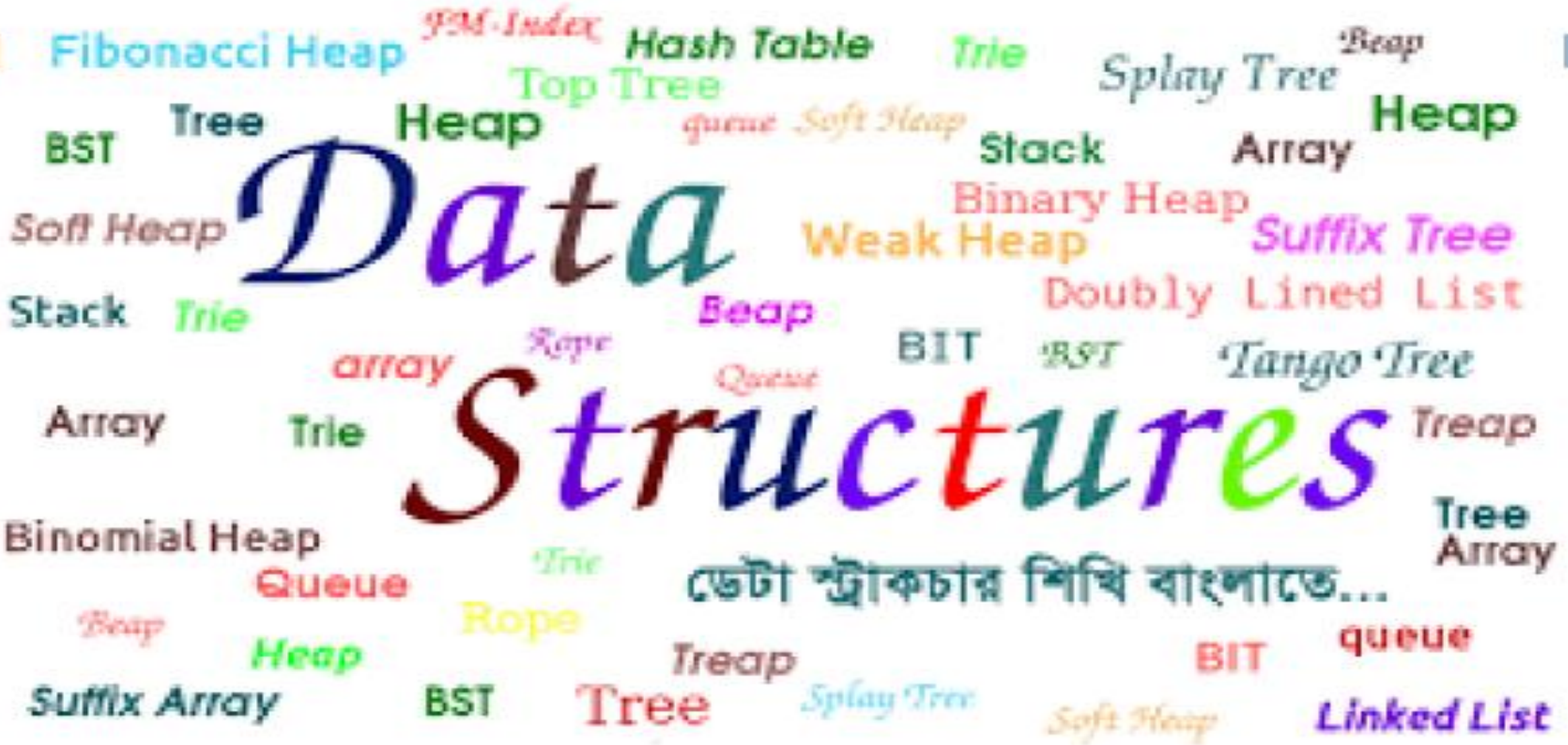

Data
Structures
Fibonacci Heap
FM-Index
Hash Table
Trie
Beap
Splay Tree
Top Tree
Tree
Heap
BST
queue
Soft Heap
Stack
Array
Heap
Binary Heap
Soft Heap
Weak Heap
Suffix Tree
Doubly Lined List
Stack
Trie
Beap
Rope
BIT
BST
Tango Tree
array
Queue
Array
Trie
Treap
Tree
Array
Binomial Heap
Trie
ডেটা স্ট্রাকচার শিখি বাংলাতে...
Queue
Beap
Rope
Heap
Treap
BIT
queue
Suffix Array
BST
Tree
Splay Tree
Soft Heap
Linked List

