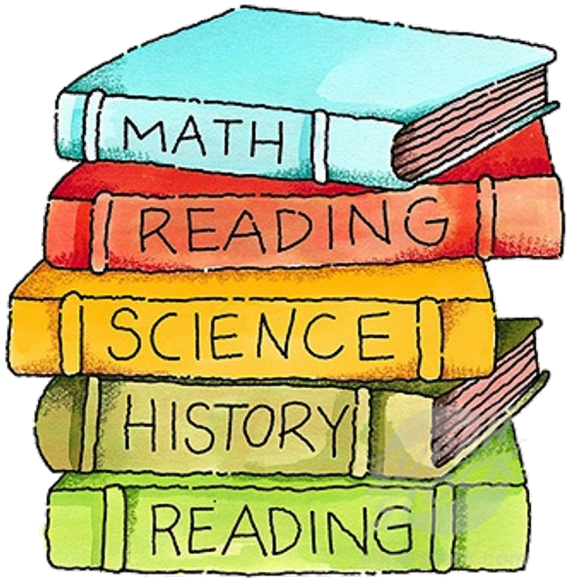


Stack (Push Down Stack)

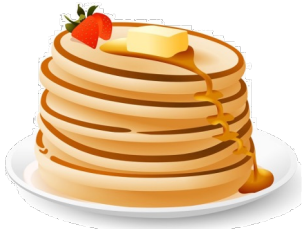
Data Structures & Algorithms

In this course, Data Structures & Algorithms :

1. **Data Structures** → abstract data types :
   stack, queue, linked list, trees, heap, graph.

2. **Algorithms** : recursion, complexity (algorithm analysis) , hashing, searching, sorting.

Stack



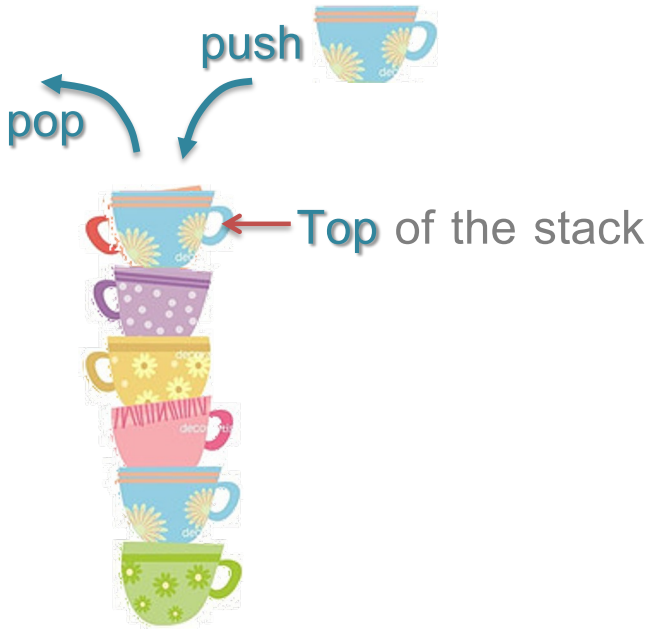
Stacks กองของ

http://clipart-library.com/search/

Stack

Stack : กองของ ของในกองมีลำดับ **ordered collection of items**
มีปลายด้านบนเรียก **top** ของ **stack**
เอาของเข้า **(push)** ออก **(pop)** ที่ **top** ของ **stack**

LIFO
Last in First out
อันสุดท้าย ถูกเอาออกก่อน



เอาออก **pop** อันไหน ? อันบนสุด **top**
ใส่ **push** ที่ไหน? **top**

http://www.clipartpanda.com

Queue

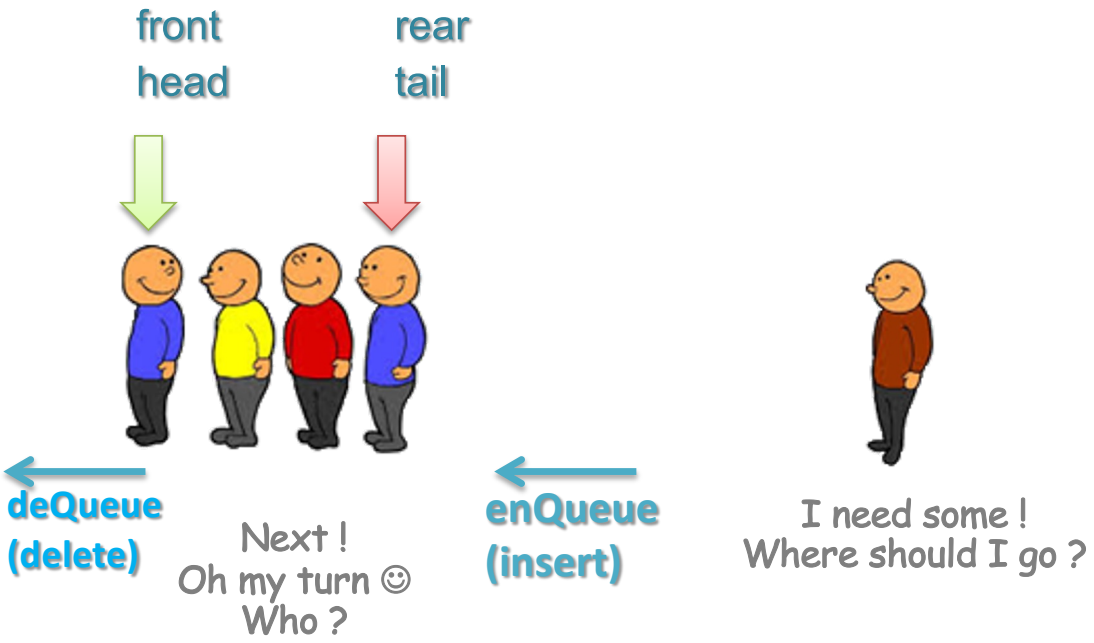
Queue แถวคอย
?

