SCJ2013 Data Structure & Algorithms

Stack

Nor Bahiah Hj Ahmad & Dayang
Norhayati A. Jawawi

Course Objectives

At the end of the lesson students are expected to be able to:

- Understand stack concept and its structure.
- Understand operations that can be done on stack.
- Understand and know how to implement stack using array and linked list.

Introduction to Stack

- Stack is a collection of items which is organized in a sequential manner.
- Example: stack of books or stac of plates.
- All additions and deletions are restricted at one end, called top.
- LAST IN FIRST OUT (LIFO) data structure.

1.0 Introduction to Stack

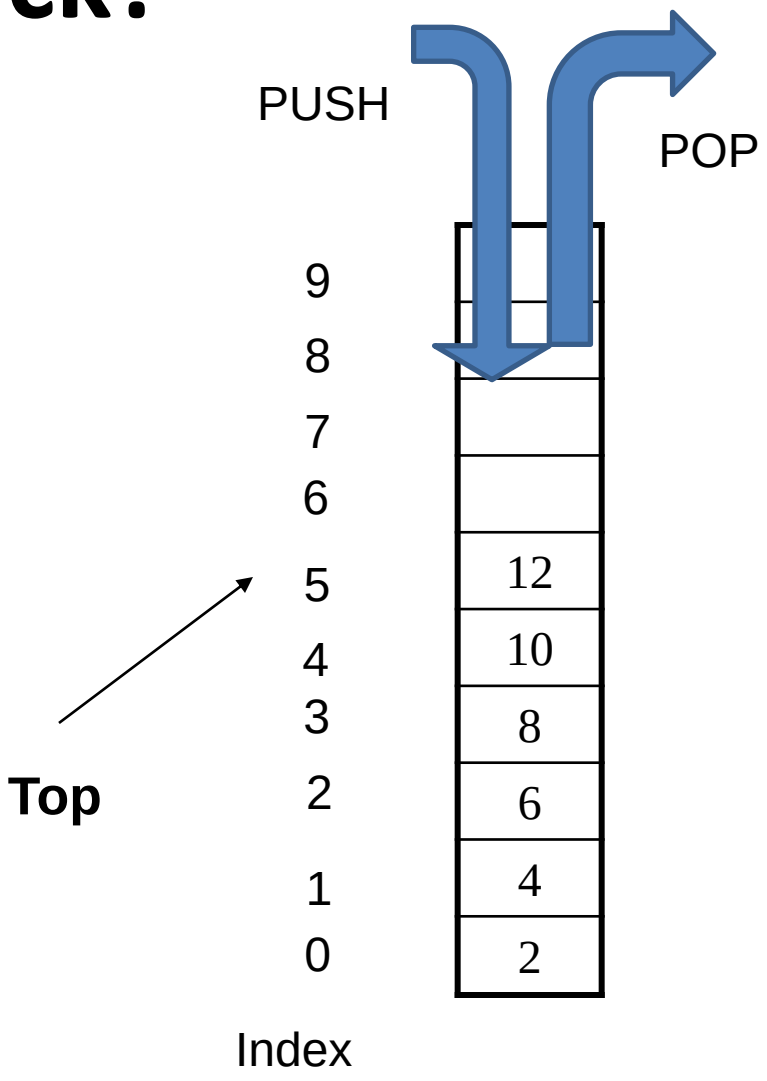
Example of Stack

- Long and narrow driveway
  - Gen2 comes in first, Exora follows, Pesona enters in last.
  - When the cars come out, Pesona comes out first, then Exora follows, and Gen2 comes out last.
- Reverse a string

