CS350: Data Structures

Stacks

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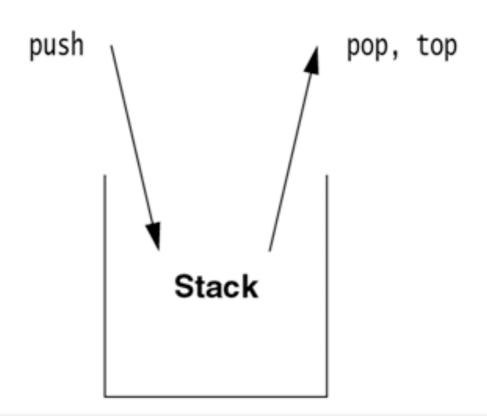


Stacks

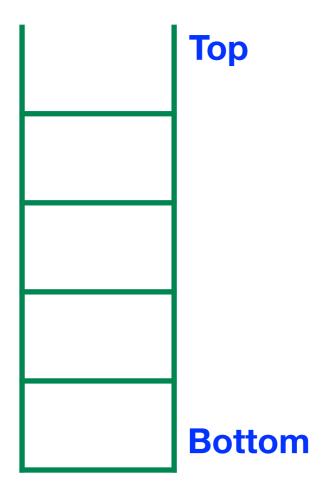
- Stacks are a very common data structure that can be used for a variety of data storage purposes
- Similar to a stack of papers sitting on a table ...
 - Items can be placed on the stack of papers
 - You can take a look at whats on the top of your stack of papers
 - Items can be removed from the top of your stack of papers
 - If you want a paper in the middle of the stack, you must remove the papers on top to get to the paper in the middle
- May also be referred to as a LIFO (Last-In-First-Out)

Stacks have three main operations

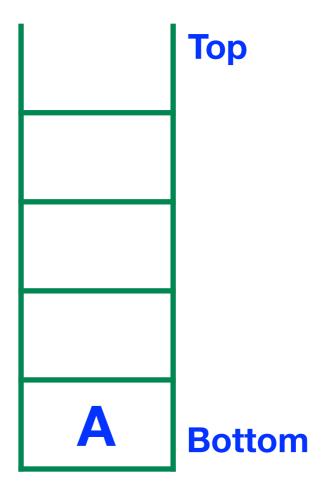
- Push puts an element on the top of the stack
- Pop removes a single element from the top of the stack
- Top or Peek returns the value of the element on the top of the stack (without removing it)



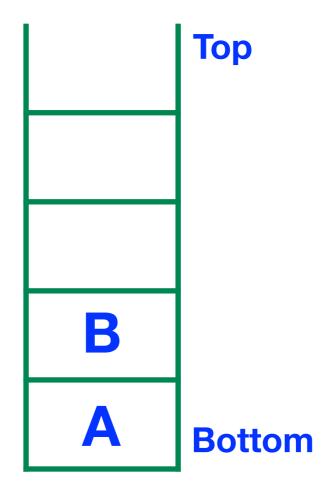
Start with Empty Stack



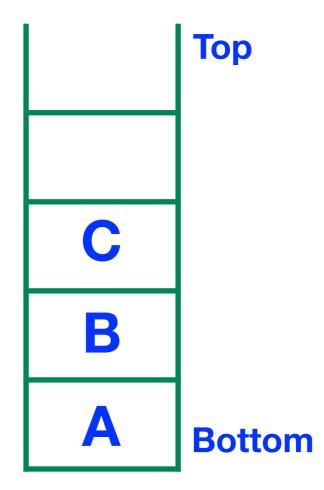
Insert Value: A



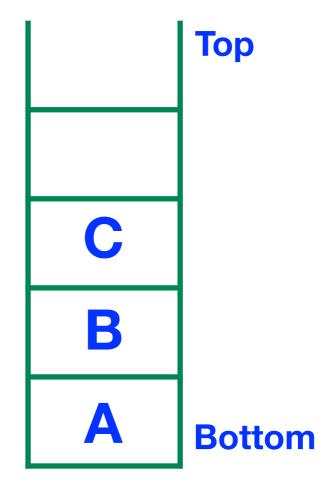
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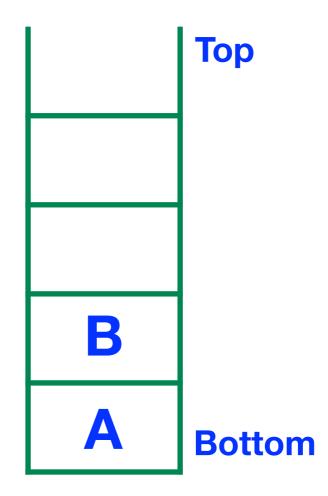
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Pop the Top of the Stack:



Pop the Top of the Stack:



A Stack Interface in Java

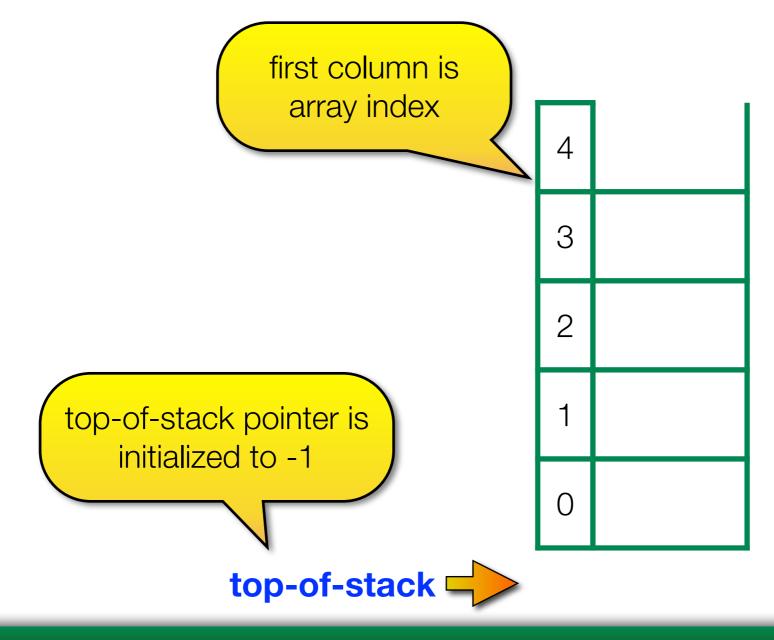
```
public interface Stack<AnyType> {
    public void     push( AnyType x );
    public AnyType pop();
    public AnyType peek();
    public boolean isEmpty();
    public void     makeEmpty();
}
```

Stack Implementations

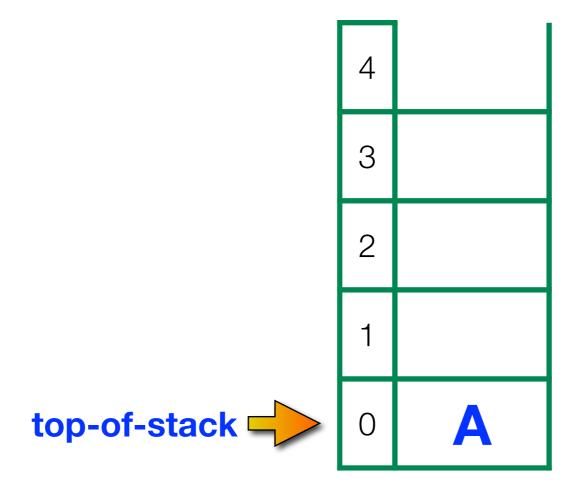
- Stacks can be implemented in multiple ways
- Two popular methods for implementing stacks include
 - (1) Arrays
 - (2) Linked Lists

 Both of these implementation approaches allow for constant time operations - O(1)

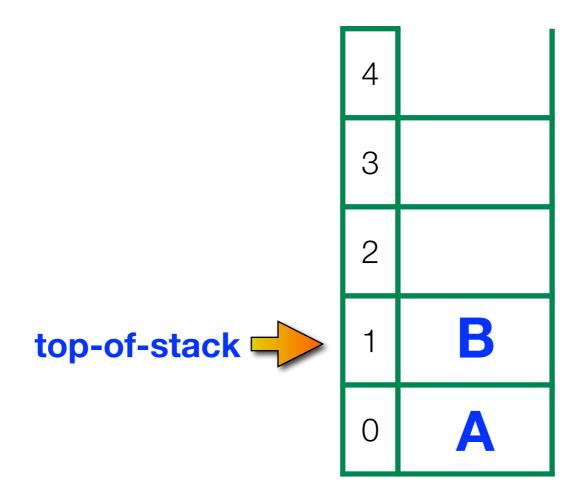
Start with Empty Stack (i.e. an array)