http://www.gograph.com/vector-clip-art/queue.html

Queue แถวคอย

Queue : แถวคอย ของในแถวมีลำดับ ordered collection of items
มีปลายด้านหนึ่งเรียก rear/tail สำหรับใส่ของเข้า (enQueue)
และอีกด้านหนึ่งเรียก front/head สำหรับเอาของออก (deQueue)

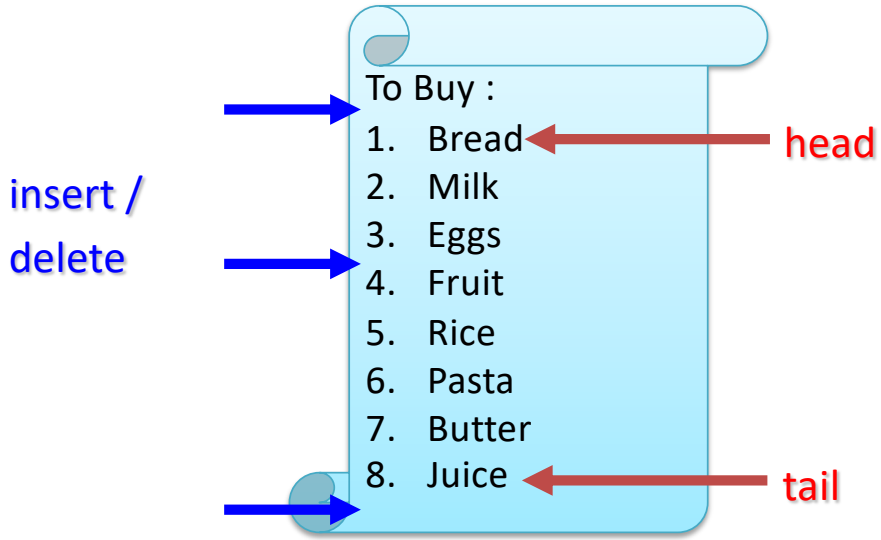
FIFO List
FirstInFirstOut



list

List : ordered collection of items ของใน list มีลำดับ
ใส่ของเข้า (insert) เอาของออก (delete) ที่ไดก็ได้

