C++ Assignments

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Exercise 1: Design your own Stack class. The program should contain the following

- **A constructor to initialize the stack**
- **peek(), pop(), push() as their usual meaning**
- **overloaded display() as**
    - **Display the whole contents of the stack**
    - **Pass a parameter providing the depth and display only that element.**

Source Code:

CustomStack header file (CustomStack.hpp)

```
#include <iostream>
constexpr int MAX_SIZE= 100;

class CustomStack {
private:
    int stack[MAX_SIZE];
    int top;

public:
    CustomStack() { top = -1; }
    int getTop() { return top; }
    void push(const int& value);
    void peek(void);
    int getPeek(void);
    int pop(void);
    void display(void);
    void display(const int& depth);
};

void CustomStack::push(const int& value) {
    if(top == MAX_SIZE - 1) {
        std::cout<<"\nStack overflow";
        return;
    }
    top++;
    stack[top] = value;
}

void CustomStack::peek() {
    if(top == -1) {
        std::cout<<"\nStack underflow";
        return;
    }
    std::cout<<"\nTop of stack is: "<<stack[top];
}
```

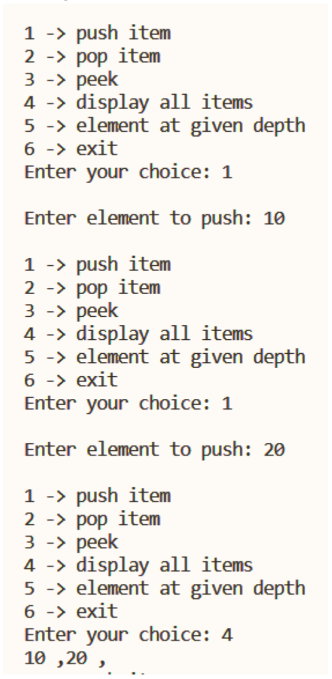
```
int CustomStack::getPeek() {
    if(top == -1)
        return INT32_MAX;
    return stack[top];
}

int CustomStack::pop() {
    if(top < 0) {
        std::cout<<"\nStack underflow";
        return INT32_MAX;
    }
    int x = stack[top];
    top--;
    return x;
}

void CustomStack::display() {
    if(top < 0) {
        std::cout<<"Stack Empty";
        return;
    }
    // std::cout<<"\nStack elements are:\n";
    for(int i=0;i<=top;i++)
        std::cout<<stack[i]<<" ,";
}

void CustomStack::display(const int& depth) {
    if(depth < 0 || depth > top) {
        std::cout<<"\nInvalid depth";
        return;
    }
    std::cout<<"\nElement at depth "<<depth<<" is: "<<stack[top - depth];
}
```

<u>Driver code (CustomStack_Driver.cpp)</u>

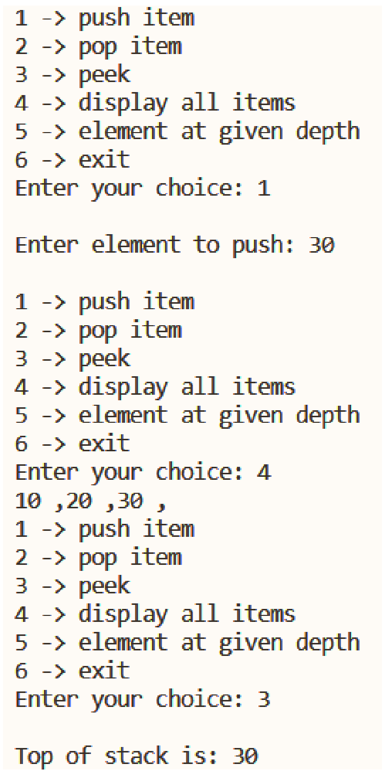
```
#include "CustomStack.hpp"

int main() {
    CustomStack *myStack = new CustomStack();
    int choice, temp;

    while(1) {
        std::cout<<"\n1 -> push item";
        std::cout<<"\n2 -> pop item";
        std::cout<<"\n3 -> peek";
        std::cout<<"\n4 -> display all items";
        std::cout<<"\n5 -> element at given depth";
        std::cout<<"\n6 -> exit";
        std::cout<<"\nEnter your choice: ";
        std::cin >> choice;

        switch (choice)
```

```
            {
            case 1:
                std::cout<<"\nEnter element to push: ";
                std::cin >> temp;
                myStack->push(temp);
                break;
            case 2:
                temp = myStack->pop();
                if(temp != INT32_MAX)
                    std::cout<<"\nPopped element is: "<<temp;
                break;
            case 3:
                myStack->peek();
                break;
            case 4:
                myStack->display();
                break;
            case 5:
                std::cout<<"\nEnter depth of element: ";
                std::cin >> temp;
                myStack->display(temp);
                break;
            case 6:
                return 0;
            default:
                break;
            }

        }
}
```

