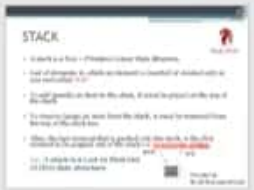

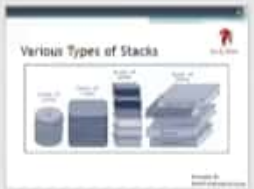

1

Study Point

Data Structures & Algorithms
Stack & its Applications

Presented By:

Sh. Muhammad Aamir
Lecturer
Department of Computer Science
GC University, Faisalabad

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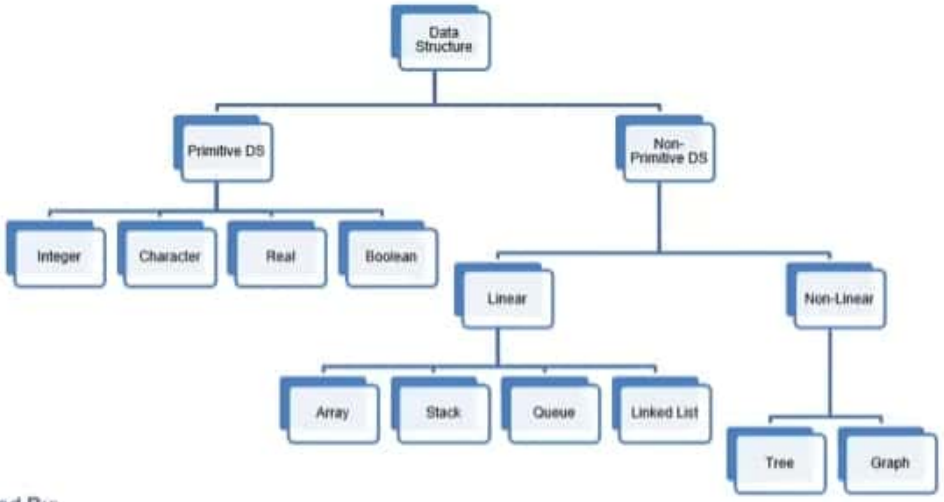
Classification of Data Structures

Study Point



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Sheikh Muhammad Aamir

1 Data Structures & Algorithms Stack & its Applications
2 Classification of Data Structures
3 STACK
4 Various Types of Stacks
5 LIFO

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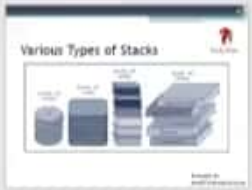
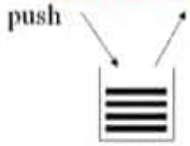


STACK

Study Point

- A stack is a Non – Primitive Linear Data Structure
- List of elements in which an element is inserted or deleted only at one end called TOP
- To add (**push**) an item to the stack, it must be placed on the top of the stack.
- To remove (**pop**) an item from the stack, it must be removed from the top of the stack too.
- Thus, the last element that is pushed into the stack, is the first element to be popped out of the stack i.e. **in reverse order**.

i.e., **A stack is a Last In First Out (LIFO) data structure**



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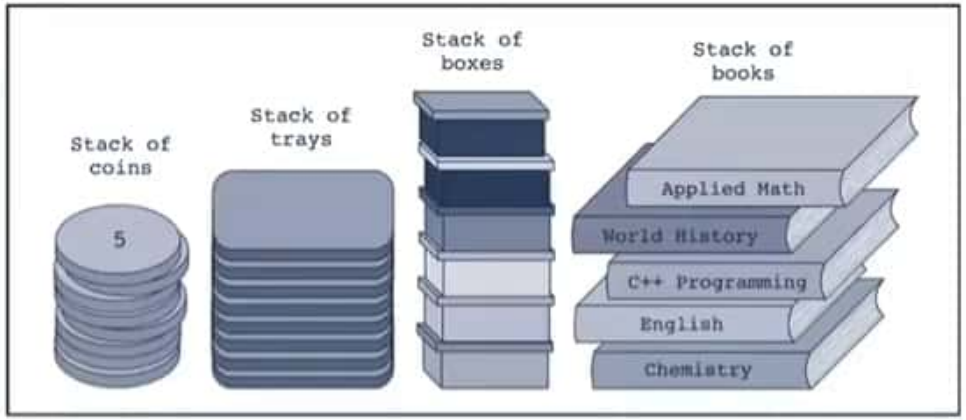
Various Types of Stacks

Study Point



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LIFO

Study Point

- Last In First Out (LIFO) data structure
  - Top element of stack is first element to be removed from stack
  - Elements added and removed from one end (top)

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3 STACK
4 Various Types of Stacks
5 LIFO
6 Postponed Decisions
7 Postponed Decisions...