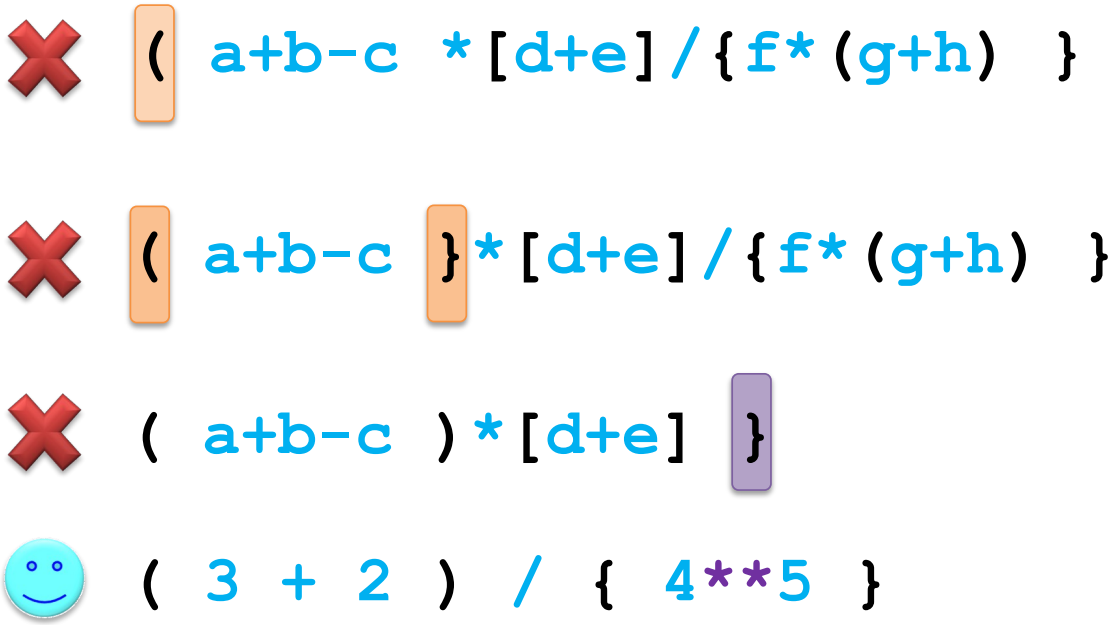
Superset of **Stack** & **Queue**



Stack Applications

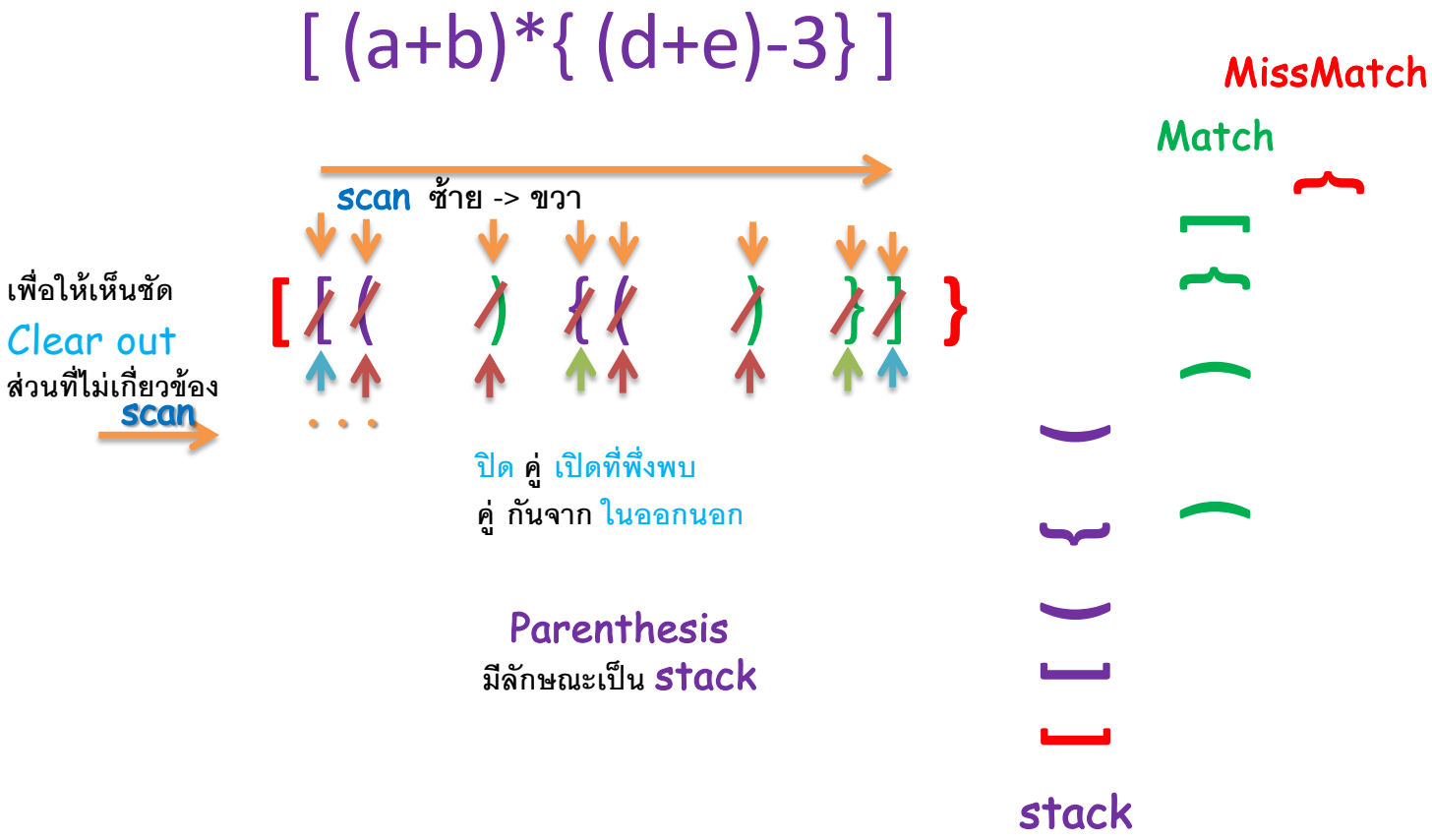
1. Parenthesis Matching
2. Evaluate Postfix Expression
3. Infix to Postfix Conversion (Reverse Polish Notation)
4. Function Call (clearly see in recursion)

Parenthesis Matching



Match ? Algorithm ?

Parenthesis Matching



Stack Implementation

Logical ADT : Implementation ?

1. Data : ของมีลำดับ มีปลายบน Python List

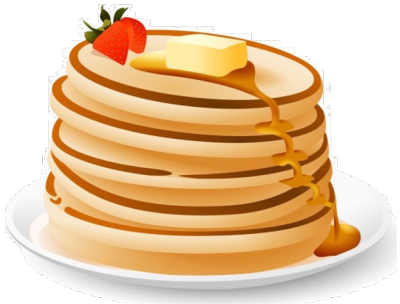
2. Methods :

1.	init empty stack	init()	S = []
2.	insert i ที่ top	push(i)	S.append(i) ใส่ท้าย
3.	เอาของที่ top ออก	i = pop()	i = S.pop() อันท้าย
4.	ดูของที่ top (ไม่เอาออก)	i = peek()	
5.	stack empty ?	b = isEmpty()	
6.	stack full ?	b = isFull()	
7.	หาจำนวนของใน stack	i = size()	

LIFO

Last in First out

Stack Data Implementation



1. Data :

`__init__()` : **constructor** ให้ค่าตั้งต้น

2 underscores 2 underscores

Data Implementation : __init__()