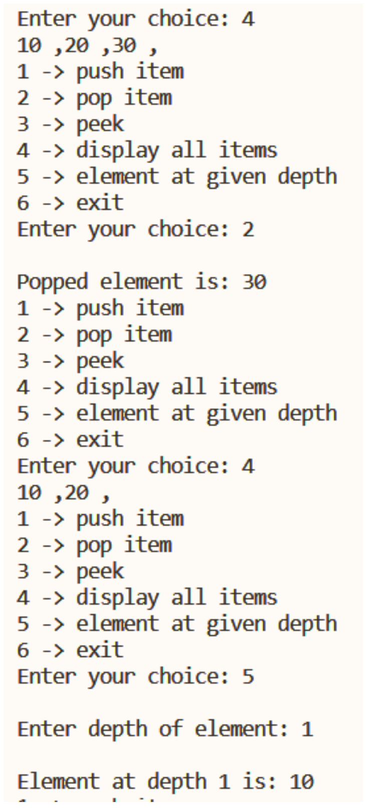
Output:



```
1 -> push item
2 -> pop item
3 -> peek
4 -> display all items
5 -> element at given depth
6 -> exit
Enter your choice: 1

Enter element to push: 10

1 -> push item
2 -> pop item
3 -> peek
4 -> display all items
5 -> element at given depth
6 -> exit
Enter your choice: 1

Enter element to push: 20

1 -> push item
2 -> pop item
3 -> peek
4 -> display all items
5 -> element at given depth
6 -> exit
Enter your choice: 4
10 ,20 ,
```



```
1 -> push item
2 -> pop item
3 -> peek
4 -> display all items
5 -> element at given depth
6 -> exit
Enter your choice: 1

Enter element to push: 30

1 -> push item
2 -> pop item
3 -> peek
4 -> display all items
5 -> element at given depth
6 -> exit
Enter your choice: 4
10 ,20 ,30 ,
1 -> push item
2 -> pop item
3 -> peek
4 -> display all items
5 -> element at given depth
6 -> exit
Enter your choice: 3

Top of stack is: 30
```



```
Enter your choice: 4
10 ,20 ,30 ,
1 -> push item
2 -> pop item
3 -> peek
4 -> display all items
5 -> element at given depth
6 -> exit
Enter your choice: 2

Popped element is: 30
1 -> push item
2 -> pop item
3 -> peek
4 -> display all items
5 -> element at given depth
6 -> exit
Enter your choice: 4
10 ,20 ,
1 -> push item
2 -> pop item
3 -> peek
4 -> display all items
5 -> element at given depth
6 -> exit
Enter your choice: 5

Enter depth of element: 1

Element at depth 1 is: 10
```

Exercise 2: Inherit the custom stack created before and the inherited class should allow the following –

- **A number is to be pushed in if and only if it is less than the one currently at the top**

With the help of such stack objects, solve the Tower Of Hanoi problem most economically, by arranging a sequence of haphazard numbers in the original base stack in ascending order for the final stack.

Source Code:

CustomStack header file (CustomStack.hpp)

```
#include <iostream>
constexpr int MAX_SIZE= 100;

class CustomStack {
private:
    int stack[MAX_SIZE];
    int top;

public:
    CustomStack() { top = -1; }
    int getTop() { return top; }
    void push(const int& value);
    void peek(void);
    int getPeek(void);
    int pop(void);
    void display(void);
    void display(const int& depth);
};

void CustomStack::push(const int& value) {
    if(top == MAX_SIZE - 1) {
        std::cout<<"\nStack overflow";
        return;
    }
    top++;
    stack[top] = value;
}

void CustomStack::peek() {
    if(top == -1) {
        std::cout<<"\nStack underflow";
        return;
    }
    std::cout<<"\nTop of stack is: "<<stack[top];
}
```

```
int CustomStack::getPeek() {
    if(top == -1)
        return INT32_MAX;
    return stack[top];
}

int CustomStack::pop() {
    if(top < 0) {
        std::cout<<"\nStack underflow";
        return INT32_MAX;
    }
    int x = stack[top];
    top--;
    return x;
}

void CustomStack::display() {
    if(top < 0) {
        std::cout<<"Stack Empty";
        return;
    }
    // std::cout<<"\nStack elements are:\n";
    for(int i=0;i<=top;i++)
        std::cout<<stack[i]<<" ,";
}

void CustomStack::display(const int& depth) {
    if(depth < 0 || depth > top) {
        std::cout<<"\nInvalid depth";
        return;
    }
    std::cout<<"\nElement at depth "<<depth<<" is: "<<stack[top - depth];
}
```