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Postponed Decisions

- Stacks are frequently used to indicate the order of the processing of data when certain steps of the processing must be postponed until other conditions are fulfilled.

- Suppose we are working on Project–A, while working we need working on Project–B in order to complete the Project–A. Then we place the folder containing the data of A onto a Stack and begin to process Project–B. However, suppose that while processing Project–B we led to Project–C, for the same reason and similar process for Project–D.

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Postponed Decisions...

Study Point

- On the other hand, suppose we are able to complete the processing of D. Then the only project we may continue to process is Project–C, which is on the top of the Stack. Hence, we remove C from the stack and continue to process C.

- Similarly, after completing the processing of C, we remove B from the stack and continue the process B. Finally, after completing the processing of B, we remove the last folder of A from the stack, leaving the Stack empty and continue the processing of our original Project–A.

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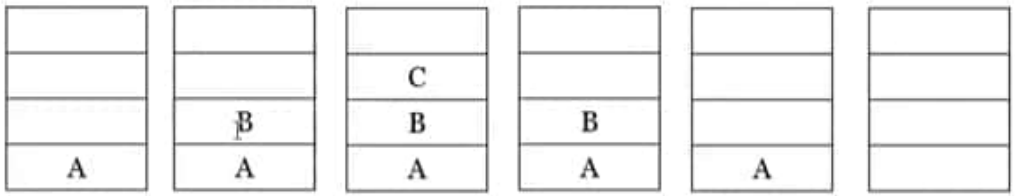
Postponed Decisions...

Study Point



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Study Point

Postponed Decision...

$n! = n\,(n-1)!$

$(n-1)! = (n-1)\,(n-2)!$

$4! = 4\,(4-1)! = 4 * 3!$

$3! = 3\,(3-1)! = 3 * 2!$

$2! = 2\,(2-1)! = 2 * 1!$

$1! = 1$

$2! = 2 * 1 = 2$

$3! = 3 * 2 = 6$

$4! = 4 * 6 = 24$

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Operations on Stack

Study Point

- Push operation for Insertion
- Pop operation for Deletion

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Push Method

Study Point

- push() method adds an element at the top the stack.
- It takes as argument an Object to be pushed.

- It first checks if there is room left in the stack. If no room is left, it throws an exception. Otherwise, it puts the object into the stack array, by incrementing TOP variable by one.

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Pop Method

Study Point

- The pop method removes an item from the stack and returns that item.
- The pop method first checks if the stack is empty. If the stack is empty, it throws an exception like Stack is empty. Otherwise, it simply decreases TOP by one and returns the item found at the top of the stack.

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Array Representation of Stacks

Study Point

- Stack is maintained by a linear array, an indicator TOP, which contains the location of top element of the stack; and a variable N which represent the maximum size of array STACK.
- The TOP = 0 or TOP = NULL will indicate that the stack is empty.

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Another Example of Stack

Study Point

Stack with size N = 7
TOP = 0 (indicates the Stack is empty)

1	2	3	4	5	6	7

PUSH(25)
TOP

1	2	3	4	5	6	7
25						

PUSH(10)
PUSH(50)
PUSH(75)

TOP

1	2	3	4	5	6	7
25	10	50	75			

Stack operations using array...

