National University of Computer and Emerging Sciences

Lab Manual 10
Object Oriented Programming – CL1004

Course Instructor	Dr. Saira Karim
Lab Instructor(s)	Ms. Amna Zulfiqar Mr. Muhammad Adeel
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Department of Computer Science
FAST-NU, Lahore, Pakistan

Important Note:

- You may find the syntax to accomplish these exercises from lecture demo.
- Add Necessary Comments in you code to justify your logic.
- Comment exercise number or statement at the start of your code
- Save each exercise in .cpp file with your roll no, ex and lab number e.g.
- 22LXXXX_EX01_Lab01.cpp

- Place all of your exercises in a folder a Zip it (Do not create .rar file) with roll no and lab no. e.g. 22LXXX_Lab01.zip
- Make sure that the interface of your program is user friendly i.e. properly display information.

Lab Manual-10 Polymorphism

Exercise 1:

For the first part of this lab, we are going to see if base class pointers can point to an object of derived class and vice versa. Perform the following steps

- Create a class called Animal.
- An animal can speak so create a public method named speak in the which returns a char *
- Modify the definition of the speak method so that it returns the string "speak() called.".
- A Dog is an Animal. Create a class named Dog. Use public inheritance.
- The Dog class will inherit the speak method from Animal. Override this method in the Dog class so that it returns "woof!" when called.
- Add the following lines in the main function of your program, note the output and paste it in the space provided below.

```
Animal objAnimal;
Dog objDog;
Animal *ptrAnimal = &objAnimal;
Dog *ptrDog = &objDog;

cout << objAnimal.speak() << endl;
cout << objDog.speak() << endl; cout
<< ptrAnimal->speak() << endl; cout
<< ptrDog->speak() << endl;
```

Output: speak() called. woof! speak() called. woof!

You can see that we have created two objects, one for each class and two pointers in the same manner. The pointer to Animal is pointing to an object of the class Animal and the pointer to Dog is pointing to the object of class Dog. In this example, ptrAnimal called the speak() method of the class Animal whereas ptrDog called the speak() method of the class Dog. If we want to use the definition of the base class method that we have overloaded in a derived class from a derived class pointer, we have to follow this syntax

```
ptrDog->Animal::speak();
```

Modify the last line of your program to use the syntax above, execute it and paste the output in the box below

Output:
speak() called.
woof!
speak() called.
speak() called.

Exercise 2:

Now we will see what happens if we change this. Change the main function so that **ptrAnimal** is pointing to the object of **Dog**, execute your program and paste the output below:

Output:
speak() called.
woof!
speak() called.
speak() called.

Now modify the code so that **ptrDog** points to **objAnimal** and compile your program. It will not compile successfully. Paste the error in the space below. What does this show?

Error:
E0144 a value of type "animal *" cannot be used to initialize an entity of type "dog *"

You can see that there was no problem pointing to an object of a derived class by a pointer of the base class but when calling a function through this pointer, the definition of the base class is used. In the other case, there was a compilation error which showed that it is not possible to point a derived class pointer to an object of base class.

Exercise 3:

Change the main function of your program and replace it with the code below. Execute it and paste the output in the box below.

```
Dog lassie;
Animal *myPet = &lassie;
cout << myPet->speak() << endl;
```

Output:
```
speak() called.
```

You will see that as expected, the speak() method of the base class was called. What if we wanted to use the definition of the derived class function? To accomplish this, we can add the keyword virtual to the declaration of the speak() method in the Animal class. Specifying a function as virtual makes sure that whenever we use a base class pointer pointing to an object

```
virtual char *     speak()
{
        return "speak() called.";
}
```

of a derived class to call a function, the definition of the method declared in the derived class is used. Modify the speak method of the Animal class as shown below, compile your code, execute it and paste the output in the space provided below.

Output:
woof!

Exercise 4:

In the above exercises, we have seen a very simple implementation of Polymorphism. The real power of this feature is realized when we have a collection of objects of multiple derived classes and we use a pointer of the base class to call their respective overloaded methods. A Cat is an animal too. Let's see how we can use an array of base class pointers to utilize the essence of polymorphism.

