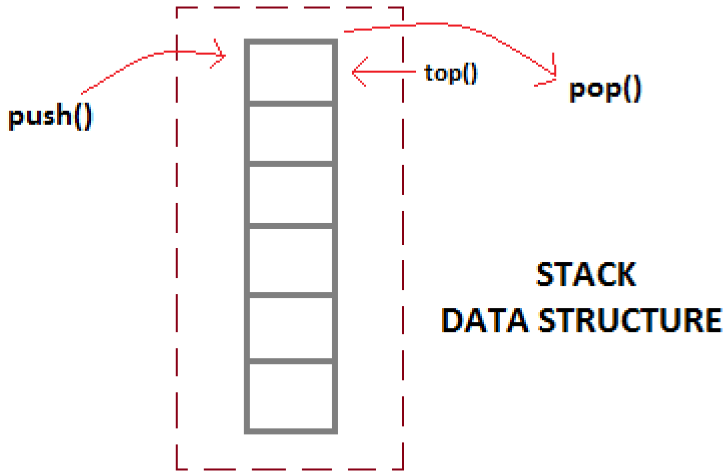
What is Stack Data Structure?

Stack is an abstract data type with a bounded(predefined) capacity. It is a simple data structure that allows adding and removing elements in a particular order. Every time an element is added, it goes on the **top** of the stack and the only element that can be removed is the element that is at the top of the stack, just like a pile of objects.



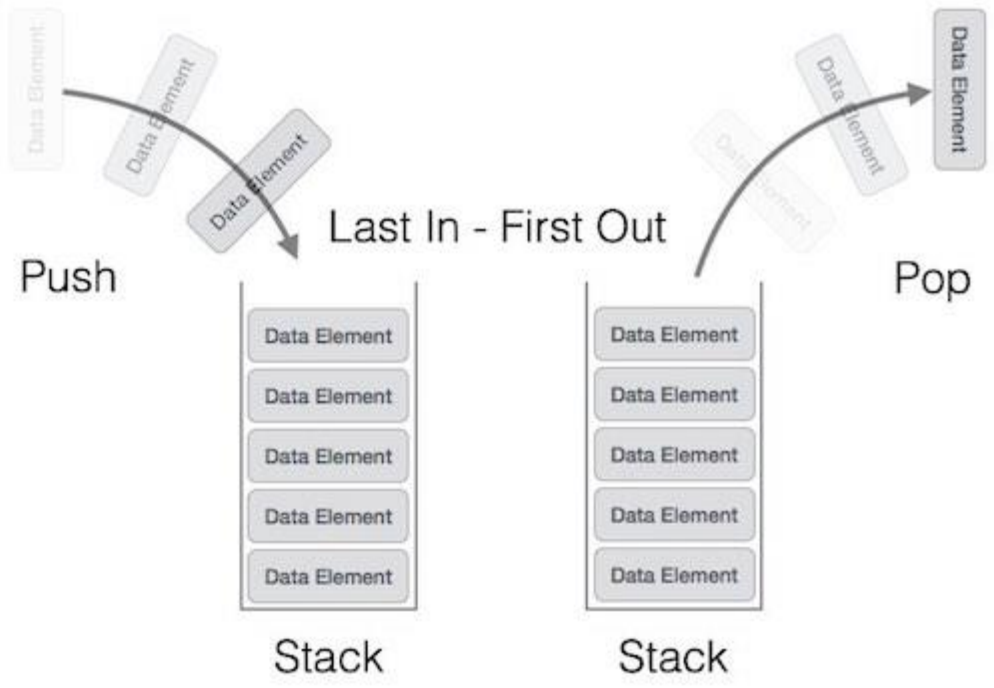
It is named stack as it behaves like a real-world stack, for example – a deck of cards or a pile of plates, etc.

A real-world stack allows operations at one end only. For example, we can place or remove a card or plate from the top of the stack only. Likewise, Stack ADT allows all data operations at one end only. At any given time, we can only access the top element of a stack.

This feature makes it LIFO data structure. LIFO stands for Last-in-first-out. Here, the element which is placed (inserted or added) last, is accessed first. In stack terminology, insertion operation is called **PUSH** operation and removal operation is called **POP** operation.

Stack Representation

The following diagram depicts a stack and its operations −



A stack can be implemented by means of Array, Structure, Pointer, and Linked List. Stack can either be a fixed size one or it may have a sense of dynamic resizing. Here, we are going to implement stack using arrays, which makes it a fixed size stack implementation.