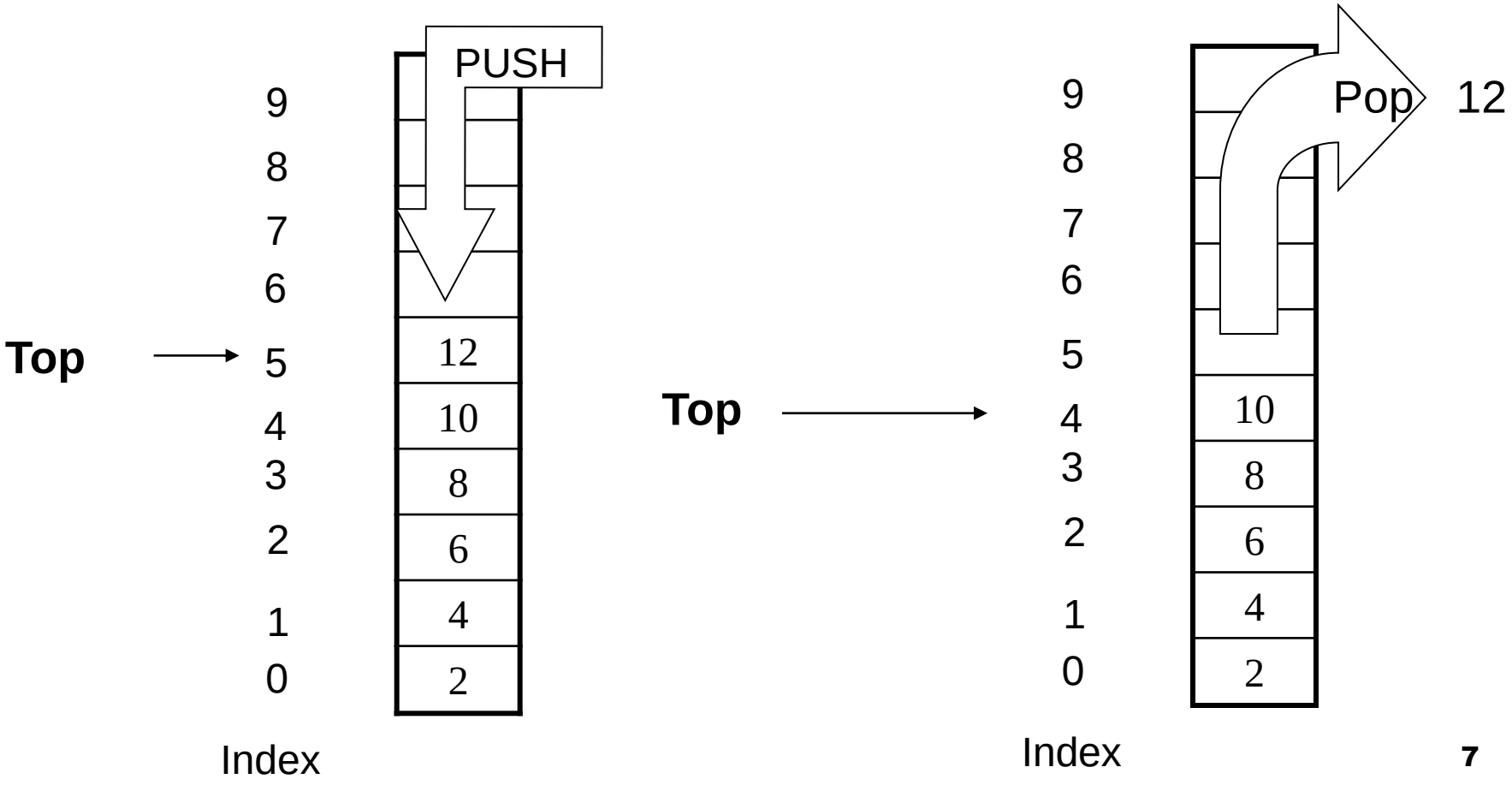
  Example: TOP , Reverse: POT
- Brackets balancing in compiler
- Page-visited history in a Web browser
- Undo operation in many editor tools
- Check nesting structure

What Is Stack?

- Stack is an abstract data type
- Adding an entry on the top (push)
- Deleting an entry from the top (pop)
- A stack is open at one end (the top) only. You can push entry onto the top, or pop the top entry out of the stack.