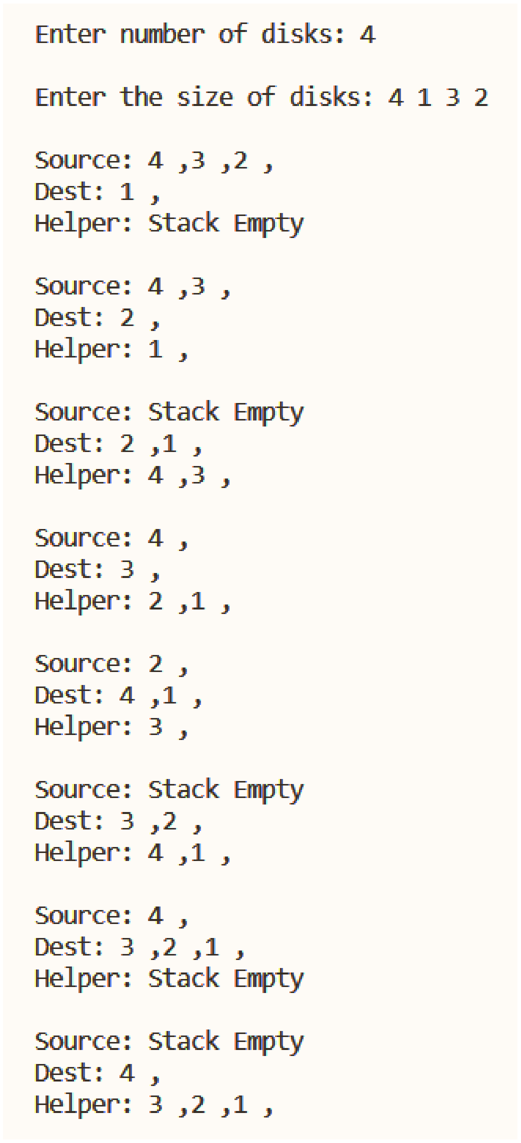
<u>DescendingStack header file (DescendingStack.hpp) Inherits Custom stack previously made</u>

```
#include "CustomStack.hpp"

class DescendingStack : public CustomStack {
public:
    DescendingStack() { }

    DescendingStack(CustomStack s) {
        //constructor for creating sorted stack from normal custom stack
        int a[MAX_SIZE], k=0;
        while(s.getTop() >= 0) {
            int x = s.pop();
            a[k] = x;
            k++;
        }

        //now sort and push in new Descending stack
        for(int i=0;i<k;i++)
            for(int j=0;j<k-i-1;j++)
                if(a[j] < a[j+1])
                    std::swap(a[j], a[j+1]);

        for(int i=0;i<k;i++)
            this->push(a[i]);

    }

    void push(const int& value) {
        if(getTop() == -1)
            CustomStack::push(value);
        else if(getPeek() > value)
            CustomStack::push(value);
        else
            std::cout<<"\nInvalid input";
    }

};
```

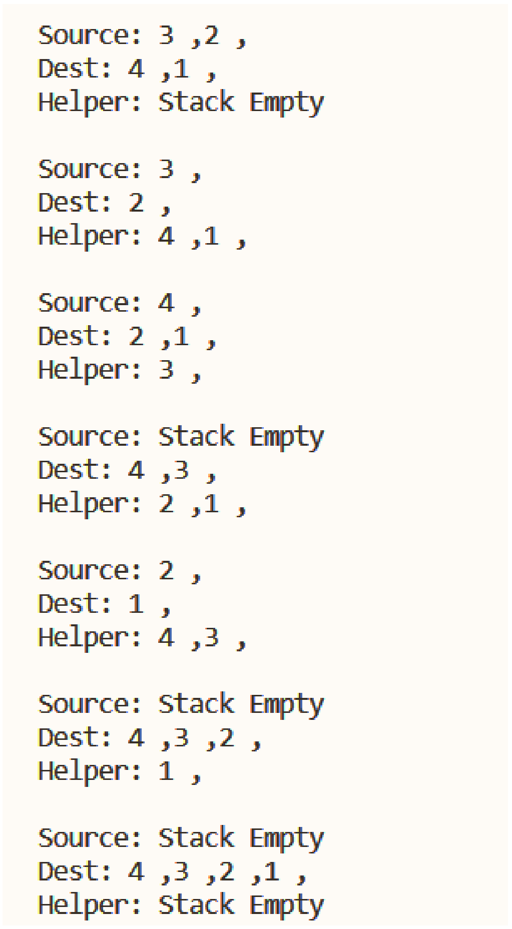
Driver code (TowerOfHanoi.cpp)

```
#include "DescendingStack.hpp"

void towerOfHanoi(int , DescendingStack& , DescendingStack& ,
DescendingStack& );

int main()
{
    int numberOfDisks;
    int temp;
    CustomStack s;

    std::cout<<"\nEnter number of disks: ";
    std::cin>>numberOfDisks;
    std::cout<<"\nEnter the size of disks: ";
    for(int i=1;i<=numberOfDisks;i++) {
        std::cin>>temp;
        s.push(temp);
    }

    DescendingStack from_rod(s), to_rod, aux_rod;

    towerOfHanoi(numberOfDisks, from_rod, to_rod, aux_rod);

}

void towerOfHanoi(int n, DescendingStack& from_rod, DescendingStack&
to_rod, DescendingStack& aux_rod)
{
    if (n == 0)
        return;
    towerOfHanoi(n - 1, from_rod, aux_rod, to_rod);
    int currentDisk = from_rod.pop();
    to_rod.push(currentDisk);

    std::cout<<"\nSource: ";
    from_rod.display();
    std::cout<<"\nDest: ";
    to_rod.display();
    std::cout<<"\nHelper: ";
    aux_rod.display();
    std::cout<<"\n";

    towerOfHanoi(n - 1, aux_rod, to_rod, from_rod);

}
```