Basic Operations

Stack operations may involve initializing the stack, using it and then de-initializing it. Apart from these basic stuffs, a stack is used for the following two primary operations −

- **push()** − Pushing (storing) an element on the stack.
- **pop()** − Removing (accessing) an element from the stack.

When data is PUSHed onto stack.

To use a stack efficiently, we need to check the status of stack as well. For the same purpose, the following functionality is added to stacks −

- **peek()** − get the top data element of the stack, without removing it.
- **isFull()** − check if stack is full.
- **isEmpty()** − check if stack is empty.

At all times, we maintain a pointer to the last PUSHed data on the stack. As this pointer always represents the top of the stack, hence named **top**. The **top**pointer provides top value of the stack without actually removing it.

First we should learn about procedures to support stack functions –

peek()

Algorithm of peek() function –

```
begin procedure peek
   return stack[top]
end procedure
```

Implementation of peek() function in C programming language –

Example

```
int peek() {

   return stack[top];

}
```

isfull()

Algorithm of isfull() function –

```
begin procedure isfull



   if top equals to MAXSIZE

      return true

   else

      return false

   endif



end procedure
```

Implementation of isfull() function in C programming language –

Example

```
bool isfull() {
   if(top == MAXSIZE)

      return true;

   else

      return false;

}
```

isempty()

Algorithm of isempty() function −

```
begin procedure isempty


   if top less than 1

      return true

   else

      return false

   endif


end procedure
```

Implementation of isempty() function in C programming language is slightly different. We initialize top at -1, as the index in array starts from 0. So we check if the top is below zero or -1 to determine if the stack is empty. Here's the code −

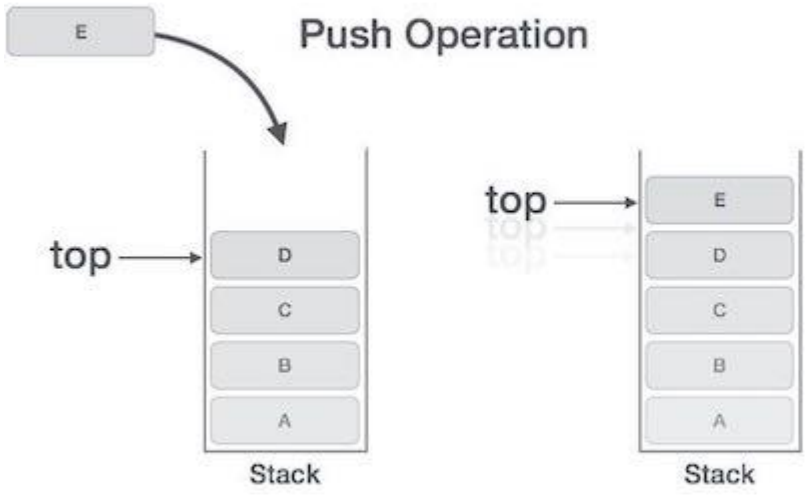
Example

```
bool isempty() {

   if(top == -1)

      return true;

   else

      return false;

}
```

Push Operation

The process of putting a new data element onto stack is known as a Push Operation. Push operation involves a series of steps −

- **Step 1** − Checks if the stack is full.
- **Step 2** − If the stack is full, produces an error and exit.
- **Step 3** − If the stack is not full, increments **top** to point next empty space.
- **Step 4** − Adds data element to the stack location, where top is pointing.
- **Step 5** − Returns success.



If the linked list is used to implement the stack, then in step 3, we need to allocate space dynamically.

Algorithm for PUSH operation

1. Check if the stack is **full** or not.
2. If the stack is full, then print error of overflow and exit the program.
3. If the stack is not full, then increment the top and add the element.