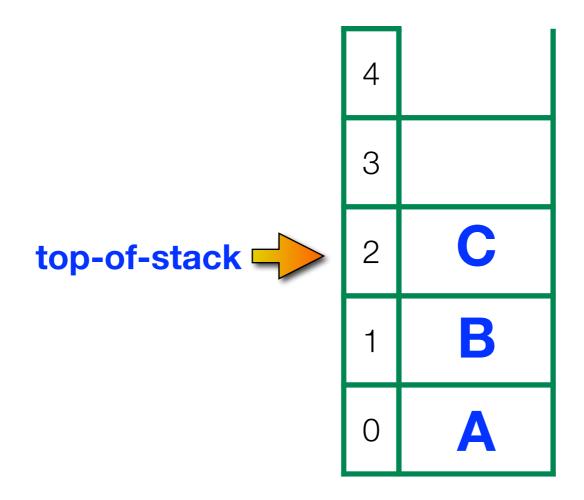
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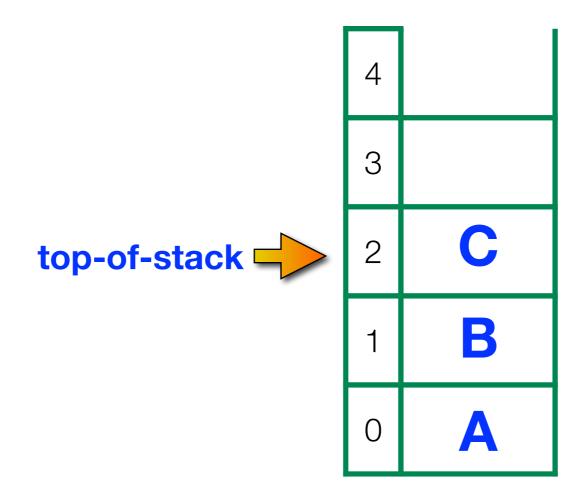
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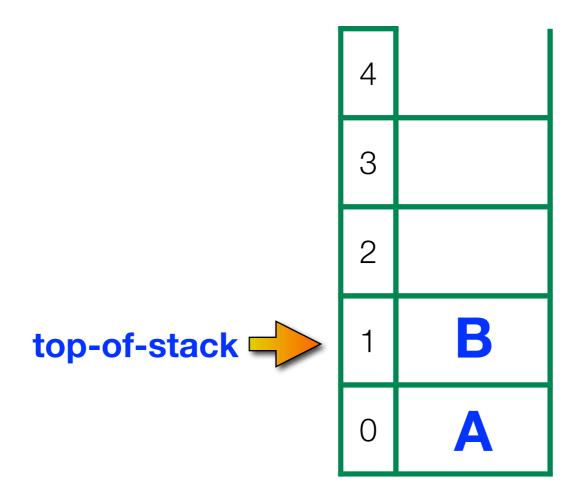
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Pop the Top of the Stack:



Pop the Top of the Stack:



Considerations when using an array implementation

- Push, Pop, and Peek operations all run in constant time ... in most cases
- What happens when your array is full and you want to Push another element?
 - Array must be increased in size which takes time an more memory

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- Time to copy and create new array is O(N)
- Time to copy array is amortized over the lifetime of the array
- May not be suitable for all types of systems (e.g. RTOS)

```
/**
  * Stack constructor
  */
public ArrayStack( )
{
    theArray = (AnyType []) new Object[ DEFAULT_CAPACITY ];
    topOfStack = -1;
}
```

```
/**
 * Test if the stack is logically empty.
 * @return true if empty, false otherwise.
 */
public boolean isEmpty()
{
   return topOfStack == -1;
}
```

```
/**
  * Make the stack logically empty.
  */
public void makeEmpty( )
{
    topOfStack = -1;
}
```

```
**
 * Insert a new item into the stack.
 * @param x the item to insert.
 */
public void push( AnyType x )
{
   if( topOfStack + 1 == theArray.length )
      doubleArray( );
   theArray[ ++topOfStack ] = x;
}
```

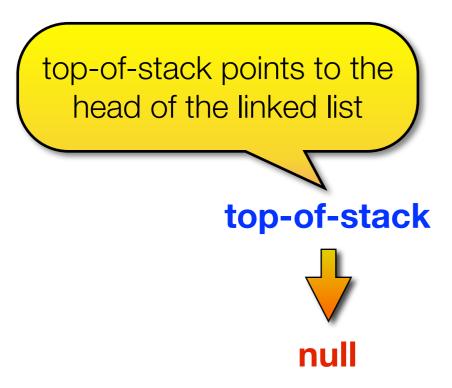
```
/**
 * Remove the most recently inserted item from the stack.
 * @throws UnderflowException if the stack is empty.
 */
public void pop()
{
   if( isEmpty( ) )
      throw new UnderflowException( "ArrayStack pop" );
   topOfStack--;
}
```

```
/**
 * Get the most recently inserted item in the stack.
 * Does not alter the stack.
 * @return the most recently inserted item in the stack.
 * @throws UnderflowException if the stack is empty.
 */
public AnyType peek( )
{
   if( isEmpty( ) )
      throw new UnderflowException( "ArrayStack top" );
   return theArray[ topOfStack ];
}
```