Last-in First-out (LIFO)



Stack implementation

- Stack is an abstract data structure
- Item can be Integer, Double, String, and also can be any data type, such as Employee, Student…
- How to implement a general stack for all those types?
- We can implement stack using array or linked list.

Implementation for Stack

Array

- **Size of stack is fixed during declaration**
- Item can be pushed if there is some space available, need isFull( ) operations.
- Need a variable called, top to keep track the top of a stack.
- Stack is empty when the value of Top is –1.

Linked List

- **Size of stack is flexible**. Item can be pushed and popped dynamically.
- Need a pointer, called top to point to top of stack.

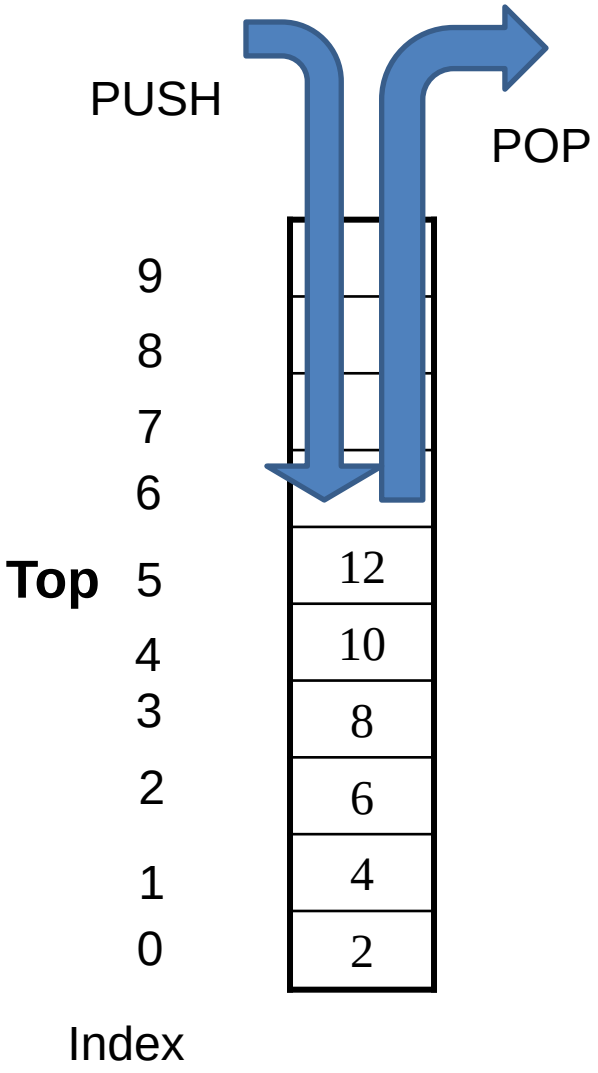
2.0 Array Implementation of Stack

Array Implementation of Stack

Stack Operations:

- createStack()
- push(item)
- pop( )
- isEmpty( )
- isFull( )
- stackTop()

"Stack can be visualized as array, BUT the operations can be done on top stack only. "



Array Implementation of Stack

3 things to be considered for stack with array

1. **Stack Empty :** when top is -1.
2. **Push operations:** To insert item into stack

   2 statements must be used

   ```
   top = top + 1;
   stack[top] = newitem;
   ```

3. **pop operations:** To delete item from stack.

   2 statements should be used

   Item = stack[top]; or stackTop();

   top = top – 1;

- `Item = stack[top];` statement is needed if we want to check the value to be popped.