LECTURE NO. 8: APPLICATIONS ON STACK

- Application of stack
- Expression Evaluation.
- Postfix Evaluation
- Infix to Postfix Conversion

Stack Application

Stack applications

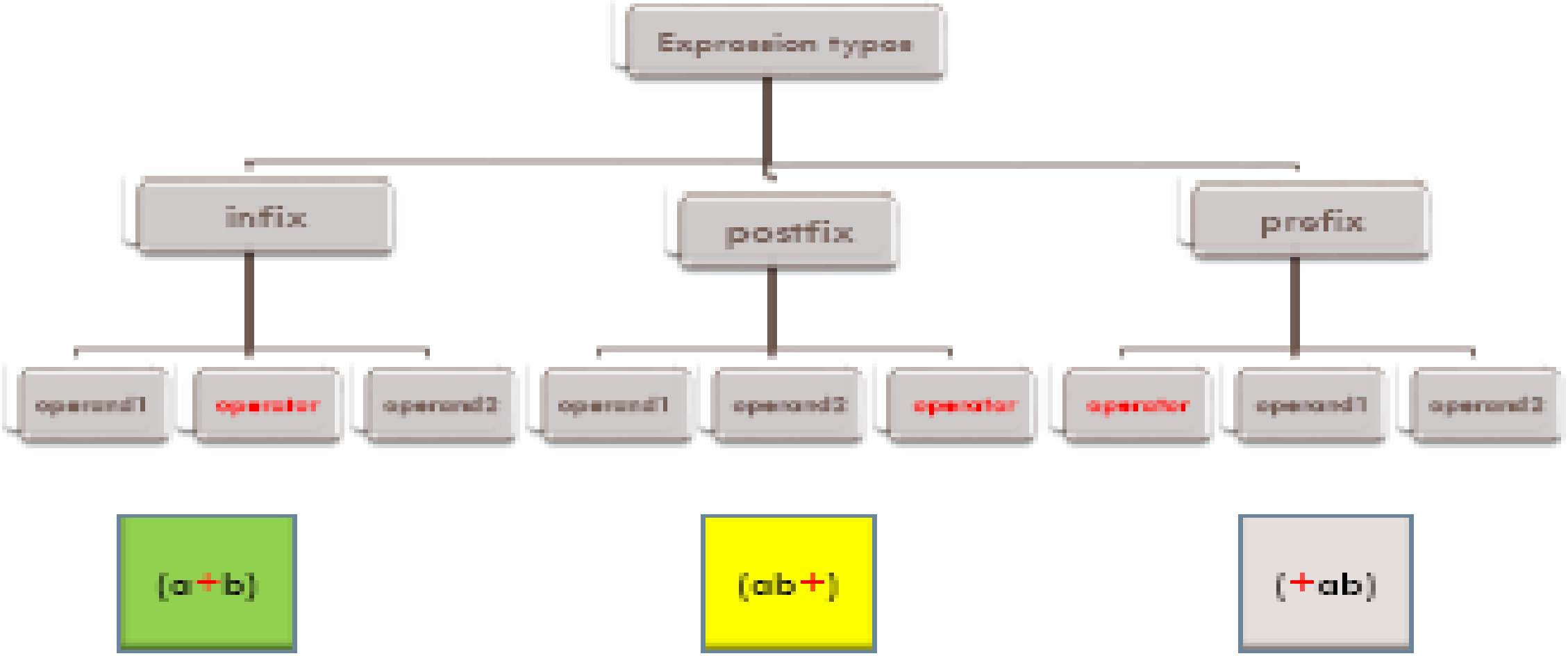
- Balancing symbols
- Expression evaluation
- Reversal of sequences.
- Backtracking (game playing, finding paths, exhaustive searching)
- Function calls
- Page-visited history in a Web browser.
- Undo sequence in a text editor.

Expression evaluation

What is an Expression

- An expression is a collection of operators and operands that represents a specific value.
- An operator is a symbol which performs a particular task like arithmetic operation or logical operation or conditional operation etc.
- Operands are the values on which the operators can perform the task. Here operand can be a direct value or variable or address of memory location.

Expression types



Expression Conversion

- We can also convert one type of expression to another type of expression like Infix to Postfix, Infix to Prefix, Postfix to Prefix.

- Infix postfix prefix

A+B-C AB+C- -+ABC

Expression Conversion rules

- To convert any Infix expression into Postfix or Prefix expression we can use the following procedure:

1) Find all the operators in the given Infix Expression.
2) Find the order of operators evaluated according to their Operator precedence.
3) Convert each operator into required type of expression (Postfix or Prefix) in the same order.

