OPERATOR OVERLOADING AS NON-FUNCTIONS

GENERAL SYNTAX:

```
TYPE₁ operator OP(TYPE₂ lhs, TYPE₃ rhs)
{

}
```

EXAMPLE:

```
//Rupee.h
//Globally Defined
Rupee operator+( const Rupee& e1, const Rupee& e2)  // addition.
                        {
                                Rupee temp(e1);
                                temp += e2;
                                return temp;
                        }
```

ISSUE:
A global function cannot access the private members of the class i.e. data. The function operator+() shown above therefore uses the += operator, whose operator function is defined as a public method.
A global operator function can be declared as a "**friend**" of the class to allow it access to the private members of that class.

EXAMPLE:

```
//Inside class Rupee
friend Rupee operator+( const Rupee& e1, const Rupee& e2);


//Globally Defined
Rupee operator+( const Rupee& e1, const Rupee& e2)  // addition.
                    {
                            Rupee temp; temp.data = e1.data + e2.data;
                            return temp;
                    }
```

LAB 11 EXERCISES

INSTRUCTIONS:

NOTE: Violation of any of the following instructions may lead to the cancellation of your submission.

1) Create a folder and name it by your student id (k15-1234).
2) Paste the .cpp file for each question with the names such as Q1.cpp, Q2.cpp and so on into that folder.
3) Submit the zipped folder on slate.

QUESTION#1

You are required to develop a location based System as per the following requirements:

1) Create a class (Location), that takes two inputs latitude (integer) and longitude (integer). The values for both inputs are set through the constructor.
2) The "Location" class is capable of displaying both the values without being able to alter them through Display().
3) Create another class (Details) which extends the functionality of Location class by displaying another location related attribute i.e. address through the function Display().The function being unable to alter the values. Set the value of address through constructor.
4) The "int main()" function should be coded as follows:

    a) Create one initialized instance (details) of "Details" class and three initialized instances (obj1, obj2 and obj3) of Location class having the following values (10,20),(5,30) and (90,90) respectively.
    b) Display the contents of each instance.
    c) Perform the pre increment operation on obj1 and display the result.
    d) Perform the post increment operation on obj1 , assign it to obj2 and display the result for obj2.
    e) Add "10" to obj1 (keeping "10" the operand on right hand side), assign the result to obj2 and display the result for obj2.
    f) Add "10" to obj1 (keeping "10" the operand on left hand side), assign the result to obj2 and display the result for obj2.
    g) Assign the contents of obj3 to obj1 and obj2 in a single statement and display the results for all three instances.
    h) Reference the instance of "Details" class by a pointer to the "Location" class. Use this pointer to display the address.
    i) Return 0.

QUESTION#2

Define a class named PrimeNumber that stores a prime number. The default constructor should set the prime number to 1. Add another constructor that allows the caller to set the prime number. Also, add a function to get the prime number. Finally, overload the prefix and postfix ++ and -- operators so they return a PrimeNumber object that is the next largest prime number (for ++) and the next smallest prime number (for --). For example, if the object's prime number is set to 13, then invoking ++ should return a PrimeNumber object whose prime number is set to 17. Create an appropriate test program for the class.

QUESTION#3

Design a class called NumDays. The class's purpose is to store a value that represents a number of work hours and convert it to a number of days. For example, 8 hours would be converted to 1 day, 12 hours would be converted to 1.5 days, and 18 hours would be converted to 2.25 days. The class should have a constructor that accepts a number of hours, as well as member functions for storing and retrieving the hours and days. The class should also have the following overloaded operators:

- The addition operator +. The number of hours in the sum of two objects is the sum of the number of hours in the individual objects.
- The subtraction operator -. The number of hours in the difference of two objects X and Y is the number of hours in X minus the number of hours in Y.
- Prefix and postfix Increment operators ++. The number of hours in an object is incremented by 1.

Prefix and postfix decrement operators --. The number of hours in an object is decremented by 1.

QUESTION#4

Complete the following tasks:

a. Design a PhoneCall class that holds a phone number to which a call is placed, the length of the call in minutes, and the rate charged per minute.

b. Overload the == operator to compare two PhoneCalls. Consider one PhoneCall to be equal to another if both calls are placed to the same number.

c. Create a main() function that allows you to enter 10 PhoneCalls into an array. If a PhoneCall has already been placed to a number, do not allow a second PhoneCall to the same number. Save the file as PhoneCall.cpp.