1. **Data Implementation : Stack** กองของซ้อนกัน ของมีลำดับ มีปลายด้านบน -> Python List
   ทำใน constructor

self คือ object ที่เรียก method ในแต่ละครั้ง
เช่น `s = Stack()`
self หมายถึง s เสมือนเรียก `s = Stack(s)`
self จะถูก pass เป็น arg. ตัวแรก โดยอัตโนมัติ

docstring : ใน triple quote
`print(Stack.__doc__)`
→ docstring

constructor
ถูกเรียกโดยอัตโนมัติเมื่อ
instantiate instance ใหม่

```
class Stack:
    """ class Stack
        create empty stack
    """
    total = 0          # class data
    def __init__(self):
        self.items = []
        self.size = 0
        Stack.total  += 1
```

Class Data
สำหรับทุก stack

items , size:
Instance Attributes /data
สำหรับแต่ละ instance

items	[ ]
size	0

```
s = Stack()
print(s.items)    []
print(s.size)     0
s2 = Stack()
print(s.total) → 2
```

เรียกชื่อ class :
สร้าง object ใหม่ (instantiate instance/obj)
ไปเรียก constructor ฟังก์ชั่น __init__()

Mutable Type Default Argument

Default argument :
ให้ = ค่านี้ เมื่อไม่มีการ pass ค่ามา

ค่า default จะถูกสร้างขึ้นครั้งเดียว
ณ function definition ใน scope ที่ define functon
ต้องระวัง เมื่อเป็น mutable type

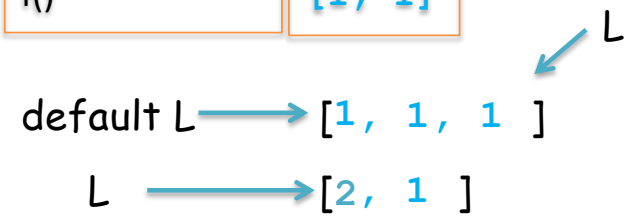
```
def f( L = [] ):
    print(L)
    L.append(1)

f()
f()
f([2])
f()
```

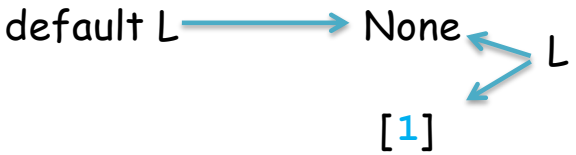
output

```
[]
[1]
[2]
[1, 1]
```

ถ้า f() เป็น constructor ของ stack
จึง init empty stack เพียงครั้งแรกเท่านั้น ทางแก้ →

```
def f(L = None):
    if L is None:
        L = []
    else :
        pass

    L.append(1)

f()
f()
```





__init__() with Default Argument

```
class Stack:
    """ class Stack
        default : empty stack /
        Stack([list])
    """
 def __init__(self, list = None):
        if list == None:
            self.items = []
        else:
            self.items = list
```

default argument

ถ้าไม่มีการ pass arg. มา

list = None

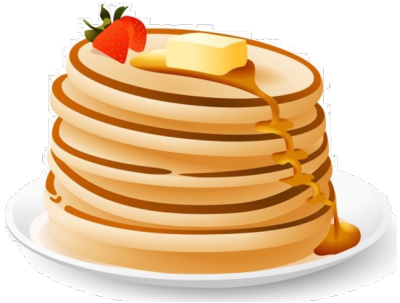
ถ้า pass arg. มา

list = ตัวที่ pass มา

```
s = Stack()
s1 = Stack(['A', 'B', 'C'])
```

ไม่เหมือนกับ C++ & Java ใน Python มี constructor ได้ตัวเดียว

Stack Operation Implementation



1. Data :

    __init__() : constructor ให้ค่าตั้งต้น

2. Methods (Operations) :

    2. push() : ใส่ ด้านบน top
    3. pop () : เอาออก ด้านบน **top**
    4. peek() : ดู top ไม่เอาออก
    5. isEmpty() : stack ว่าง ?
    6. size() : มีของกี่อัน

push()

```
class Stack:
    def __init__(self, list = None):
        if list == None:
            self.items = []
        else:
            self.items = list
        self.size = len(self.items)

    def push(self, i):
        self.items.append(i)
        self.size += 1
```

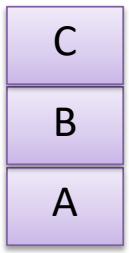
Check Stack Overflow ?
-> No
Python list automatically expanding size

list.append (i): insert i ที่ท้าย list

```
s = Stack()
s.push('A')
s.push('B')
s.push('C')
```

s.items

```
[]
['A']
['A', 'B']
['A', 'B', 'C' ]
```



pop()

```
class Stack:
    def __init__(self, list = None):
        if list == None:
            self.items = []
        else:
            self.items = list
```

```
def pop(self):    # remove & return อันบนสุด
        return self.items.pop()
```

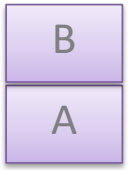
อย่าลืม return !!!

list.pop() : delete ตัวสุดท้ายของ list

list.pop(i) : delete ตัวที่ index i ของ list

```
print(s.items)
print(s.pop())
print(s.pop())
s.pop()
```

```
['A', 'B']
B
A
# error Stack Underflow
```



peek()