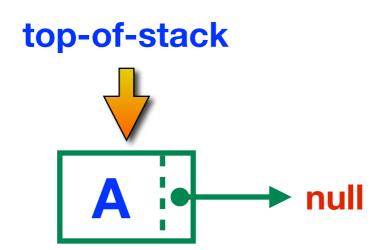
```
/**
 * Internal method to extend theArray.
 */
private void doubleArray( )
{
    AnyType [] newArray;

    newArray = (AnyType []) new Object[ theArray.length * 2 ];
    for( int i = 0; i < theArray.length; i++ )
        newArray[ i ] = theArray[ i ];
    theArray = newArray;
}</pre>
```

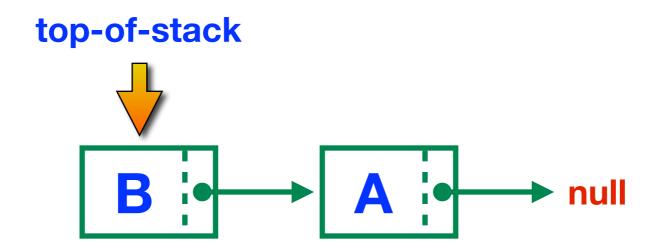
Start with Empty Stack (i.e. a null LinkedList)



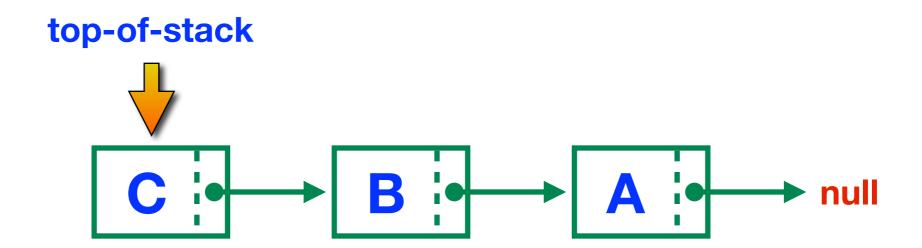
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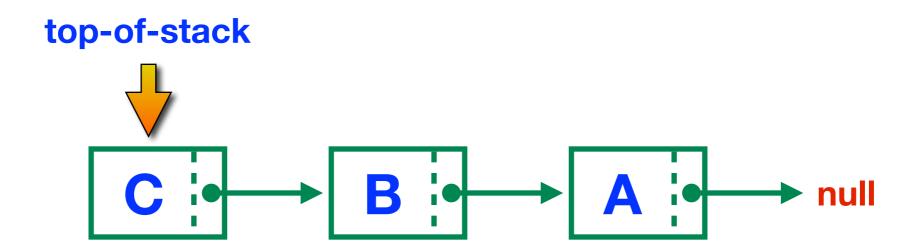
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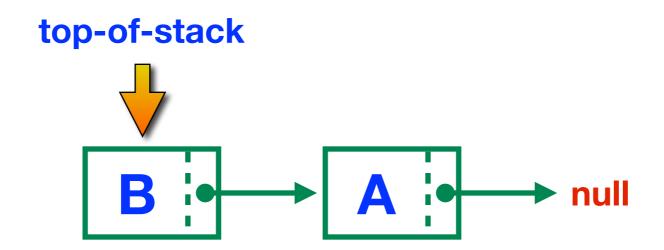
Insert Value: C



Pop the Top of the Stack:



Pop the Top of the Stack:



Considerations when using a LinkedList implementation

- Push, Pop, and Peek operations all run in constant time ... still
- Each element inserted into the stack requires a pointer to the data and a second pointer to the next node in the LinkedList

```
/**
  * Stack constructor
  */
public ListStack( )
{
    topOfStack = null;
}
private ListNode<AnyType> topOfStack;
```

```
/**
 * Test if the stack is logically empty.
 * @return true if empty, false otherwise.
 */
public boolean isEmpty()
{
   return topOfStack == null;
}
```

```
/**
  * Make the stack logically empty.
  */
public void makeEmpty( )
{
    topOfStack = null;
}
```

```
**
 * Insert a new item into the stack.
 * @param x the item to insert.
 */
public void push( AnyType x )
{
    topOfStack = new ListNode<AnyType>( x, topOfStack );
}
```

```
/**
  * Remove the most recently inserted item from the stack.
  * @throws UnderflowException if the stack is empty.
  */
public void pop()
{
    if( isEmpty( ) )
        throw new UnderflowException( "ListStack pop" );
    topOfStack = topOfStack.next;
}
```

```
/**
 * Get the most recently inserted item in the stack.
 * Does not alter the stack.
 * @return the most recently inserted item in the stack.
 * @throws UnderflowException if the stack is empty.
 */
public AnyType peek()
{
   if( isEmpty( ) )
      throw new UnderflowException( "ListStack top" );
   return topOfStack.element;
}
```

Example Applications for Stacks

Postfix expression evaluation

- Checking for balanced delimiters
 - Balancing parenthesis/braces in a programming languages