Output:



```
Enter number of disks: 4

Enter the size of disks: 4 1 3 2

Source: 4 ,3 ,2 ,
Dest: 1 ,
Helper: Stack Empty

Source: 4 ,3 ,
Dest: 2 ,
Helper: 1 ,

Source: Stack Empty
Dest: 2 ,1 ,
Helper: 4 ,3 ,

Source: 4 ,
Dest: 3 ,
Helper: 2 ,1 ,

Source: 2 ,
Dest: 4 ,1 ,
Helper: 3 ,

Source: Stack Empty
Dest: 3 ,2 ,
Helper: 4 ,1 ,

Source: 4 ,
Dest: 3 ,2 ,1 ,
Helper: Stack Empty

Source: Stack Empty
Dest: 4 ,
Helper: 3 ,2 ,1 ,
```



```
Source: 3 ,2 ,
Dest: 4 ,1 ,
Helper: Stack Empty

Source: 3 ,
Dest: 2 ,
Helper: 4 ,1 ,

Source: 4 ,
Dest: 2 ,1 ,
Helper: 3 ,

Source: Stack Empty
Dest: 4 ,3 ,
Helper: 2 ,1 ,

Source: 2 ,
Dest: 1 ,
Helper: 4 ,3 ,

Source: Stack Empty
Dest: 4 ,3 ,2 ,
Helper: 1 ,

Source: Stack Empty
Dest: 4 ,3 ,2 ,1 ,
Helper: Stack Empty
```

Exercise 3A: Modify the custom stack class created above with templates to store objects of own class of own design while keeping all the constraints same.

Source Code:

Generic_Stack header file (Generic_Stack.hpp)

```
#include <iostream>

template <typename T, int N>
class Generic_Stack {
private:
    T stack[N];
    int top;
public:
    Generic_Stack() { top = -1; }
    int getTop() { return top; }
    void push(const T& value);
    void peek(void);
    T pop(void);
    void display(void);
    void display(const int& depth);
};

template <typename T, int N>
void Generic_Stack<T, N>::push(const T& value) {
    if(top == N - 1) {
        std::cout<<"\nStack overflow";
        return;
    }
    top++;
    stack[top] = value;
}

template <typename T, int N>
void Generic_Stack<T, N>::peek() {
    if(top == -1) {
        std::cout<<"\nStack underflow";
        return;
    }
    std::cout<<"\nTop of stack is: "<<stack[top];
}

template <typename T, int N>
T Generic_Stack<T, N>::pop() {
    T x = stack[top];
    top--;
    return x;
}

template <typename T, int N>
void Generic_Stack<T, N>::display() {
    if(top < 0) {
        std::cout<<"\nStack underflow";
        return;
    }
    std::cout<<"\nStack elements are:\n";
    for(int i=0;i<=top;i++)
        std::cout<<stack[i]<<" ,";
}

template <typename T, int N>
void Generic_Stack<T, N>::display(const int& depth) {
    if(depth < 0 || depth > top) {
        std::cout<<"\nInvalid depth";
        return;
    }
    std::cout<<"\nElement at depth "<<depth<<" is: "<<stack[top - depth];
}
```