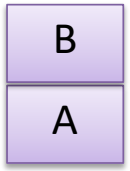
```
class Stack:
    def __init__(self, list = None):
        if list == None:
            self.items = []
        else:
            self.items = list
```

```
def peek(self):    # return อันบนสุด
        return self.items[ -1]
```

-1 : last index

```
print(s.items)

print(s.peek())

print(s.items)
```

```
['A', 'B']

B

['A', 'B']
```



isEmpty()

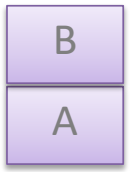
```
class Stack:
    def __init__(self, list = None):
        if list == None:
            self.items = []
        else:
            self.items = list
```

```
def isEmpty(self):
    return self.items == []
```

```
return  len(self.items) == 0
```

```
print(s.items)

print(s.isEmpty())
```

```
['A', 'B']

false
```



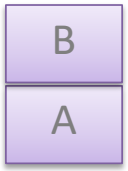
size()

```
class Stack:
    def __init__(self, list = None):
        if list == None:
            self.items = []
        else:
            self.items = list
```

```
def size(self):
        return len(self.items)
```

```
print(s.items)
print(s.size())
```

```
['A', 'B']
2
```



Stack Implementation

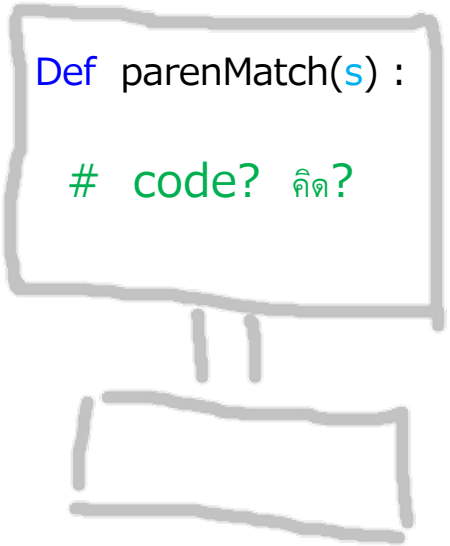
```
class Stack:
    """ class Stack
        default : empty stack / Stack([...])
    """
    def __init__(self, list = None):
        if list == None:
            self.items = []
        else:
            self.items = list

    def __str__(self):
        s = 'stack of '+ str(self.size())+' items : '
        for ele in self.items:
            s += str(ele)+' '
        return s
```

__str__() ต้อง return string

```
    def push(self, i):
        self.items.append(i)

    def pop(self):
        return self.items.pop()

    def peek(self):
        return self.items[-1]

    def isEmpty(self):
        return self.items == []

    def size(self):
        return len(self.items)
```

```
s1 = Stack([1,2,3])

print(s1.items)          [1, 2, 3]

print(s1)                stack of 3 items : 1 2 3
```

Writing Code



Design

Code : difficult

```
if openParen(c) :
    s.push(c)
elif closeParen(c) :
    ch = s.pop()
    match = isMatch(c, ch)
```

Pseudocode : easier

```
if (c is an open parenthesis)
    push c to stack s
else if (c is an close parenthesis)
    pop ch from stack s
    if (ch matches c)
        match = true
    else match = false
```

Python : Parenthesis Matching

```
def parenMatching(str):
    s = Stack()
    i = 0                          # index : str[i]
    error = 0

    while i < len(str) and error == 0 :
        c = str[i]
        if c in '{[(':
            s.push(c)
        else:
            if c in '}])':
                if s.size() > 0:
                    if not match(s.pop(),c):
                        error = 1      # open & close not match
                else:                  # empty stack
                        error = 2      # no open paren
        i += 1


    if s.size() > 0:               # stack not empty
        error = 3                  # open paren(s) excesses
    return error,c,i,s
```

```
str = '[{a+b-c}'
err,c,i,s = parenMatching(str)
if err == 1:
    print(str , 'unmatch open-close  ')
elif err == 2:
    print(str , 'close paren excess')
elif err == 3:
    print(str , 'open paren(s) excess  ', s.size(),': ',end='' )
    for ele in s.item:
        print(ele,sep=' ',end = '')
    print()
else:
    print(str, 'MATCH')
```

```
def match(open, close):
    return (open == '(' and close == ')') or \
           (open == '{' and close == '}') or \
           (open == '[' and close == ']')
```

```
def match2(op,cl):
    opens = "([{"
    closes = ")]}"
    return opens.index(op) == closes.index(cl)
```

Stack Application

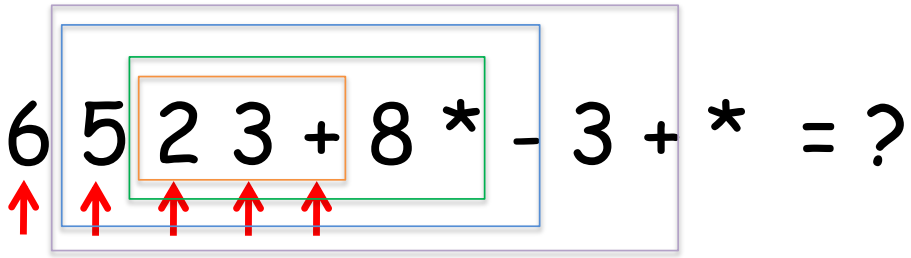
1. Parenthesis Matching
2. Evaluate Postfix Expression
3. Infix to Postfix Conversion (Reverse Polish Notation)
4. Function Call (clearly see in recursion)