Expression Conversion Example

Consider the following Infix Expression to be converted into Postfix Expression.

A + B * C

Step 1: The Operators in the given Infix Expression : +, *

Step 2: The Order of Operators according to their preference : * ,+

Step 3: Now, convert the first operator *

A + B C *

Step 4: Convert the next operator +

A BC* +

Infix to postfix Conversion

- The rules to be remembered during infix to postfix conversion are:

1.Parenthesize the expression starting from left to light.

2. During parenthesizing the expression, the operands associated with operator having higher precedence are first parenthesized.

3. The sub-expression (part of expression), which has been converted into postfix, is to be treated as single operand.

4. Once the expression is converted to postfix form, remove the parenthesis.

Infix to postfix Conversion

- To rewrite A+B*C in postfix:

infix form	A+B*C
1. parentheses for emphasis	A+(B*C)
2. convert the multiplication	A+(BC*)
3. convert the addition	A(BC*)+
postfix form	ABC*+

- To rewrite(A+B)*C in postfix

infix form	(A+B)*C
1. convert the addition	(AB+)*C
2. convert the multiplication	(AB+)C*
postfix form	AB+C*

Infix to postfix Conversion

- Example: infix expression to the postfix exp.

(A + B) * C / D + E ^ A / B

- Solution

[(A + B) * C / D] + [E ^ A / B]

[(AB+)*C/D]+[(EA^)/B]

[(AB+)*C/D]+[(EA^)B/]

[(AB+)C*D/]+[(EA^)B/]

(AB+)C*D/(EA^)B/+

AB+C*D/EA^B/+

Infix to postfix Conversion

Infix	postfix
A+B	AB+
A+B-C	AB+C-
(A+B)*(C-D)	AB+CD-*
A^B*C-D+E/F/(G+H)	AB^C*D-EF/GH+/+
((A+B)*C-(D-E))^(F+G)	AB+C*DE--FG+^
A-B/(C*D^E)	ABCDE^*/-

Infix to prefix Conversion

Infix	prefix
A+B	+AB
A+B-C	-+ABC
(A+B)*(C-D)	*+AB-CD
A^B*C-D+E/F/(G+H)	+-*^ABCD//EF+GH
((A+B)*C-(D-E))^(F+G)	^-*+ABC-DE+FG
A-B/(C*D^E)	-A/B*C^DE

Infix to postfix algorithm(using stack)

- **Step 1** : Scan the Infix Expression from left to right.
- **Step 2** : If the scanned character is an operand, append it with final Infix to Postfix string.
- **Step 3** : Else,
  - **Step 3.1** : If the precedence order of the scanned(incoming) operator is greater than the precedence order of the operator in the stack (or the stack is empty or the stack contains a '(' or '[' or '{'), push it on stack.
- **Step 3.2** : Else, Pop all the operators from the stack which are greater than or equal to in precedence than that of the scanned operator. After doing that Push the scanned operator to the stack. (If you encounter parenthesis while popping then stop there and push the scanned operator in the stack.)

Infix to postfix algorithm(using stack)

- **Step 4** : If the scanned character is an '(' or '[' or '{', push it to the stack.
- **Step 5** : If the scanned character is an ')'or ']' or '}', pop the stack and output it until a '(' or '[' or '{' respectively is encountered, and discard both the parenthesis.
- **Step 6** : Repeat steps 2-6 until infix expression is scanned.
- **Step 7** : Print the output
- **Step 8** : Pop and output from the stack until it is not empty

Infix to postfix algorithm(using stack)

Input infix_str(infix expression)

Output postfix_str(postfix expression).

1. Push "(" onto stack, and add ")" to the end of infix_str(infix expression).

2. Scan infix_str from left to right and repeat Steps 3 to 6 for each element of P until the stack is empty.

3. If an operand is encountered, add it to postfix_str(postfix expression).

4. If a left parenthesis is encountered, push it onto stack.

Infix to postfix algorithm(using stack)

5. If an operator ⊗ is encountered, then:

   (*a*) Repeatedly pop from stack and add postfix_str each operator (on the top of stack), which has the same precedence as, or higher precedence than ⊗.

   (*b*) push ⊗ onto stack.

6. If a right parenthesis is encountered, then:

   (*a*) Repeatedly pop from stack and add it to postfix_str

   (on the top of stack until a left parenthesis is encountered.

   (*b*) Remove the left parenthesis. [Do not add the left parenthesis to postfix_str.]

