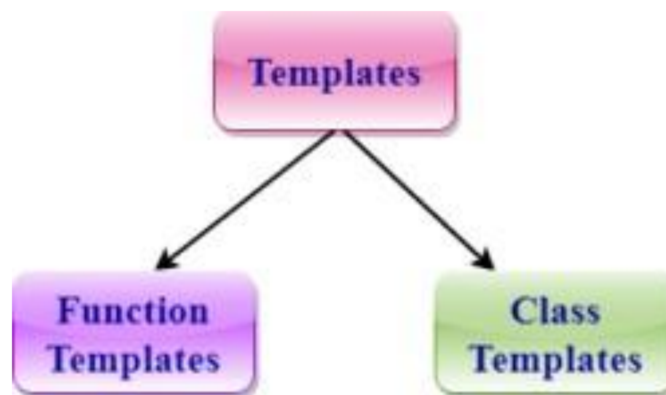
Templates

Templates are powerful features of C++ which allows you to write generic programs. Generic programming is a technique where generic types are used as parameters in algorithms so that we don't need to write the same code for different data types. In simple terms, you can create a single function or a class to work with different data types using templates.

Templates are often used in larger codebase for the purpose of code reusability and flexibility of the programs.

The concept of templates can be used in two different ways:

- Function Templates
- Class Templates



Function Templates

A function template works in a similar to a normal function, with one key difference. A single function template can work with different data types at once but, a single normal function can only work with one set of data types.

Normally, if you need to perform identical operations on two or more types of data, you use function overloading to create two functions with the required function declaration.

However, a better approach would be to use function templates because you can perform the same task writing less and maintainable code.

Syntax for declaring function templates:

A function template starts with the keyword **template** followed by template parameter/s inside **< >** which is followed by function declaration.

```
template <class T>
T someFunction(T arg)
{
   ... .. ...
}
```

In the above code, T is a template argument that accepts different data types (int, float), and **class** is a keyword.

You can also use keyword **typename** instead of class in the above example. When, an argument of a data type is passed to someFunction( ), compiler generates a new version of someFunction() for the given data type.

```
// template function
template <class T>
```

```
T Large(T n1, T n2)
{
	return (n1 > n2) ? n1 : n2;
}

int main()
{
	int i1, i2;
	float f1, f2;

	cout << "Enter two integers:\n";
	cin >> i1 >> i2;
	cout << Large(i1, i2) <<" is larger." << endl;

	cout << "\nEnter two floating-point numbers:\n";
	cin >> f1 >> f2;
	cout << Large(f1, f2) <<" is larger." << endl;

	return 0;
}
```

Output

```
Enter two integers:
5
10
10 is larger.

Enter two floating-point numbers:
12.4
10.2
12.4 is larger.
```

In the above program, a function template Large() is defined that accepts two arguments n1 and n2 of data type T. T signifies that argument can be of any data type. Large() function returns the largest among the two arguments using a simple conditional operation.

Inside the main() function, variables of two different data types: int and float are declared. The variables are then passed to the Large() function template as normal functions. During run-time, when an integer is passed to the template function, compiler knows it has to generate a Large() function to accept the int arguments and does so.

Similarly, when floating-point data are passed, it knows the argument data types and generates the Large() function accordingly.

This way, using only a single function template replaced two identical normal functions and made your code maintainable.

Class Templates
Like function templates, you can also create class templates for generic class operations.
Sometimes, you need a class implementation that is same for all classes, only the data types used are different.
Normally, you would need to create a different class for each data type OR create different member variables and functions within a single class.
This will unnecessarily bloat your code base and will be hard to maintain, as a change is one class/function should be performed on all classes/functions.
However, class templates make it easy to reuse the same code for all data types.
Syntax:

```
template <class T>
class className
{
   ... .. ...
public:
   T var;
   T someOperation(T arg);
   ... .. ...
};
```

In the above declaration, T is the template argument which is a placeholder for the data type used.
Inside the class body, a member variable var and a member function someOperation() are both of type T.
How to create a class template object?
To create a class template object, you need to define the data type inside a < > when creation. className<dataType> classObject;
For example:

```
className<int> classObject;

className<float> classObject;
```

Example: Program to add, subtract, multiply and divide two numbers using class template

```
 #include <iostream.h>
template <class T>
class Calculator
{
private:
		T num1, num2;

public:
		Calculator(T n1, T n2)
		{
```

```
            num1 = n1;
            num2 = n2;
        }

        void displayResult()
        {
            cout << "Numbers are: " << num1 << " and " << num2 << "." << endl;
            cout << "Addition is: " << add() << endl;
            cout << "Subtraction is: " << subtract() << endl;
            cout << "Product is: " << multiply() << endl;
            cout << "Division is: " << divide() << endl;
        }

        T add() { return num1 + num2; }

        T subtract() { return num1 - num2; }

        T multiply() { return num1 * num2; }

        T divide() { return num1 / num2; }
};

int main()
{
        Calculator<int> intCalc(2, 1);
        Calculator<float> floatCalc(2.4, 1.2);

        cout << "Int results:" << endl;
        intCalc.displayResult();

        cout << endl << "Float results:" << endl;
        floatCalc.displayResult();

        return 0;
}
```

Output

```
Int results:
Numbers are: 2 and 1.
Addition is: 3
Subtraction is: 1
Product is: 2
Division is: 2

Float results:
```

Numbers are: 2.4 and 1.2.
Addition is: 3.6
Subtraction is: 1.2
Product is: 2.88
Division is: 2