Postfix Notation (Polish Notation)

Infix Form	Prefix Form	Postfix Form
a + b	+ a b	a b +
a + b * c	+ a * b c	a b c * +

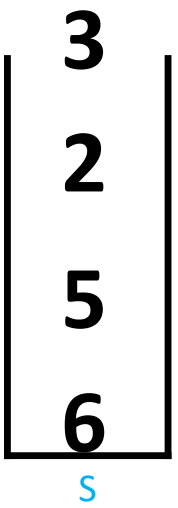
Evaluate Postfix Notation

Postfix Notation มีธรรมชาติเป็น **stack**: **operator** เป็นของ **operands 2** ตัวก่อนหน้ามัน



input: 6523

Push : 6, 5, 2, 3



input: +

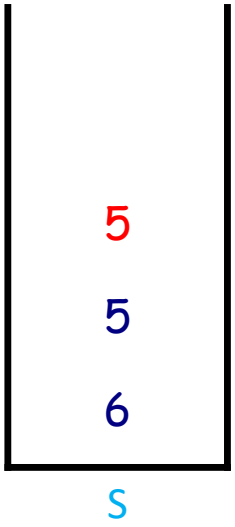
o2 <- pop#1

o1 <- pop#2

push

\+

5

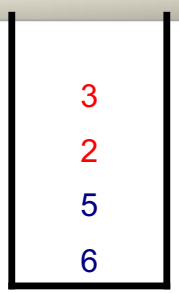


What 's next ?

6 5 2 3 + 8 * - 3 + * = ?

input: 6523

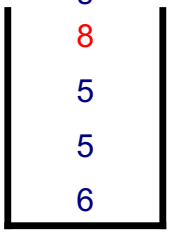
Push : 6 5 2 3



s

input: 8

push 8

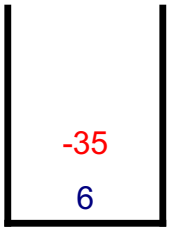


input: -

pop#1 → 40

pop#2 → 5

push 5-40

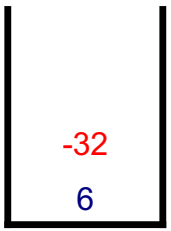


input: +

pop#1 → 3

pop#2 → -35

push -35+3

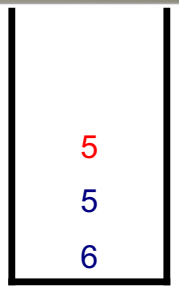


input: +

pop#1 → 3

pop#2 → 2

push 2+3



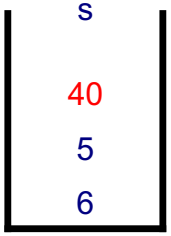
s

input: *

pop#1 → 8

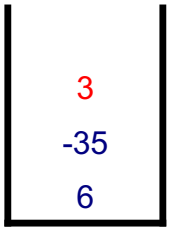
pop#2 → 5

push 5*8



input: 3

push 3

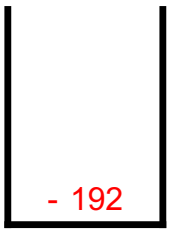


input: *

pop#1 → -32

pop#2 → 6

push 6 * -32



Stack Application

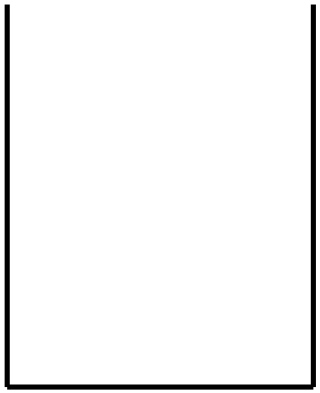
1. Parenthesis Matching
2. Evaluate Postfix Expression
3. Infix to Postfix Conversion (Reverse Polish Notation)
4. Function Call (clearly see in recursion)