Infix to postfix: example 1

infix expression: *A + B*

we have two elements,

An empty expression string *postfix_str*

An empty operator stack *stack_op*

1- *postfix_string* *A*

stack_op

2- *postfix_string* *A*

stack_op +

3- *postfix_string* *A B*

stack_op +

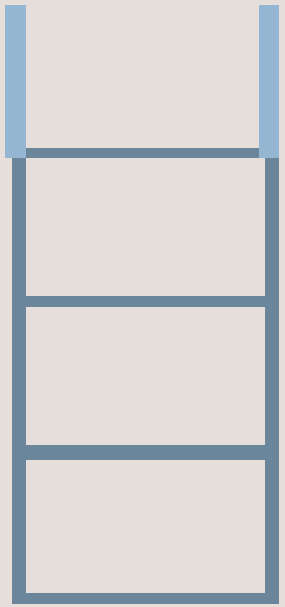
4- *pop* the *stack_op* and add element to *postfix_string*

postfix_string *A B+*

Infix to postfix Example2

- Consider the following Infix Expression...

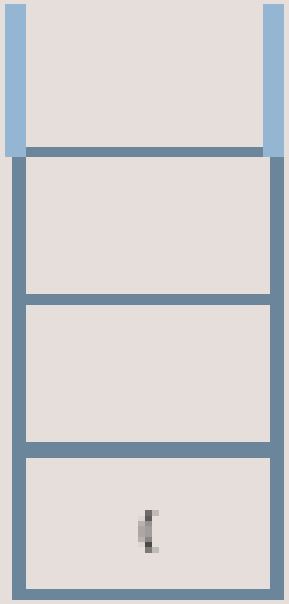
(A + B) * (C - D)

Reading Character	Stack	Postfix expression
Initially	Stack is empty 	empty

Infix to postfix Example2

- Consider the following Infix Expression...

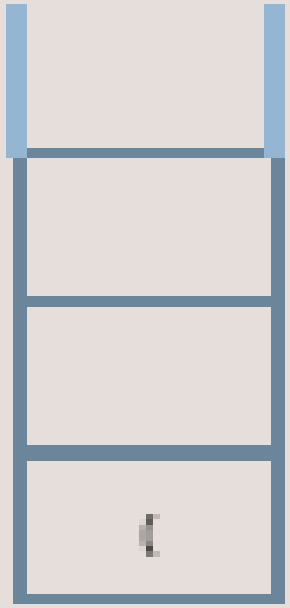
(A + B) * (C - D)

Reading Character	Stack	Postfix expression
(	Push C 	empty

Infix to postfix Example2

- Consider the following Infix Expression...

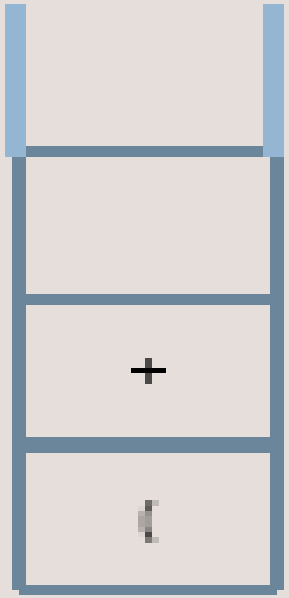
(A + B) * (C - D)

Reading Character	Stack	Postfix expression
A	No operation 	A

Infix to postfix Example2

- Consider the following Infix Expression...

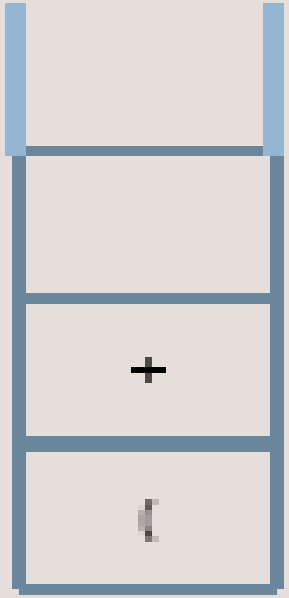
(A + B) * (C - D)

Reading Character	Stack	Postfix expression
+	Push + 	A

Infix to postfix Example2

- Consider the following Infix Expression...

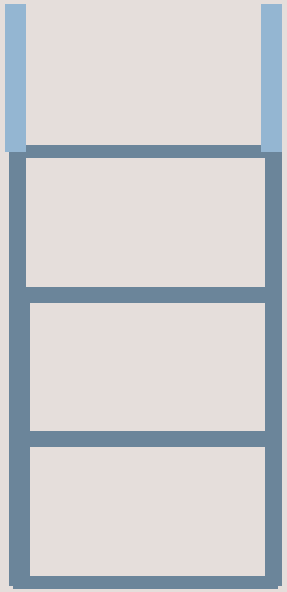
(A + B) * (C - D)

Reading Character	Stack	Postfix expression
B	No operation 	AB

Infix to postfix Example2

- Consider the following Infix Expression...