Study Point

POP( ) [returns 75 from TOP]

TOP

1	2	3	4	5	6	7
25	10	50				

POP( ) [returns 50 from TOP]

TOP

1	2	3	4	5	6	7
25	10					

PUSH(55) [insert 55 into the stack]

TOP

1	2	3	4	5	6	7
25	10	55				

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Push Procedure

Study Point

Push (STACK, TOP, X, N)

1. If TOP > = N Then [Is stack already filled ?]
   Write : Stack is Full
   Else:
   Set TOP := TOP +1 [Increasing TOP by 1]
   Set STACK[TOP] := X [Insert X item at new TOP position]
   [End of If structure]
2. Return

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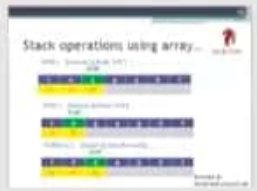

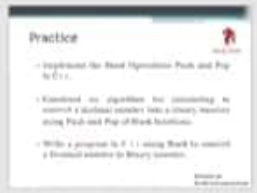

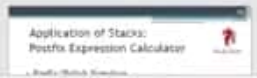

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Pop Procedure

Study Point

POP (STACK, TOP,N)

1. If TOP = 0 Then [Is stack already empty ?]
   Write: Stack Empty
   Return
   Else:
   Set X := STACK[TOP] [Assigns TOP element to X]
   Set TOP := TOP – 1 [TOP decreases by 1]
   Return X
   [end of if structure]

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Practice

Study Point

- Implement the Stack Operations Push and Pop in C++.
- Construct an algorithm for calculating to convert a decimal number into a binary number using Push and Pop of Stack functions.
- Write a program in C ++ using Stack to convert a Decimal number to Binary number.

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20


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22


23


Applications of Stack:

Arithmetic Expressions Solving

Study Point

- Let Q be an expression that contains
  - operands and operators
- Expression can be written in three format
  - Infix Notation
  - Prefix Notation
  - Postfix Notation
- Evaluation of Q by using reverse Polish (Postfix) notation
- Prefix Expression is known as Polish Notation
- Suffix/Postfix Expression is known as Reverse Polish Notation

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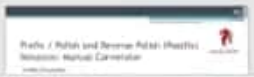

Study Point

Expressions

- Infix Notation

  e.g. A + B
- Prefix Notation (Polish Notation)

  e.g. + AB
- Postfix Notation (Reverse Polish Notation)

  e.g. AB +

Here A, and B are operands whereas + is an operator

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Operator Precedence

Study Point

- Highest: Exponentiation (^ , $, ↑)
- Next Highest: Multiplication (*) and Division (/)
- Lowest: Addition (+) and Subtraction (-)

- All these precedence for binary operations

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Expression Evaluation: Example

Study Point

$$2 \wedge 3 + 5 * 2 \wedge 2 - 12 / 6$$
$$= 8 + 5 * 4 - 12 / 6$$
$$= 8 + 20 - 2$$
$$= 28 - 2$$
$$= 26$$

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Prefix / Polish and Reverse Polish (Postfix) Notation: Manual Conversion

Study Point

Prefix Examples

A + B	(A + B) * C	A + (B*C)	(A+B) / (C – D)
=+AB	= +AB * C = *+ABC	= A + *BC = + A*BC	= +AB / -CD = /+AB-CD

Postfix Examples

A + B	(A + B) * C	A + (B*C)	(A+B) / (C – D)
=AB+	= AB+ * C = AB+C*	= A + BC* = ABC*+	= AB+ / CD- = AB+CD-/

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Manual Infix to Prefix and Postfix Conversion ...

Study Point

Infix Expression	Prefix Expression	Postfix Expression
(A+B) * (C-D)	= +AB * - CD	= AB+ * CD-
	= *+AB – CD	= AB+ CD- *
A + B * C – (D $ 2 * 3)	A +B * C – ($ D2 * 3)	A +B * C – (D2 $ * 3)
	=A +B * C – (*$ D2 3)	=A +B * C – (D2 $ * 3)
	=A + *B C – (*$ D2 3)	=A +B C * – D2 $ 3 *
	=+A *B C – *$ D2 3	=A B C * + – D2 $ 3 *
	= - +A *B C *$ D2 3	=A B C * + D2 $ 3 * -

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Study Point

For Practice

Convert Infix to Prefix and Postfix Notation Manually

1. A + B * (C + D) / F + D * E
2. (A + B) / C * D – E
3. 12 / (7 – 3) + 2 * (1 + 5)

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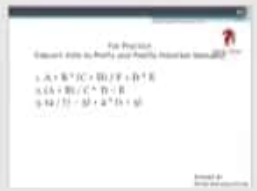

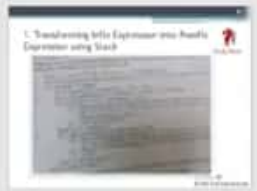

Expression Solving using STACK

Study Point

1. Infix to Postfix Conversion using STACK
2. Evaluation of Postfix Expression using STACK

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1. Transforming Infix Expression into Postfix Expression using Stack

Study Point

POLISH(Q, P)
Suppose Q is an arithmetic expression written in infix notation. This algorithm finds the equivalent postfix expression P.