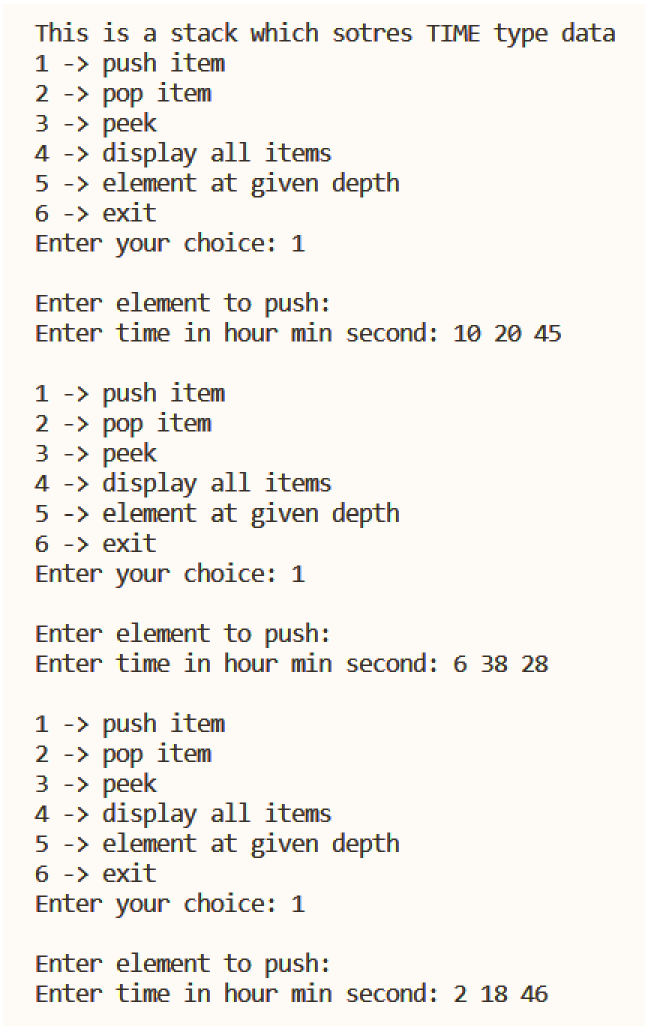
TIME class header file (TIME.hpp) the custom class to be stored:

```
#pragma once
#include <iostream>

class TIME {
private:
    int hour, min, sec;

public:
    TIME() {}
    TIME(int hour, int min, int sec) {
        this->hour = hour;
        this->min = min;
        this->sec = sec;
    }

    friend std::ostream& operator << (std::ostream& out, const TIME& time)
{
        out << time.hour << ":" << time.min << ":" << time.sec;
        return out;
    }

    friend std::istream& operator >> (std::istream& in, TIME& time) {
        std::cout<<"\nEnter time in hour min second: ";
        in >> time.hour;
        in >> time.min;
        in >> time.sec;
        return in;
    }

};
```

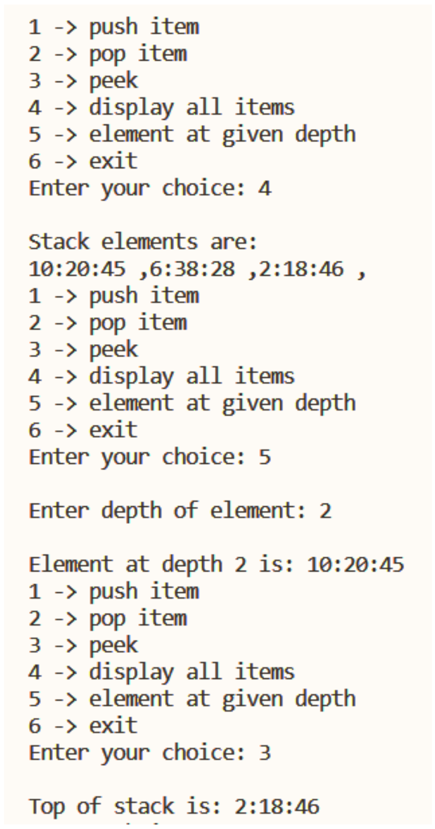
Driver code (Generic_Stack_Driver.cpp):

```cpp
#include "Generic_Stack.hpp"
#include "TIME.hpp"

int main() {
    Generic_Stack<TIME, 10> myStack;
    TIME temp;
    int depth;
    int choice;
    std::cout<<"\nThis is a stack which sotres TIME type data";

    while(1) {
        std::cout<<"\n1 -> push item";
        std::cout<<"\n2 -> pop item";
        std::cout<<"\n3 -> peek";
        std::cout<<"\n4 -> display all items";
        std::cout<<"\n5 -> element at given depth";
        std::cout<<"\n6 -> exit";
        std::cout<<"\nEnter your choice: ";
        std::cin >> choice;

        switch (choice)
        {
        case 1:
            std::cout<<"\nEnter element to push: ";
            std::cin >> temp;
            myStack.push(temp);
            break;
        case 2:
            temp = myStack.pop();
            std::cout<<"\nPopped element is: "<<temp;
            break;
        case 3:
            myStack.peek();
            break;
        case 4:
            myStack.display();
            break;
        case 5:
            std::cout<<"\nEnter depth of element: ";
            std::cin >> depth;
            myStack.display(depth);
            break;
        case 6:
            return 0;
        default:
            break;
        }

    }
}
```