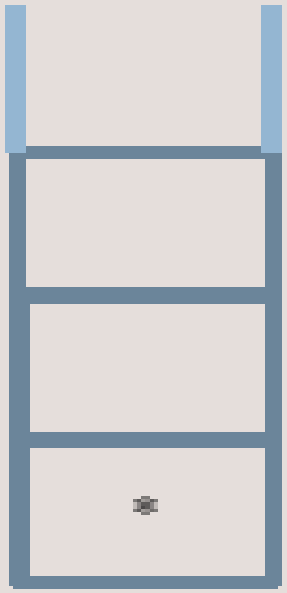
(A + B) * (C - D)

Reading Character	Stack	Postfix expression
)	Pop all elements until reach (Pop + Pop (	AB+

Infix to postfix Example2

- Consider the following Infix Expression...

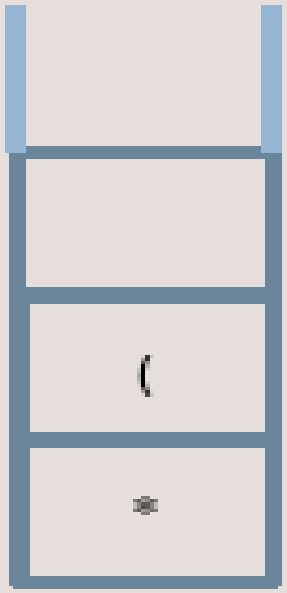
(A + B) * (C - D)

Reading Character	Stack	Postfix expression
*	Push * 	AB+

Infix to postfix Example2

- Consider the following Infix Expression...

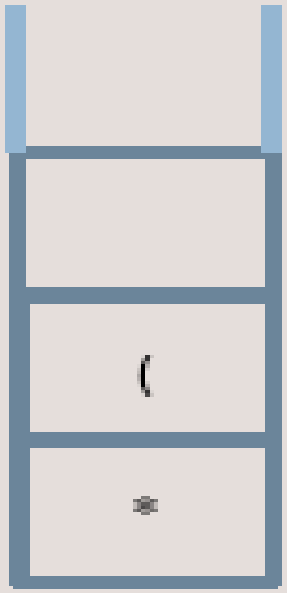
(A + B) * (C - D)

Reading Character	Stack	Postfix expression
(	Push (	AB+

Infix to postfix Example2

- Consider the following Infix Expression...

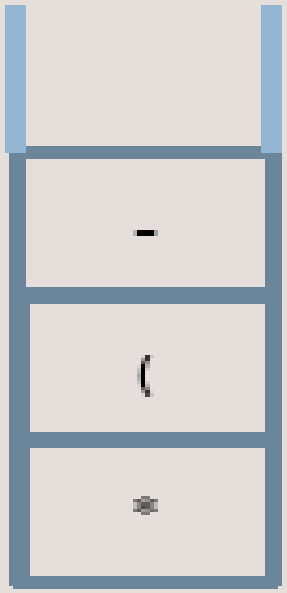
(A + B) * (C - D)

Reading Character	Stack	Postfix expression
C	No operation 	AB+C

Infix to postfix Example2

- Consider the following Infix Expression...

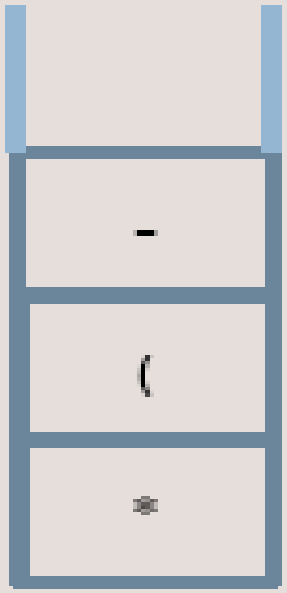
(A + B) * (C - D)

Reading Character	Stack	Postfix expression
-	Push - 	AB+C

Infix to postfix Example2

- Consider the following Infix Expression...