1. Push "(" onto STACK, and add ")" to the end of Q.
2. Scan Q from left to right and repeat Steps 3 to 6 for each element of Q until the STACK is empty:
3. If an operand is encountered, add it to P.
4. If a left parenthesis is encountered, push it onto STACK.
5. If an operator ⊗ is encountered, then:
   (a) Repeatedly pop from STACK and add to P each operator (on the top of STACK) which has the same precedence as or higher precedence than ⊗.
   (b) Add ⊗ to STACK.
   [End of If structure.]
6. If a right parenthesis is encountered, then:
   (a) Repeatedly pop from STACK and add to P each operator (on the top of STACK) until a left parenthesis is encountered.
   (b) Remove the left parenthesis. [Do not add the left parenthesis to P.]
   [End of If structure.]
[End of Step 2 loop.]

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Transforming Infix Expression into Postfix Expression using Stack : Example

- Infix Expression will be as : A * (B + C) –D / E)

Study Point

Now reading last symbol

Sr.	Scanned Symbol	STACK	Expression P
1		(	
2	A	(	A
3	*	(*	A
4	(	(* (	A
5	B	(* (	A B
6	+	(* (+	A B
7	C	(* (+	A B C
8	)	(*	A B C +
9	-	(-	A B C + *
10	D	(-	A B C + * D
11	/	(- /	A B C + * D
12	E	(- /	A B C + * D E
13	)		A B C + * D E / -

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Transforming Infix Expression into Postfix Expression using Stack: Practice Questions

Study Point

1. A / B – C + D * E – A * C
2. (A + B) / C * D – E
3. A + B * (C ^ D – E)
4. (A – B) * (A + B)
5. 2 * 3 + 5 * 4 - 9

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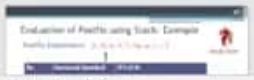

Expression Solving using STACK

Study Point

1. Infix to Postfix Conversion using STACK
2. Evaluation of Postfix Expression using STACK

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2. Evaluation of a Postfix Expression using Stack

Study Point

This algorithm finds the VALUE of an arithmetic expression P written in postfix notation.

1. Add a right parenthesis ")" at the end of P [This acts as a sentinel.]
2. Scan P from left to right and repeat Steps 3 and 4 for each element of P until the sentinel ")" is encountered.
3. If an operand is encountered, put it on STACK.
4. If an operator ⊗ is encountered, then:
   (a) Remove the two top elements of STACK, where A is the top element and B is the next-to-top element.
   (b) Evaluate B ⊗ A.
   (c) Place the result of (b) back on STACK.
   [End of If structure.]
   [End of Step 2 loop.]
5. Set VALUE equal to the top element on STACK.
6. Exit

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Evaluation of Postfix using Stack: Example

Study Point

Infix Expression (Q): 5*(6+2)-(12/4)

Postfix Expression (P): 5 , 6, 2, +, *, 12, 4, /, -

Step 1: Place) at the end of P

Postfix Expression (P): 5 , 6, 2, +, *, 12, 4, /, -,)

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Evaluation of Postfix using Stack: Example

Postfix Expression: 5 , 6, 2, +, *, 12, 4, /, -,)

Sr.	Scanned Symbol	STACK
1	5	5
2	6	5, 6
3	2	5, 6, 2
4	+	5, 8
5	*	40
6	12	40, 12
7	4	40, 12, 4
8	/	40, 3
9	-	37
10	)	

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Evaluation of Postfix Expression using Stack: Practice Questions

Study Point

1. 2, 3, 1, *, +, 9, -
2. 7, 2, 3, *, 5, +, 8, 4, 2, /, -, *, -
3. A, B, C, D, 2, ^, *, +, 3, +, +

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