Array Implementation of Stack

Stack declaration:

```
const int size = 100;
class stack
{
  private : // data declaration
    int top ;
    char data[size] ;
  public : // function declaration
  void createStack();
  void push(char) ;    // insert operation
  void pop() ;     // delete operation
  char stackTop() ; // get top value
  bool isFull() ;  // check if stack is Full
  bool isEmpty();  // check if stack is empty
} ;
```

Array Implementation of Stack

- We need two data attributes for stack:
  1. **Data :** to store item in the stack, in this example data will store char value
  2. **top** : as index for top of stack, integer type
- Size of the array that store component of stack is 100. In this case, stack can store up to 100 char value.
- Declaration of stack instance:

  stack aStack;

Array Implementation of Stack

`createStack()` operation

- Stack will be created by initializing top to -1.
- `createStack()` implementation:

```
void stack:: createStack();
{
        top = -1;
}
```

- Top is **–1 :- means that there is no item being pushed into stack yet.**

Array Implementation of Stack

`isFull()` Operation

- This operation is needed ONLY for implementation of stack using array.
- In an array, size of the array is fixed and to create new item in the array will depend on the space available.
- This operation is needed before any push operation can be implemented on a stack.
- `bool isFull()` implementation

```
bool stack::isFull()
{
      return (top == size-1 );
}
```

- Since the size of the array is 100,
  `bool isFull()` will return ***true***, If top is 99 (100 – 1).
  `bool isFull()` will return *false*, if there is some space available, top is less than 100.

Array Implementation of Stack

`bool isEmpty()` operation

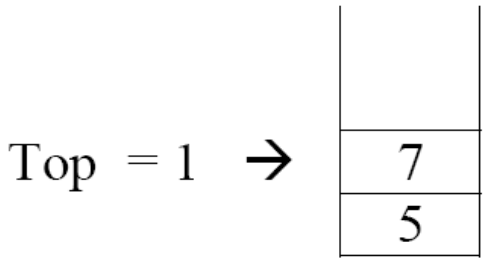
- This operation will check whether the array for stack is empty.
- This operation is needed before ANY pop operation can be done. If the stack is empty, then pop operation cannot be done.
- **`bool isEmpty()`** will return *true* if top –1 and return *false* if top is not equal to -1, showing that the stack has element in it.
- **`bool isEmpty()`** implementation :

```
bool stack::isEmpty()
{
      return ( top == -1 );
}
```

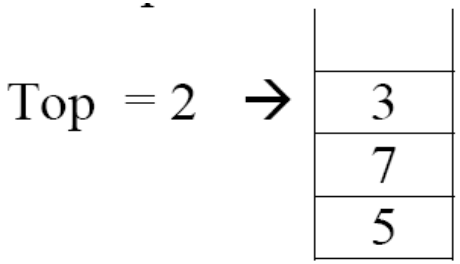
Array Implementation of Stack

`push(newItem)` operation : Insert item onto stack

- **push()** operation will insert an item at the top of stack. This operation can be done only if there is space availbale in the array
- Before any item can be inserted into a stack, isFull() operation must be called first.
- Insertion operation involve the following steps:
  - Top will be increased by 1.
    top = top + 1;
  - New item will be inserted at the top
    data[Top] = newItem;



before push()



after push()

Array Implementation of Stack

```
void stack::push(char newitem)
{
  if (isFull()) // check whether stack is full
    cout << "Sorry,Cannot push item.
              Stack is now full!"<< endl;
  else
  {  top = top + 1       // Top point to next index
     data[top] = newitem; //assign new item at top
  }//end else
}//end push()
```

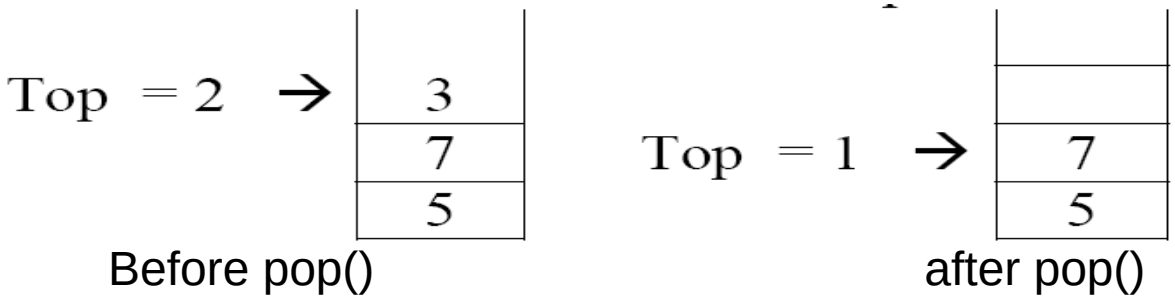
Top will be increased first before item is inserted in order to avoid inserting item at the current top value.