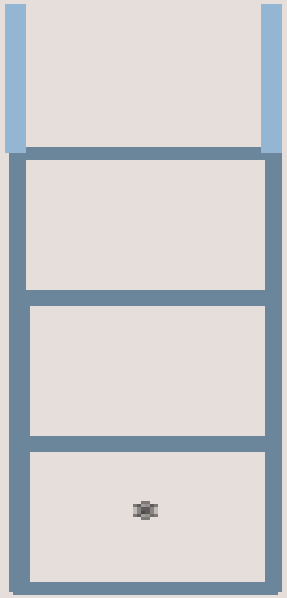
(A + B) * (C - D)

Reading Character	Stack	Postfix expression
D	No operation 	AB+CD

Infix to postfix Example2

- Consider the following Infix Expression...

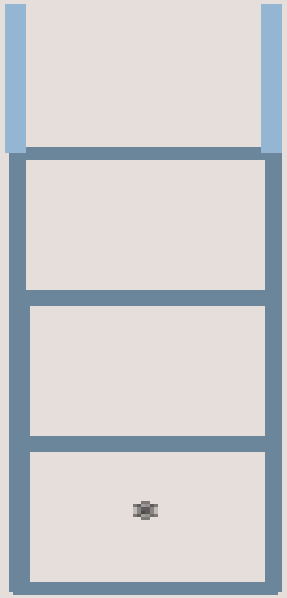
(A + B) * (C - D)

Reading Character	Stack	Postfix expression
)	Pop all elements until reach (Pop - 	AB+CD-

Infix to postfix Example2

- Consider the following Infix Expression...

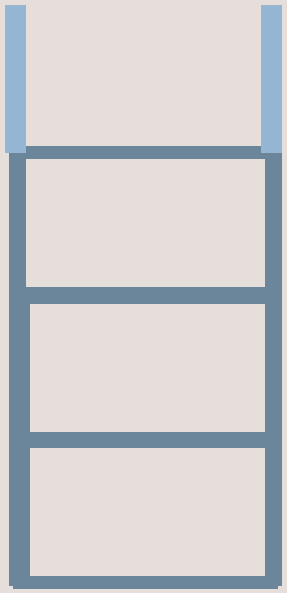
(A + B) * (C - D)

Reading Character	Stack	Postfix expression
	Pop all elements until stack is empty Pop * 	AB+CD-

Infix to postfix Example2

- Consider the following Infix Expression...

(A + B) * (C - D)

Reading Character	Stack	Postfix expression
		AB+CD-*

Infix to postfix: example 3

Infix A + (B / C - (D * E ^ F) + G) * H

Character scanned	Stack	Postfix Expression (Q)
A	(	A
+	(+	A
(	(+ (	A
B	(+ (	A B
/	(+ (/	A B
C	(+ (/	A B C
-	(+ (-	A B C /
(	(+ (- (	A B C /
D	(+ (- (	A B C / D
*	(+ (- (*	A B C / D
E	(+ (- (*	A B C / D E
^	(+ (- (* ^	A B C / D E
F	(+ (- (* ^	A B C / D E F
)	(+ (-	A B C / D E F ^ *
+	(+ (+	A B C / D E F ^ * -
G	(+ (+	A B C / D E F ^ * - G
)	(+	A B C / D E F ^ * - G +
*	(+ *	A B C / D E F ^ * - G +
H	(+ *	A B C / D E F ^ * - G + H
)		A B C / D E F ^ * - G + H * +

Expression Evaluation

Expression Evaluation

- Expression evaluations is one of the major application that illustrates the different types of stacks.
- We have five binary operations: addition, subtraction, multiplication, division, and exponentiation.
- The first four are available in C++ and are denoted by the usual operators + , - , *, and / .
- The fifth exponentiation is represented by the operator ^

  A^B A is raised to the power B

Expression Evaluation

- In order to get the value of any expression (infix, postfix, prefix).
- You have to know the priority or precedence of each operator in the expression.
- Then the highest Priority will be executed first then the less priority and the less and .....

Expression Evaluation Priority

Priority of Operations		
	Symbol	Comment
Parentheses	[ ] , { }, ( )	highest priority
Exponentiation, +- sign	^, - (unary negation)	
Multiplication / division	*, /, %	Left to right
Addition / subtraction	+, -	Left to right

Postfix Evaluation using Stack

- To evaluate a postfix expression using Stack data structure we can use the following steps....

1. Read all the symbols one by one from left to right in the given Postfix Expression.
2. If the reading symbol is operand, then push it on to the Stack.
3. If the reading symbol is operator (+ , - , *, / etc.,), then perform TWO pop operations and store the two popped operands in two different variables (operand1 and operand2). Then perform reading symbol operation using operand1 and operand2 and push result back on to the Stack.
4. Finally! perform a pop operation and display the popped value as final result.