QUESTION#5

Complete the following tasks:

a. Design a Meal class with two fields—one that holds the name of the entrée, the other that holds a calorie count integer. Include a constructor that sets a Meal's fields with parameters, or uses default values when no parameters are provided.

b. Include an overloaded insertion operator function that displays a Meal's values.

c. Include an overloaded extraction operator that prompts a user for an entrée name and calorie count for a meal.

d. Include an overloaded operator+()function that allows you to add two or more Meal objects. Adding two Meal objects means adding their calorie values and creating a summary Meal object in which you store "Daily Total" in the entrée field.

e. Write a main()function that declares four Meal objects named breakfast, lunch, dinner, and total. Provide values for the breakfast, lunch, and dinner objects. Include the statement total = breakfast + lunch + dinner; in your program, then display values for the four Meal objects. Save the file as Meal.cpp.

f. Write a main()function that declares an array of 21 Meal objects. Allow a user to enter values for 21 Meals for the week. Total these meals and display the calorie total for the end of the week. (Hint: You might find it useful to create a constructor for the Meal class.) Save the file as Meal2.cpp.

QUESTION#6

Define a class for complex numbers. A complex number is a number of the form

a + b*i

where for our purposes, a and b are numbers of type double , and i is a number that represents the quantity $\sqrt{-1}$. Represent a complex number as two values of type double . Name the member variables real and imaginary . (The variable for the number that is multiplied by i is the one called imaginary .) Call the class Complex .

Include a constructor with two parameters of type double that can be used to set the member variables of an object to any values. Include a constructor that has only a single parameter of type double ; call this parameter realPart and define the constructor so that the object will be initialized to realPart + 0*i . Include a default constructor that initializes an object to 0 (that is, to 0 + 0*i). Overload all the following operators so that they correctly apply to the type Complex : == , + , - , * , >> , and << . You should also write a test program to test your class.

Hints: To add or subtract two complex numbers, add or subtract the two member variables of type double . The product of two complex numbers is given by the following formula:

$$(\boldsymbol{a} + \boldsymbol{b} * \boldsymbol{i}) * (\boldsymbol{c} + \boldsymbol{d} * \boldsymbol{i}) == (\boldsymbol{a} * \boldsymbol{c} - \boldsymbol{b} * \boldsymbol{d}) + (\boldsymbol{a} * \boldsymbol{d} + \boldsymbol{b} * \boldsymbol{c}) * \boldsymbol{i}$$

In the interface file, you should define a constant i as follows: const Complex i(0, 1); This defined constant i will be the same as the i discussed above.

QUESTION#7

Define a class for rational numbers. A rational number is a number that can be represented as the quotient of two integers. For example, 1/2, 3/4, 64/2, and so forth are all rational numbers. (By 1/2 and so on we mean the everyday fraction, not the integer division this expression would produce in a C++ program.) Represent rational numbers as two values of type **`int`**, one for the numerator and one for the denominator. Call the class **`Rational`** .
Include a constructor with two arguments that can be used to set the member variables of an object to any legitimate values. Also include a constructor that has only a single parameter of type **`int`** ; call this single parameter **`wholeNumber`** and define the constructor so that the object will be initialized to the rational number wholeNumber /1. Include a default constructor that initializes an object to 0 (that is, to 0/1).
Overload the input and output operators **>>** and **<<** . Numbers are to be input and output in the form 1/2 , 15/32 , 300/401 , and so forth. Note that the numerator, the denominator, or both may contain a minus sign, so -1/2 , 15/-32 , and -300/-401 are also possible inputs. Overload all the following operators so that they correctly apply to the type Rational : == , < , <= , > , >= , + , - , * , and / . Write a test program to test your class.
Hints: Two rational numbers a/b and c/d are equal if a*d equals c*b. If b and d are positive rational numbers, a/b is less than c/d provided a*d is less than c*b . You should include a function to normalize the values stored so that, after normalization, the denominator is positive and the numerator and denominator are as small as possible. For example, after normalization 4/-8 would be represented the same as -1/2.

QUESTION#8

Complete the following tasks:

a) Design a **ScoreKeeper** class that tracks the scores a student receives in a course. Include fields for the name of the course, an integer that holds the number of different scores a student is assigned during the course, and an integer pointer that points to a list of the student's scores on tests and assignments in a class. Include a constructor that accepts the course name and number of scored items and then prompts the user for the individual scores. Each score must be a value from 0 to 100; if the score is too high or too low, re-prompt the user for a valid score.

b) Overload an insertion operator that displays an object’s values.

c) Overload an = operator that assigns one **ScoreKeeper** to another.

Write a main()function that demonstrates the class works correctly when two objects are created, one object is assigned to another, and, subsequently, the object that was assigned goes out of scope.