Array Implementation of Stack

`pop()` Operation

- This operation will delete an item at top of scak.
- Function `isEmpty()` will be called first in order to ensure that there is item in a stack to be deleted.
- `pop()` operation will decrease the value of top by 1:

```
top = top - 1;
```



Before pop()

after pop()

Array Implementation of Stack

```
void stack::pop()
{
   char item;
   if ( isEmpty() )
        cout << "Sorry, Cannot pop item.
                        Stack is empty!" << endl;
   else
   { //display value at top to be deleted
        cout << "Popped value :" << data[top];
        top = top - 1;
         // top will hold to new index
   }// end if
}//end pop
```

Array Implementation of Stack

`stackTop()` operation : to get value at the top

```
char stackTop()
{ //function to get top value
   if (isEmpty())
      cout <<"Sorry, stack is empty!"<< endl;
   else
      return data[top];
 } // end stackTop
```

3.0 Linked List Implementation of Stack

Linked List Implementation of Stack

- Stack implemented using linked list – number of elements in stack is not restricted to certain size.
- Dynamic memory creation, memory will be assigned to stack when a new node is pushed into stack, and memory will be released when an element being popped from the stack.
- Stack using linked list implementation can be empty or contains a series of nodes.
- Each node in a stack must contain at least 2 attributes:
- i) **data** – to store information in the stack.
- ii) pointer next (store address of the next node in the stack

Linked List Implementation of Stack

Basic operations for a stack implemented using linked list:

- **`createStack()`** – initialize top
- **`push(char)`** – insert item onto stack
- **`pop()`** – delete item from stack
- **`isEmpty()`** – check whether a stack is empty.
- **`stackTop()`** – get item at top

`isFull()` operation is not needed since elements can be inserted into stack without limitation to the stack size.

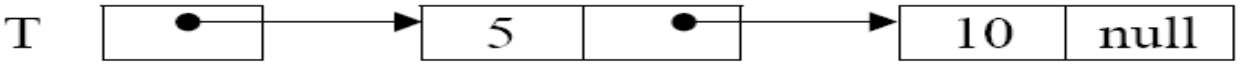
- Push and pop operations can only be done at the top ~ similar to add and delete in front of the linked list.

Linked List Implementation of Stack: push() and pop() operations

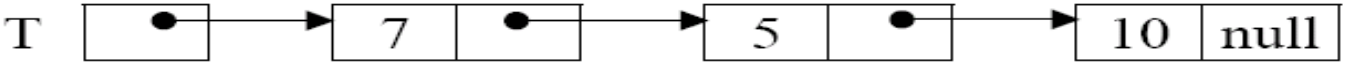
Create stack

Push : 10

Push : 5



Push : 7



Pop :

Pop

Linked List Implementation of Stack

```
class nodeStack
{
   int data;
   nodeStack *next;
};
class stack
{
   private: // pengisytiharan ahli data
      nodeStack *top;
   public : // pengisytiharan ahli fungsi
      void createStack(); // set Top to NULL
      void push(int) ; // insert item into stack
      void pop() ; // delete item from stack
      int stackTop() ; // get content at top stack
      bool isEmpty(); // check whether stack is empty
};
```

Create Stack and isEmpty()

- Creating a stack will initialize top to NULL - showing that currently, there is no node in the stack.

```
void stack::createStack()
{
    top = NULL;
}
```