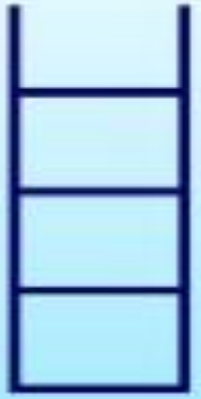
Evaluating a postfix expression

```
opndstk= the empty stack;
/* scan the input string reading one*/
/* element at a time into symb      */
while (not end of input)
{
        symb= next input character;
        if (symb is an operand)
                push (opndstk, symb);
        else // symb is an operator
        {
                opnd2=pop(opndstk);
                opnd1=pop(opndstk);
                value=result of applying symb to opnd1 and opnd2;
                push(opndstk,value);
        }
}//end while
return (pop(opndstk));
```

Postfix Evaluation Example

Postfix Expression 5 3 + 8 2 - *

Above Postfix Expression can be evaluated by using Stack Data Structure as follows...

Reading Symbol	Stack Operations	Evaluated Part of Expression
Initially	Stack is Empty 	Nothing

Postfix Evaluation Example

Postfix Expression 5 3 + 8 2 - *

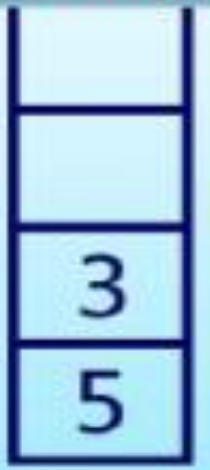
Above Postfix Expression can be evaluated by using Stack Data Structure as follows...

Reading Symbol	Stack Operations		Evaluated Part of Expression
5	push(5)		Nothing

Postfix Evaluation Example

Postfix Expression 5 3 + 8 2 - *

Above Postfix Expression can be evaluated by using Stack Data Structure as follows...

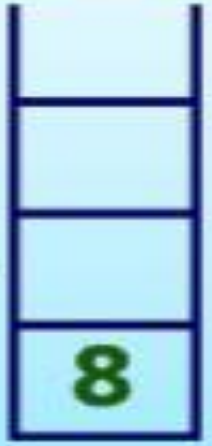
Reading Symbol	Stack Operations	Evaluated Part of Expression
3	push(3) 	Nothing

Postfix Evaluation Example

Postfix Expression 5 3 + 8 2 - *

Above Postfix Expression can be evaluated by using Stack Data Structure as follows...

Reading Symbol	Stack Operations	Evaluated Part of Expression

+	value1 = pop()
	value2 = pop()
	result = value2 + value1
	push(result)
	 
		value1 = pop(); // 3
		value2 = pop(); // 5
		result = 5 + 3; // 8
		Push(8)
		(5 + 3)

Postfix Evaluation Example

Postfix Expression 5 3 + 8 2 - *

Above Postfix Expression can be evaluated by using Stack Data Structure as follows...

Reading Symbol	Stack Operations	Evaluated Part of Expression
8	push(8) 	(5 + 3)

Postfix Evaluation Example

Postfix Expression 5 3 + 8 2 - *

Above Postfix Expression can be evaluated by using Stack Data Structure as follows...

Reading Symbol	Stack Operations	Evaluated Part of Expression
2	push(2) 	(5 + 3)

Postfix Evaluation Example

Postfix Expression 5 3 + 8 2 - *

Above Postfix Expression can be evaluated by using Stack Data Structure as follows...

Reading Symbol	Stack Operations	Evaluated Part of Expression

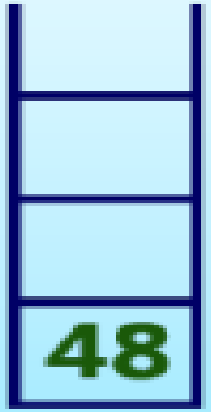
-	value1 = pop()
	value2 = pop()
	result = value2 - value1
	push(result)
	 
		value1 = pop(); // 2
		value2 = pop(); // 8
		result = 8 - 2; // 6
		Push(6)
		(8 - 2)
		(5 + 3) , (8 - 2)