- Define a class Cat. Inherit publicly from Animal just like we did in class Dog.
- Overload the speak() method so that it returns "mew!".
- Modify the main() function as shown below.
- Compile, execute and paste the output in the space given below.

```
const int size = 2;
Animal * myPets[size];
Cat whiskers;
Dog mutley;

myPets[0] = &whiskers;
myPets[1] = &mutley;

for(int i=0; i<size; i++)
      cout << myPets[i]->speak() << endl;
```

```
Output:
mew!
woof!
```

We can see that although we used the base class pointer to call the speak() method, the overloaded definitions of the derived class was used. We can also see that the "virtualness" of the function declared in Animal was inherited in the new derived class Cat as well so once a function is declared virtual, we don't need to add the keyword virtual to all derived class definitions

Exercise 5:

Modify the main function so that the size of array `myPets` is 5. Display a menu to the user asking him the type of pet for each of the 5 pets. For each input, create the object of the respective class dynamically and point to it by the corresponding pointer of the array `myPets`. Once you have taken all 5 inputs, use a loop to call the `speak()` method and delete each of the objects. You can use the following code to take the input. The declaration of `getch()` is in the header file `conio.h`.

```
int i = 0;
while (i<size)
{
	cout << "Press 1 for a Dog and 2 for a Cat." << endl ;
	switch (getch())
	{
		case '1':
			myPets[i] = new Dog;
			cout << "Dog added at position "<< i <<endl<<endl;
			i++;
			break;
		case '2':
			myPets[i] = new Cat;
			cout << "Cat added at position "<< i <<endl<<endl;
			i++;
			break;
		default:
			cout<<"Invalid input. Enter again." <<endl<<endl;
			break;
	}
}
```

Exercise 6:

Although things seem to be fine on the surface, there is a problem in the program we just wrote. To observe this problem, we must add destructors for all classes. Paste the following inline definitions of the destructors in their corresponding classes, execute the program and paste the output below.

```
~Animal()    { cout << "~Animal() called."<<endl; }
```

```
~Cat(){ cout << "~Cat() called."<<endl;    }
```

```
~Dog(){ cout << "~Dog() called."<<endl;    }
```

Output:

woof!

mew!

woof!

mew!

woof!

~Animal() called.

~Animal() called.

~Animal() called.

~Animal() called.

~Animal() called.

Can you see what went wrong? When using delete to deallocate memory, only the base class destructor is called where as the derived class destructor is not called at all. Although this is fine in the example we are using here but it will create memory leaks if there are any dynamically allocated variables in any of the derived class. To avoid this we declare the base class destructor as virtual. Doing this will make sure that the derived class destructor is called even if you are using a base class pointer to call the destructor. Now change the definition of the base class destructor to make it virtual, execute the program and paste the output in the box given below. Make sure you can see the derived class destructors being called in the output

Output:

woof!

mew!

woof!

mew!

woof!

~Dog() called.

~Animal() called.

~Cat() called.

~Animal() called.

~Dog() called.

~Animal() called.

~Cat() called.

~Animal() called.

~Dog() called.

~Animal() called.

Exercise 7:

Sheep ‘bleat”, cows “moo” and horses “neigh”. Add these classes and overload their speak method as stated. Extend your menu to include the new classes, compile, execute and test your output.

Code of Exercise 7:

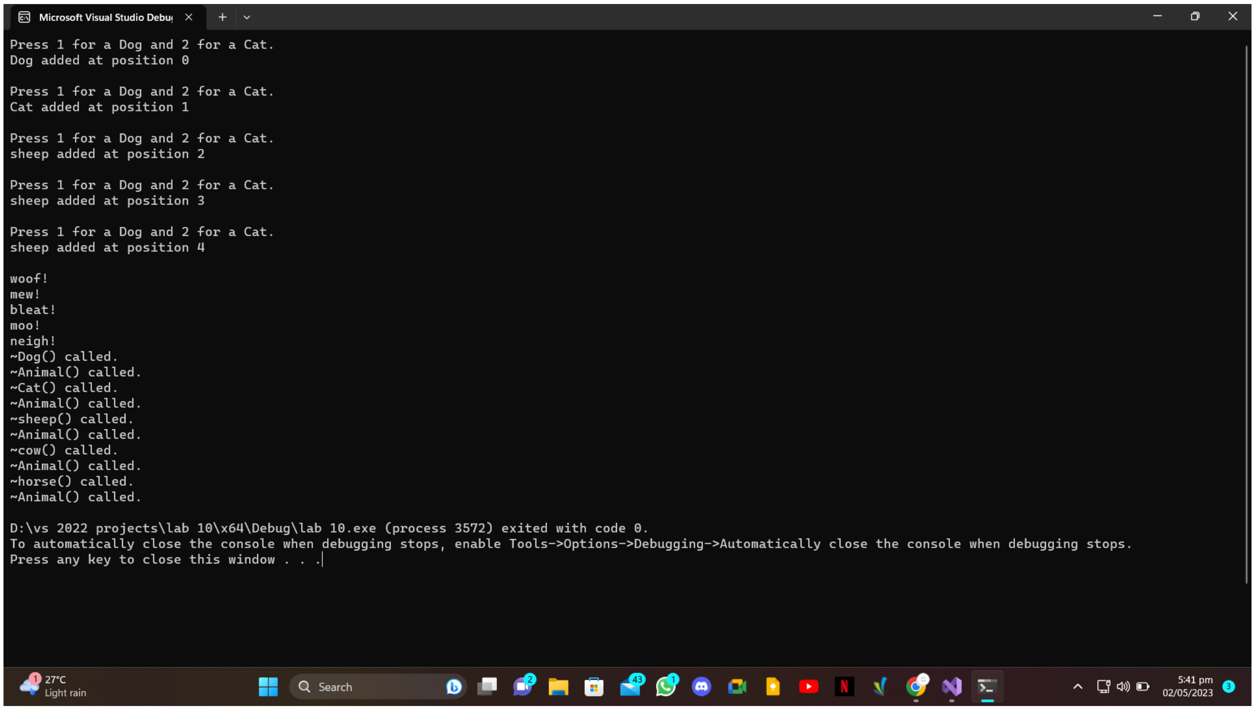
```
#include<iostream>
#include<conio.h>
using namespace std;
class animal
{
public:
	virtual string speak();

	virtual ~animal() { cout << "~Animal() called." << endl; }
};
 string animal::speak()
{
	string a = "speak() called.";
	return a;
}
class dog:public animal
{
public:
	string speak()
	{
		string a = "woof! ";
		return a;
	}
	~dog() { cout << "~Dog() called." << endl; }
};
class cat:public animal
{
public:
	string speak()
	{
		string a = "mew! ";
		return a;
	}
	~cat() { cout << "~Cat() called." << endl; }
};
class sheep:public animal
{
	public:
	string speak()
	{
		string a = "bleat! ";
		return a;
```

```
	}
	~sheep() { cout << "~sheep() called." << endl; }
};
class cow :public animal
{
public:
	string speak()
	{
		string a = "moo! ";
		return a;
	}
	~cow() { cout << "~cow() called." << endl; }
};
class horse :public animal
{
public:
	string speak()
	{
		string a = "neigh! ";
		return a;
	}
	~horse() { cout << "~horse() called." << endl; }
};
int main()
{
	int i = 0;
	const int size = 5;
	animal* myPets[size];
	while (i < size)
	{
		cout << "Press 1 for a Dog and 2 for a Cat." << endl;
		switch (_getch())
		{
		case '1':
			myPets[i] = new dog;
			cout << "Dog added at position " << i << endl << endl; i++;
			break;
		case '2':
			myPets[i] = new cat;
			cout << "Cat added at position " << i << endl << endl; i++;
			break;
		case'3':
			myPets[i] = new sheep;
			cout << "sheep added at position " << i << endl << endl; i++;
			break;
		case'4':
			myPets[i] = new cow;
			cout << "sheep added at position " << i << endl << endl; i++;
			break;
		case'5':
			myPets[i] = new horse;
```

```
				cout << "sheep added at position " << i << endl << endl; i++;
				break;
			default:
				cout << "Invalid input. Enter again." << endl << endl; break;
			}
		}
		for (int i = 0; i < size; i++)
		{
			cout << myPets[i]->speak() << endl;
		}
		for (int i = 0; i < size; i++)
		{
			delete myPets[i];
		}
}
```

```
Result of your Tested Output:
Press 1 for a Dog and 2 for a Cat.
Dog added at position 0

Press 1 for a Dog and 2 for a Cat.
Cat added at position 1

Press 1 for a Dog and 2 for a Cat.
sheep added at position 2

Press 1 for a Dog and 2 for a Cat.
sheep added at position 3

Press 1 for a Dog and 2 for a Cat.
sheep added at position 4

woof!
mew!
bleat!
moo!
neigh!
~Dog() called.
~Animal() called.
~Cat() called.
~Animal() called.
~sheep() called.
~Animal() called.
~cow() called.
~Animal() called.
~horse() called.
~Animal() called.
```

Screenshot:



```
Press 1 for a Dog and 2 for a Cat.
Dog added at position 0

Press 1 for a Dog and 2 for a Cat.
Cat added at position 1

Press 1 for a Dog and 2 for a Cat.
sheep added at position 2

Press 1 for a Dog and 2 for a Cat.
sheep added at position 3

Press 1 for a Dog and 2 for a Cat.
sheep added at position 4

woof!
mew!
bleat!
moo!
neigh!
~Dog() called.
~Animal() called.
~Cat() called.
~Animal() called.
~sheep() called.
~Animal() called.
~cow() called.
~Animal() called.
~horse() called.
~Animal() called.

D:\vs 2022 projects\lab 10\x64\Debug\lab 10.exe (process 3572) exited with code 0.
To automatically close the console when debugging stops, enable Tools->Options->Debugging->Automatically close the console when debugging stops.
Press any key to close this window . . .
```