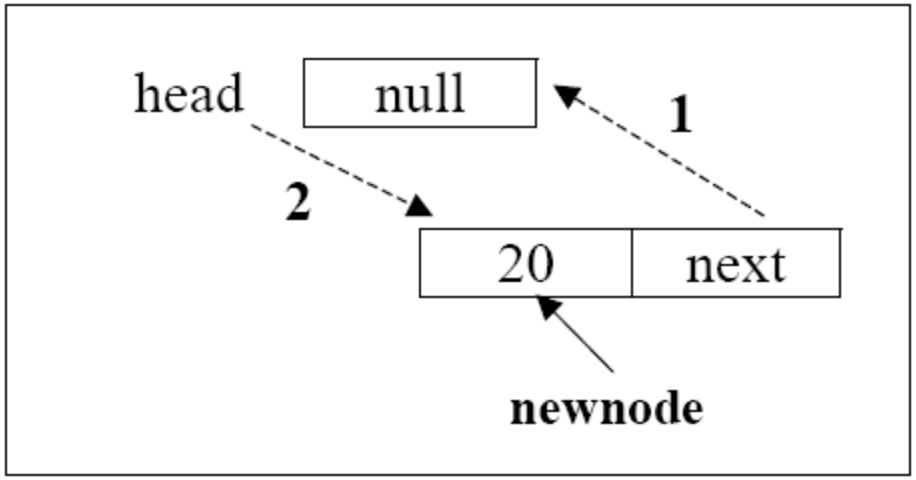
- Is Empty() stack will return true if stack is empty, top is NULL.

```
bool stack::isEmpty()
{
 return (top == NULL);
}
```

`push()` operations

- 2 conditions for inserting element in stack:
  - Insert to empty stack.
  - Insert item to non empty stack : stack with value.

`push()` to empty stack



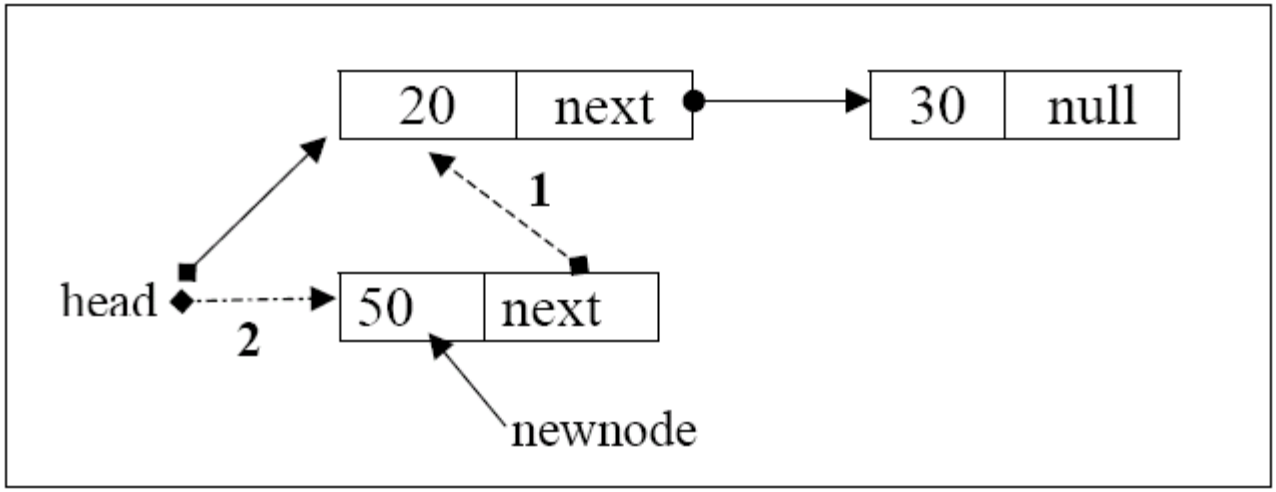
In this situation the new node being inserted, will become the first item in stack.