Postfix Evaluation Example

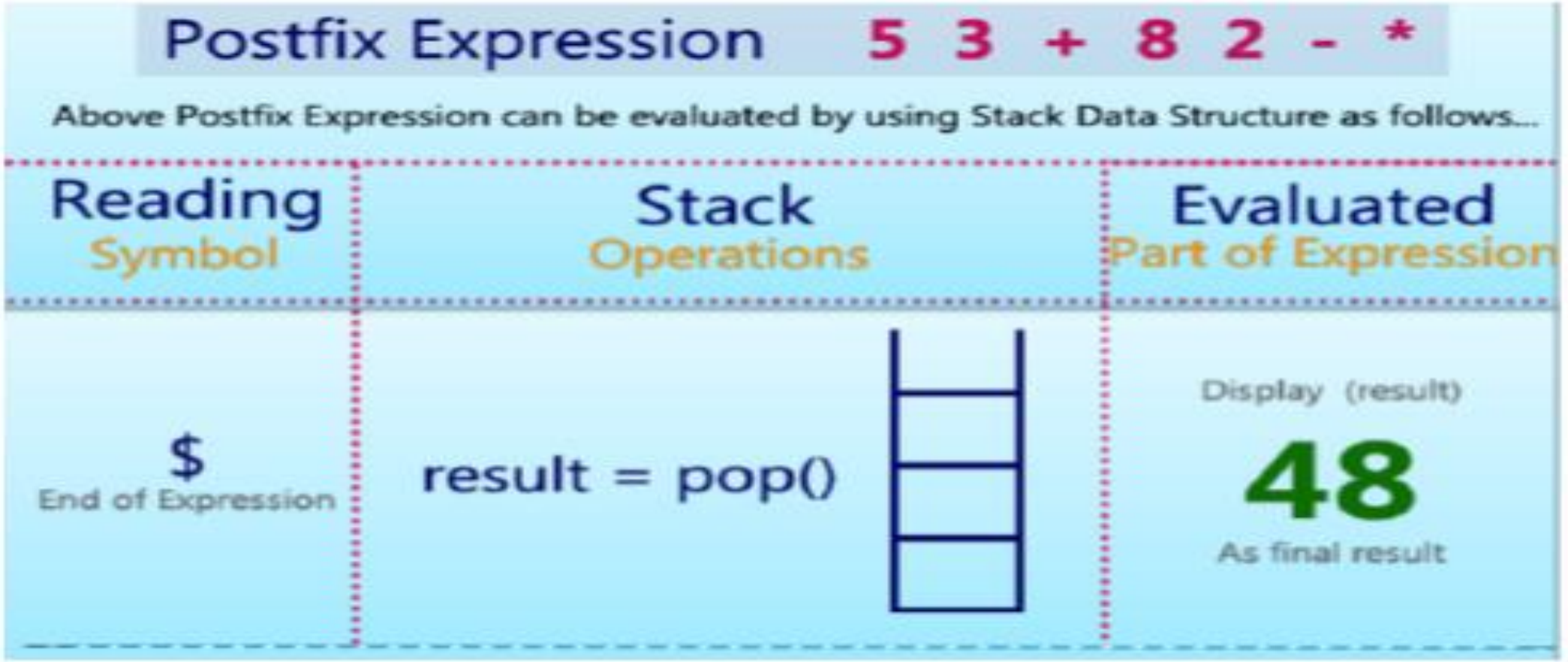
Postfix Expression 5 3 + 8 2 - *

Above Postfix Expression can be evaluated by using Stack Data Structure as follows...

Reading Symbol	Stack Operations	Evaluated Part of Expression

*	value1 = pop()
	value2 = pop()
	result = value2 * value1
	push(result)
	 
		value1 = pop(); // 6
		value2 = pop(); // 8
		result = 8 * 6; // 48
		Push(48)
		(6 * 8)
		(5 + 3) * (8 - 2)

Postfix Evaluation Example



Evaluating a postfix expression

6 2 3 + - 3 8 2 / + * 2 ^ 3 +

symb	opnd1	opnd2	value	opndstk
push(6)				6
push(2)				6, 2
push(3)				6, 2, 3
+	pop(2)	pop(3)	push(5)	6, 5
-	pop(6)	pop(5)	push(1)	1
push(3)	pop(6)	pop(5)	push(1)	1, 3
push(8)	pop(6)	pop(5)	push(1)	1, 3, 8
push(2)	pop(6)	pop(5)	push(1)	1, 3, 8, 2
/	pop(8)	pop(2)	push(4)	1, 3, 4
+	pop(3)	pop(4)	push(7)	1, 7
*	pop(1)	pop(7)	push(7)	7
push(2)	pop(1)	pop(7)	push(7)	7, 2
^	pop(7)	pop(2)	push(49)	49
push(3)	pop(7)	pop(2)	push(49)	49, 3
+	pop(49)	pop(3)	push(52)	52


THANK
YOU


Any
Question?