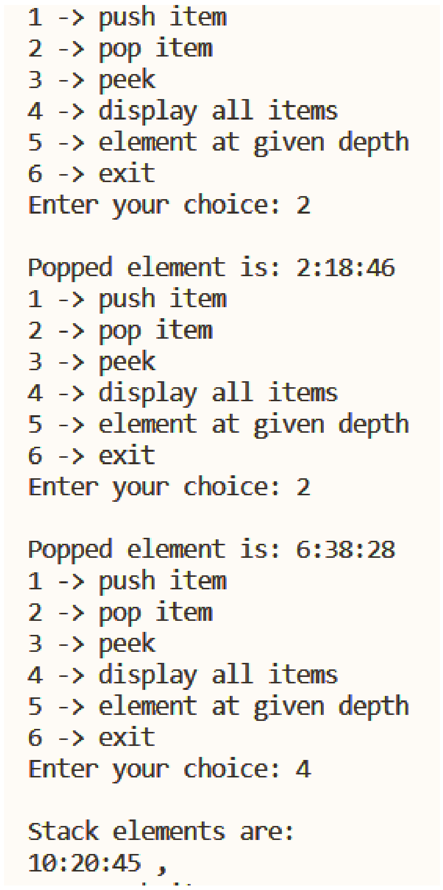
Output:



```
This is a stack which sotres TIME type data
1 -> push item
2 -> pop item
3 -> peek
4 -> display all items
5 -> element at given depth
6 -> exit
Enter your choice: 1

Enter element to push:
Enter time in hour min second: 10 20 45

1 -> push item
2 -> pop item
3 -> peek
4 -> display all items
5 -> element at given depth
6 -> exit
Enter your choice: 1

Enter element to push:
Enter time in hour min second: 6 38 28

1 -> push item
2 -> pop item
3 -> peek
4 -> display all items
5 -> element at given depth
6 -> exit
Enter your choice: 1

Enter element to push:
Enter time in hour min second: 2 18 46
```



```
1 -> push item
2 -> pop item
3 -> peek
4 -> display all items
5 -> element at given depth
6 -> exit
Enter your choice: 4

Stack elements are:
10:20:45 ,6:38:28 ,2:18:46 ,
1 -> push item
2 -> pop item
3 -> peek
4 -> display all items
5 -> element at given depth
6 -> exit
Enter your choice: 5

Enter depth of element: 2

Element at depth 2 is: 10:20:45
1 -> push item
2 -> pop item
3 -> peek
4 -> display all items
5 -> element at given depth
6 -> exit
Enter your choice: 3

Top of stack is: 2:18:46
```



```
1 -> push item
2 -> pop item
3 -> peek
4 -> display all items
5 -> element at given depth
6 -> exit
Enter your choice: 2

Popped element is: 2:18:46
1 -> push item
2 -> pop item
3 -> peek
4 -> display all items
5 -> element at given depth
6 -> exit
Enter your choice: 2

Popped element is: 6:38:28
1 -> push item
2 -> pop item
3 -> peek
4 -> display all items
5 -> element at given depth
6 -> exit
Enter your choice: 4

Stack elements are:
10:20:45 ,
```

Exercise 3B: Modify the above stack class created using templates and use try-throw-catch in some form to accommodate exception handling.

<u>Source Code:</u>

<u>Generic_Stack_Exp header file (Generic_Stack_Exp.hpp)</u>

```cpp
#include <iostream>
#include <string>

class customStackException {
private:
    std::string message;
public:
    customStackException(const std::string& message) {
        this->message = message;
    }
    std::string what() const {
        return message;
    }
};


//template stack class
template <typename T, int N>
class Generic_Stack {
private:
    T stack[N];
    int top;
public:
    Generic_Stack() { top = -1; }
    int getTop() { return top; }
    void push(const T& value);
    void peek(void);
    T pop(void);
    void display(void);
    void display(const int& depth);
    T getStackAvg(void);
};

template <typename T, int N>
T Generic_Stack<T, N>::getStackAvg() {
    if(top < 0)
        throw customStackException("Stack underflow");
    int temp = 0;
    for(int i=0;i<=top;i++)
        temp = temp + stack[i];
    temp /= top+1;
    return T(temp);
}

template <typename T, int N>
void Generic_Stack<T, N>::push(const T& value) {
    if(top == N - 1)
        throw customStackException("Stack Overflow");
    top++;
    stack[top] = value;
}

template <typename T, int N>
void Generic_Stack<T, N>::peek() {
    if(top == -1)
        throw customStackException("Stack underflow");
    std::cout<<"\nTop of stack is: "<<stack[top];
}

template <typename T, int N>
T Generic_Stack<T, N>::pop() {
    if(top < 0)
        throw customStackException("Stack underflow");
    int x = stack[top];
    top--;
    return x;
}

template <typename T, int N>
void Generic_Stack<T, N>::display() {
    if(top < 0)
        throw customStackException("Stack underflow");
    std::cout<<"\nStack elements are:\n";
    for(int i=0;i<=top;i++)
        std::cout<<stack[i]<<" ,";
}

template <typename T, int N>
void Generic_Stack<T, N>::display(const int& depth) {
    if(depth < 0 || depth > top)
        throw customStackException("Invalid Depth");
    std::cout<<"\nElement at depth "<<depth<<" is: "<<stack[top - depth];
}
```