Infix to Postfix Conversion

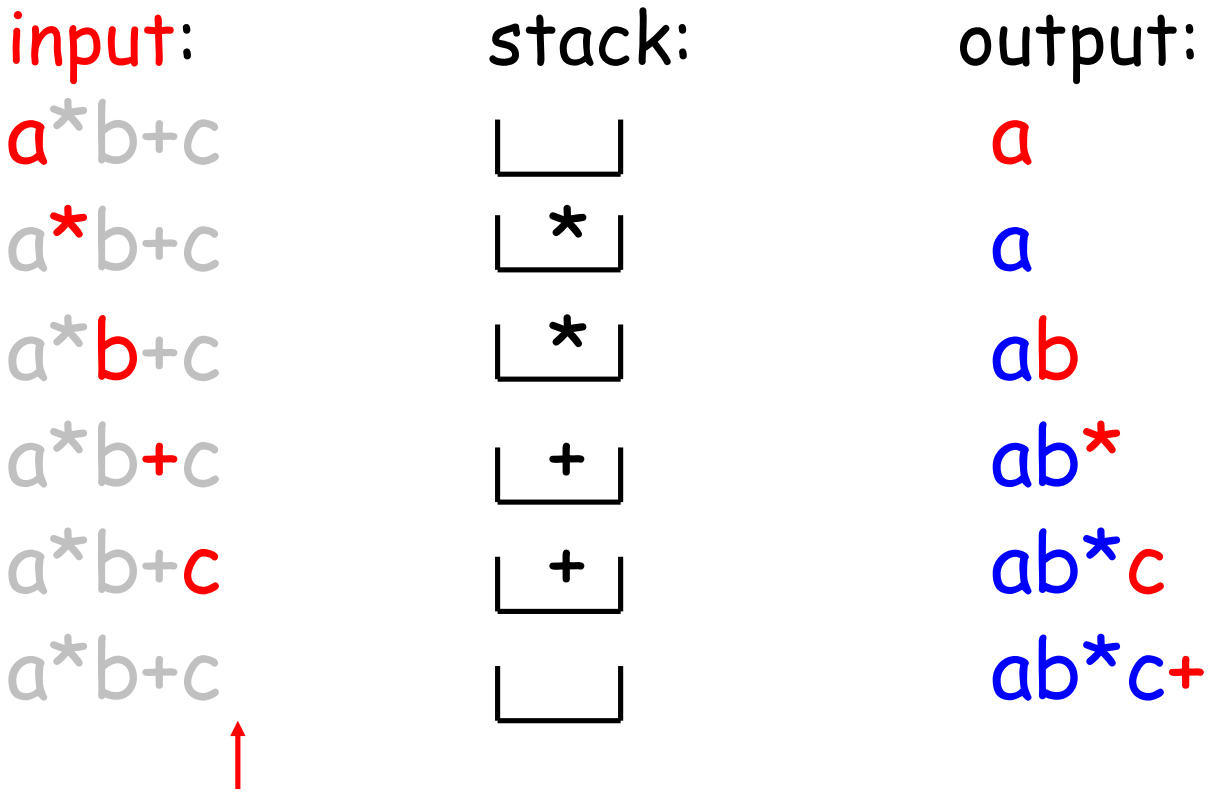
a*b+c ===> ab*c+

Notice :
output: operands' order is the same as input's.