STEP 1 : newnode-> next = head;

STEP 2 : head = newnode;

`push()` to non-empty stack

This operation is similar to inserting element in front of a linked list. The next value for the new element will point to the top of stack and head will point to the new element.



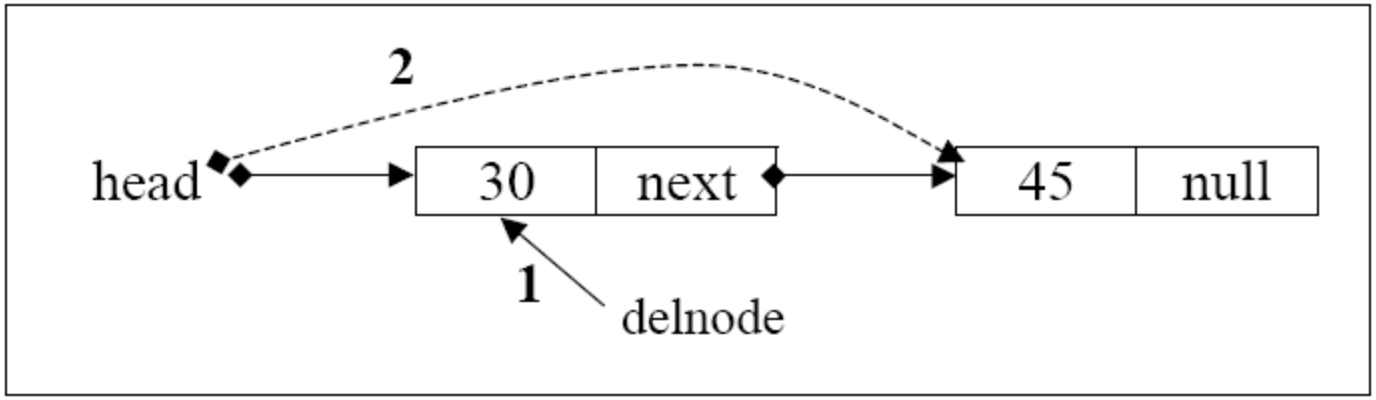
STEP 1 : newnode-> next = head;
STEP 2 : head = newnode;

Push() operations

```
void stack::push(int newitem)
{ // create newnode
  nodeStack *newnode;
  newnode = new (nodeStack);
  if( newnode == NULL)
     cout << "Cannot allocate memory…" << endl;
  else // add to empty stack, or to front stack
  { newnode->data = newitem;
    newnode->next = head;
    head = newnode;
  }// end if
} //end push operation
```

Delete item from stack (pop)

- Pop operation can only be done to non-empty stack. Before pop() operation can be done, operation must be called in order to check whether the stack is empty or there is item in the stack. If **`isEmpty()`** function return true, pop() operation cannot be done.
- During pop() operation, an external pointer is needed to point to the delete node. In the figure below, **`delnode`** is the pointer variable to point to the node that is going to be deleted.



STEP 1 : delnode = head;
STEP 2 : head = delnode -> next; or **head = head->next;**
STEP 3 : delete(delnode);

Pop() operation

```
void stack::pop()
{  nodeStack *delnode;
   if (isEmpty())
     cout <<"Sorry, Cannot pop item from
          stack.Stack is still empty!" <<endl;
   else
   {  delnode = head;
     cout << "Item to be popped from stack
                 is: " << stackTop()<<endl;
      head = delnode->next;
      delete(delnode);
    }// end else
} // end pop
```

Check item at top stack

```
int stack::stackTop()
{  if (isEmpty())
     cout <<"Sorry,Stack is still empty!"
          <<endl;
   else
      return head->data;
} // end check item at top
```

End of Stack Implementation

What we have learned so far….

- Stack is a LIFO data structure
- Can be implemented using array and link list
- Structure of a stack using array and link list
- Basic Operation for a stack
  - `createStack(),Push(),Pop()`
  - `stackTop(),isEmpty(),isFull()`