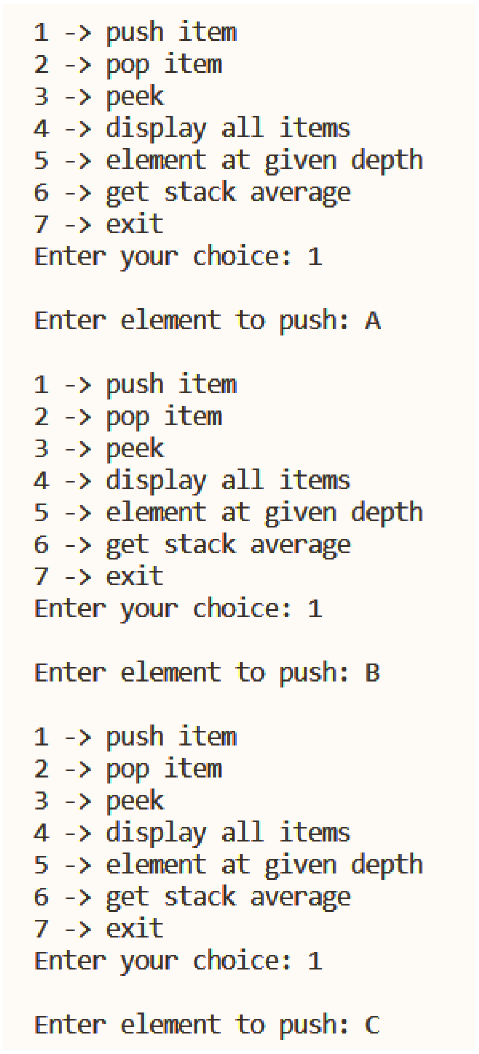
Driver class (Generic_Stack_Excp.cpp):

```
#include "Generic_Stack_Exp.hpp"

int main() {
    Generic_Stack<char, 10> myStack;
    char temp;
    int depth;
    int choice;

    while(1) {
        std::cout<<"\n1 -> push item";
        std::cout<<"\n2 -> pop item";
        std::cout<<"\n3 -> peek";
        std::cout<<"\n4 -> display all items";
```

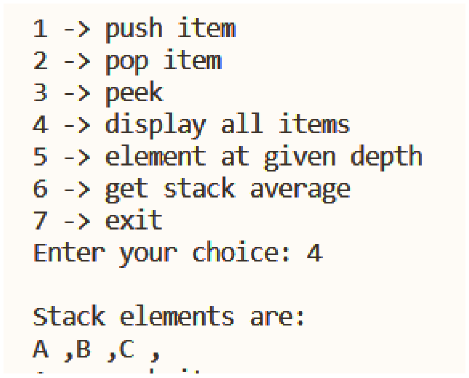
```
std::cout<<"\n5 -> element at given depth";
std::cout<<"\n6 -> get stack average";
std::cout<<"\n7 -> exit";
std::cout<<"\nEnter your choice: ";
std::cin >> choice;

switch (choice)
{
case 1:
    std::cout<<"\nEnter element to push: ";
    std::cin >> temp;
    try {
        myStack.push(temp);
    }
    catch (const customStackException& e) {
        std::cout<<"\nException: "<<e.what();
    }
    break;
case 2:
    try {
        temp = myStack.pop();
        std::cout<<"\nPopped element is: "<<temp;
    }
    catch (const customStackException& e) {
        std::cout<<"\nException: "<<e.what();
    }
    break;
case 3:
    try {
        myStack.peek();
    }
    catch (const customStackException& e) {
        std::cout<<"\nException: "<<e.what();
    }
    break;
case 4:
    try {
        myStack.display();
    }
    catch (const customStackException& e) {
        std::cout<<"\nException: "<<e.what();
    }
    break;
case 5:
    std::cout<<"\nEnter depth of element: ";
    std::cin >> depth;
    try {
        myStack.display(temp);
    }
    catch (const customStackException& e) {
        std::cout<<"\nException: "<<e.what();
    }
    break;
case 6:
```

```
                try {
                    temp = myStack.getStackAvg();
                    std::cout<<"\n"<<temp;
                }
                catch (const customStackException& e) {
                    std::cout<<"\nException: "<<e.what();
                }
                break;
            case 7:
                return 0;
            default:
                break;
            }

        }
    }
```