A simple algorithm for Push operation can be derived as follows −

```
begin procedure push: stack, data
```

```
   if stack is full
      return null
   endif

   top ← top + 1
   stack[top] ← data

end procedure
```

Implementation of this algorithm in C, is very easy. See the following code –

Example

```c
void push(int data) {
   if(!isFull()) {
      top = top + 1;
      stack[top] = data;
   } else {
      printf("Could not insert data, Stack is full.\n");
   }
}
```

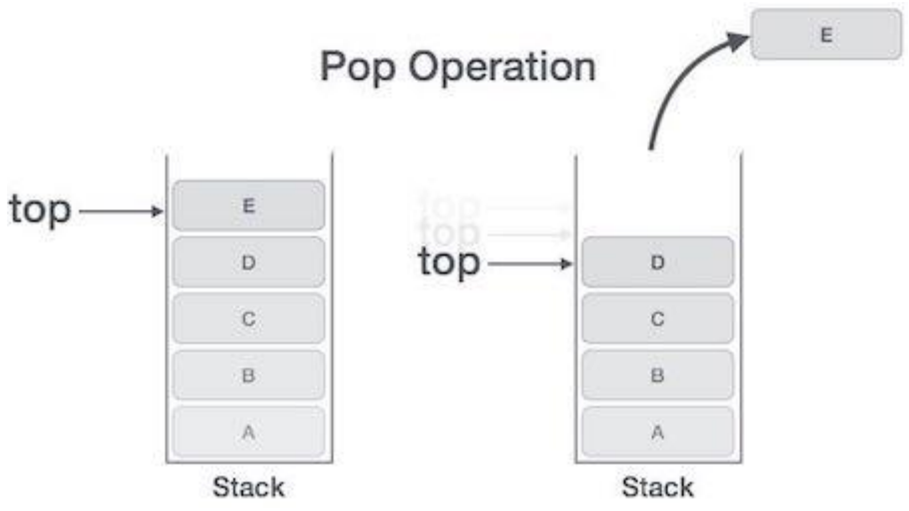
Pop Operation

Accessing the content while removing it from the stack, is known as a Pop Operation. In an array implementation of pop() operation, the data element is not actually removed, instead **top** is decremented to a lower position in the stack to point to the next value. But in linked-list implementation, pop() actually removes data element and deallocates memory space.

A Pop operation may involve the following steps –

- **Step 1** – Checks if the stack is empty.

- **Step 2** − If the stack is empty, produces an error and exit.
- **Step 3** − If the stack is not empty, accesses the data element at which **top** is pointing.
- **Step 4** − Decreases the value of top by 1.
- **Step 5** − Returns success.



Algorithm for POP operation

1. Check if the stack is empty or not.
2. If the stack is empty, then print error of underflow and exit the program.
3. If the stack is not empty, then print the element at the top and decrement the top.

A simple algorithm for Pop operation can be derived as follows −

```
begin procedure pop: stack

   if stack is empty
      return null
   endif

   data ← stack[top]
   top ← top - 1

   return data


end procedure
```

Implementation of this algorithm in C, is as follows −

Example

```
int pop(int data) {


   if(!isempty()) {

      data = stack[top];

      top = top - 1;

      return data;

   } else {

      printf("Could not retrieve data, Stack is empty.\n");

   }

}
```

Below we have a simple C++ program implementing stack data structure while following the object oriented programming concepts.

```
/*  Below program is written in C++ language  */


# include<iostream>
```

```cpp
using namespace std;

class Stack
{
    int top;
    public:
    int a[10];  //Maximum size of Stack
    Stack()
    {
        top = -1;
    }

    // declaring all the function
    void push(int x);
    int pop();
    void isEmpty();
};

// function to insert data into stack
void Stack::push(int x)
{
    if(top >= 10)
    {
        cout << "Stack Overflow \n";
    }
    else
    {
        a[++top] = x;
        cout << "Element Inserted \n";
    }
}

// function to remove data from the top of the stack
int Stack::pop()
{
    if(top < 0)
    {
        cout << "Stack Underflow \n";
        return 0;
    }
    else
    {
        int d = a[top--];
        return d;
    }
}

// function to check if stack is empty
void Stack::isEmpty()
{
    if(top < 0)
    {
        cout << "Stack is empty \n";
    }
    else
    {
        cout << "Stack is not empty \n";
    }
}

// main function
int main() {

    Stack s1;
    s1.push(10);
    s1.push(100);
    /*
        preform whatever operation you want on the stack
    */
}
```

Position of Top	Status of Stack
`-1`	Stack is Empty
`0`	Only one element in Stack
`N-1`	Stack is Full
`N`	Overflow state of Stack

Analysis of Stack Operations

Below mentioned are the time complexities for various operations that can be performed on the Stack data structure.

- **Push Operation** : O(1)
- **Pop Operation** : O(1)
- **Top Operation** : O(1)
- **Search Operation** : O(n)

The time complexities for `push()` and `pop()` functions are `O(1)` because we always have to insert or remove the data from the **top** of the stack, which is a one step process.