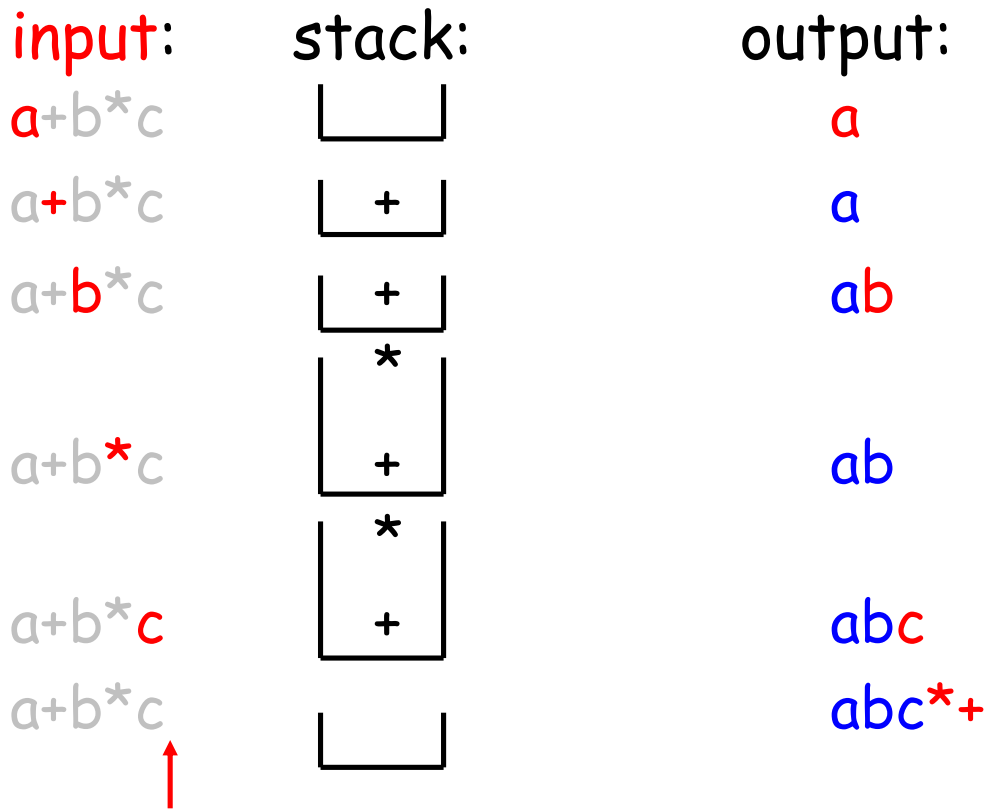
output



Infix to Postfix Conversion a*b+c ---- > ab*c+

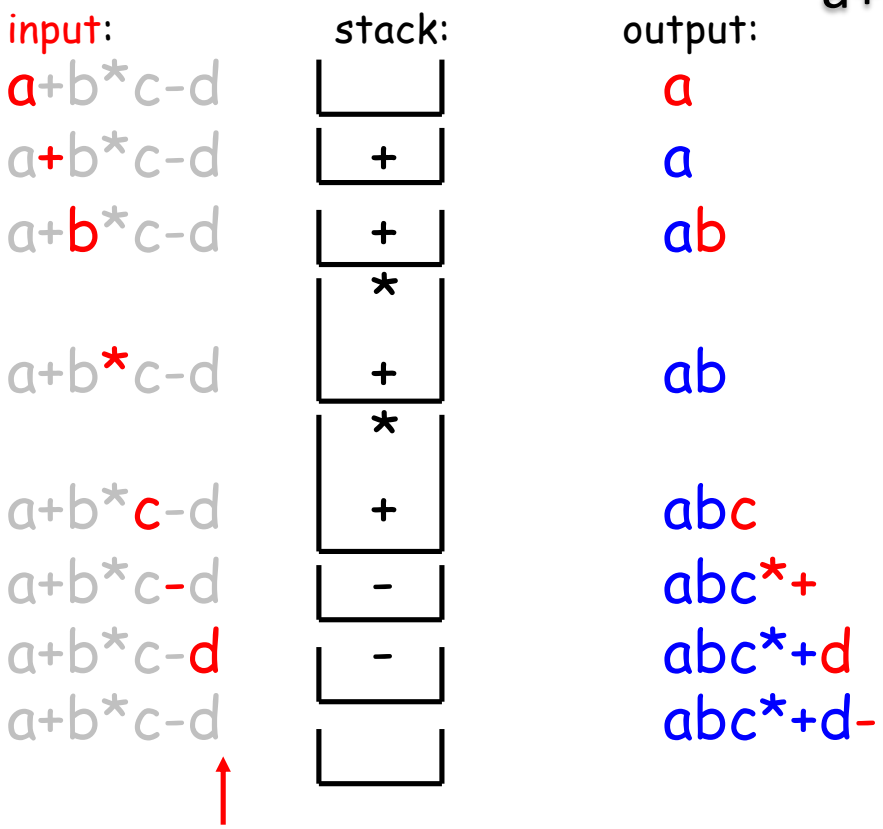


Infix to Postfix Conversion a+b*c ---- > abc*+



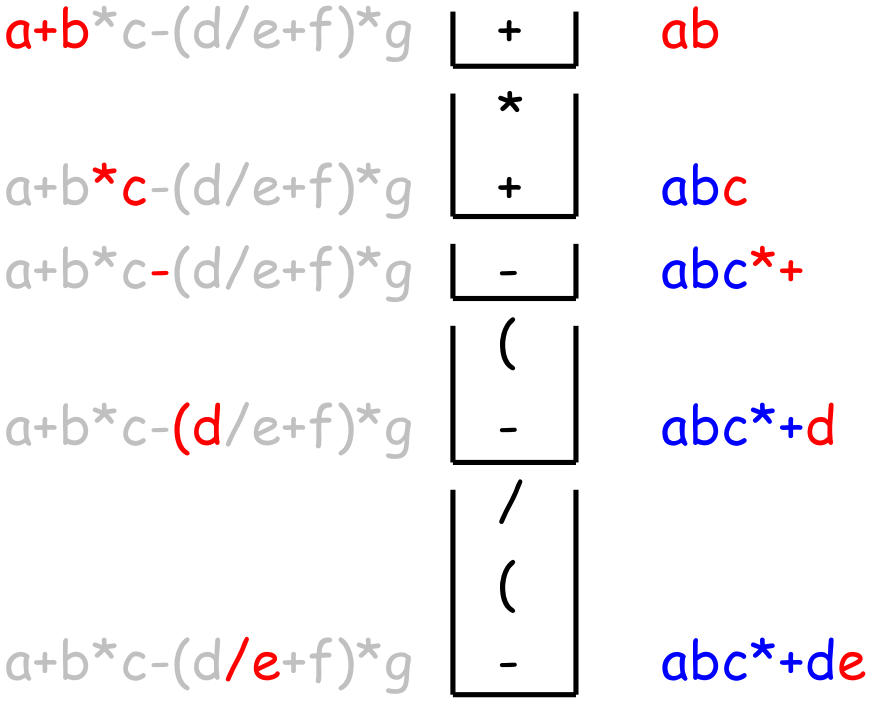
Infix to Postfix Conversion

a+b*c-d => abc*+d-



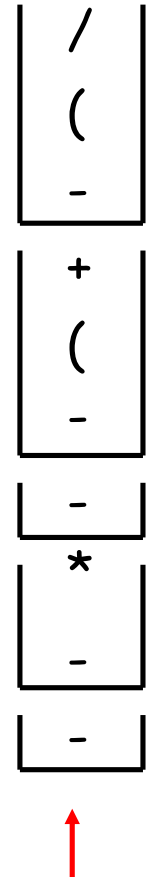
Infix to Postfix Conversion

a+b*c-(d/e+f)*g => abc*+de/f+g*-



Infix to Postfix Conversion (cont.)

a+b*c-(d/e+f)*g => abc*+de/f+g*-



a+b*c-(d/e+f)*g abc*+de

a+b*c-(d/e+f)*g abc*+de/f

a+b*c-(d/e+f)*g abc*+de/f+

a+b*c-(d/e+f)*g abc*+de/f+g

a+b*c-(d/e+f)*g abc*+de/f+g*-

Stack Application

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