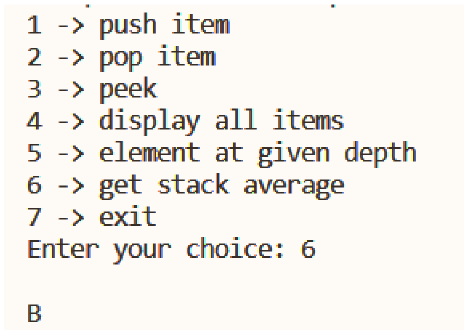
Output:



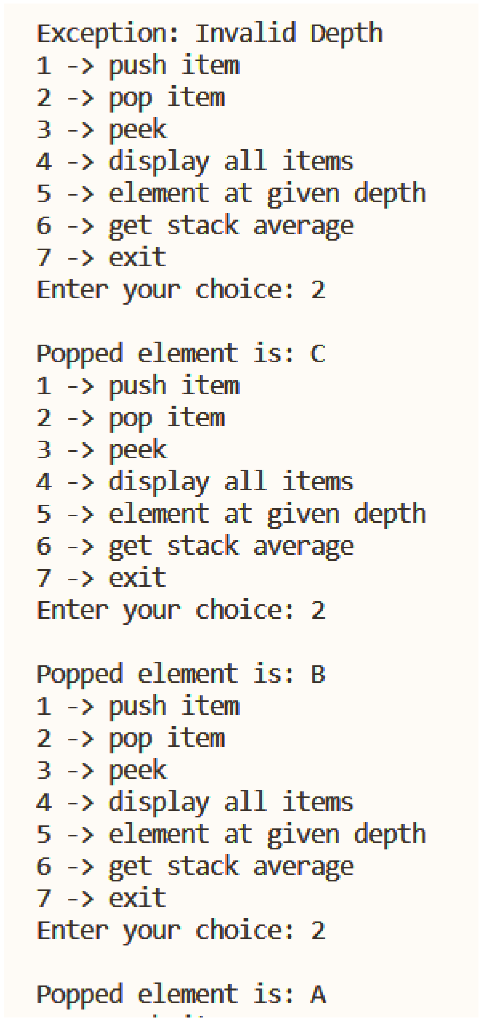
```
1 -> push item
2 -> pop item
3 -> peek
4 -> display all items
5 -> element at given depth
6 -> get stack average
7 -> exit
Enter your choice: 1

Enter element to push: A

1 -> push item
2 -> pop item
3 -> peek
4 -> display all items
5 -> element at given depth
6 -> get stack average
7 -> exit
Enter your choice: 1

Enter element to push: B

1 -> push item
2 -> pop item
3 -> peek
4 -> display all items
5 -> element at given depth
6 -> get stack average
7 -> exit
Enter your choice: 1

Enter element to push: C
```



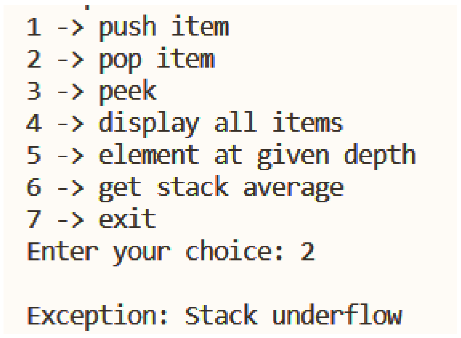
```
1 -> push item
2 -> pop item
3 -> peek
4 -> display all items
5 -> element at given depth
6 -> get stack average
7 -> exit
Enter your choice: 4

Stack elements are:
A ,B ,C ,
```



```
1 -> push item
2 -> pop item
3 -> peek
4 -> display all items
5 -> element at given depth
6 -> get stack average
7 -> exit
Enter your choice: 6

B
```



```
Exception: Invalid Depth
1 -> push item
2 -> pop item
3 -> peek
4 -> display all items
5 -> element at given depth
6 -> get stack average
7 -> exit
Enter your choice: 2

Popped element is: C
1 -> push item
2 -> pop item
3 -> peek
4 -> display all items
5 -> element at given depth
6 -> get stack average
7 -> exit
Enter your choice: 2

Popped element is: B
1 -> push item
2 -> pop item
3 -> peek
4 -> display all items
5 -> element at given depth
6 -> get stack average
7 -> exit
Enter your choice: 2

Popped element is: A
```



```
1 -> push item
2 -> pop item
3 -> peek
4 -> display all items
5 -> element at given depth
6 -> get stack average
7 -> exit
Enter your choice: 2

Exception: Stack underflow
```