Stack ADT

Tiziana Ligorio

Today's Plan

Questons?

Stack ADT

Abstract Data Types

Bag

List

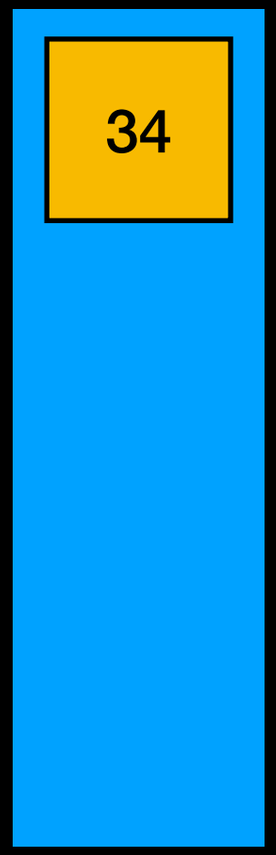
Stack

Stack

A data structure representing a stack of things

Objects can be pushed onto the stack or popped from the stack

Stack



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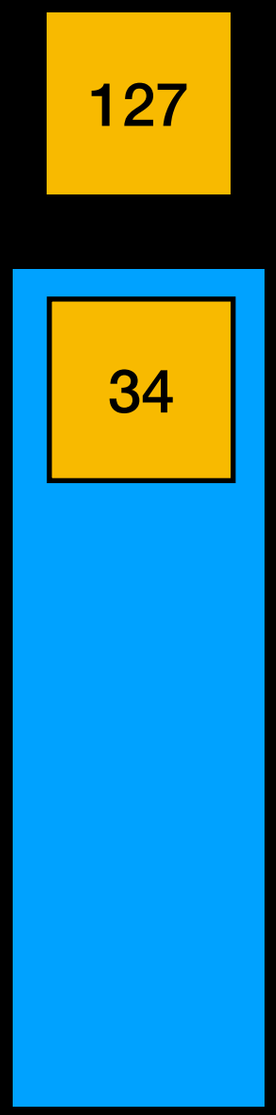

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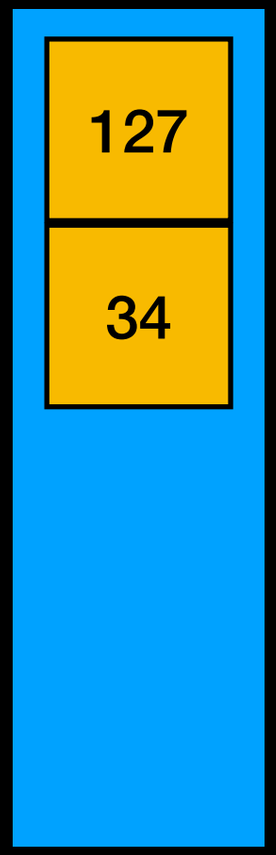

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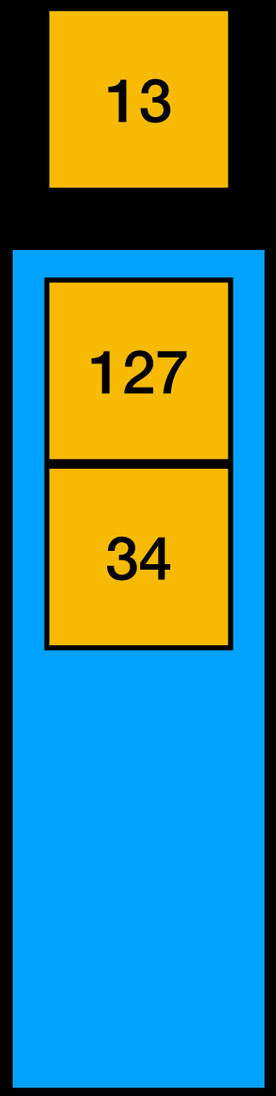

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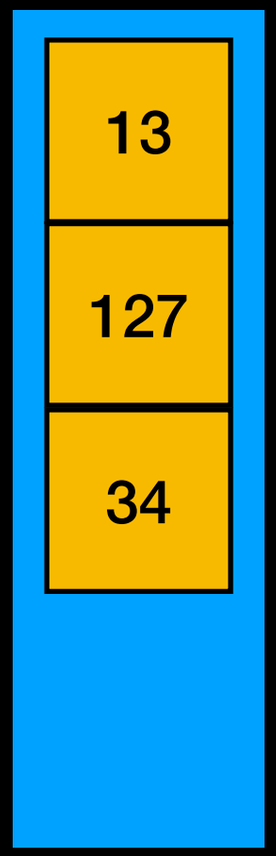

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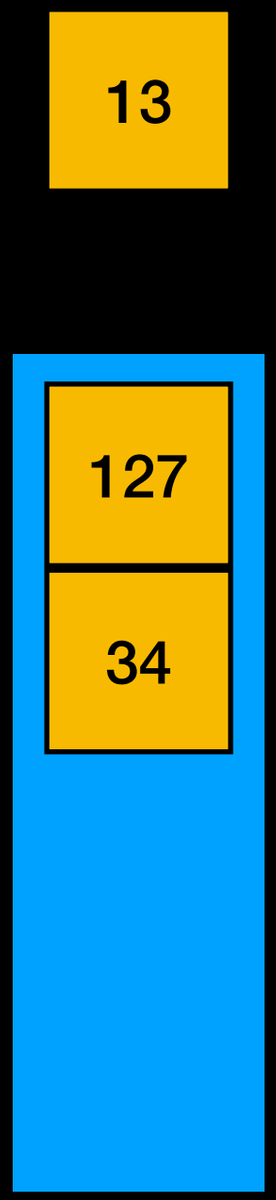

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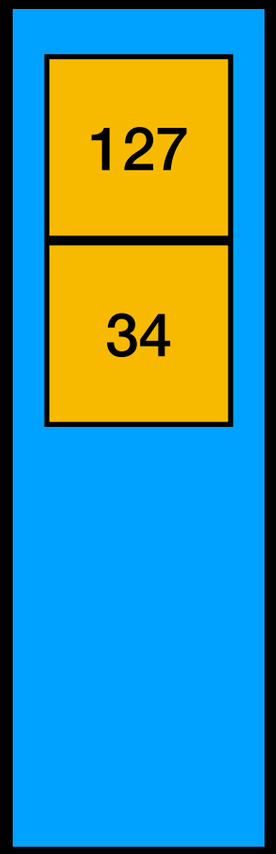
LIFO: Last In First Out

Only top of stack is accessible (top), no other objects on the stack are visible



Applications

Very simple structure

Many applications:

- program stack
- balancing parenthesis
- evaluating postfix expressions
- backtracking
- . . . and more

Program Stack

Program Stack

```
1  void f(int x, int y)
2  {
3    int a;
4    // stuff here
5    if(a<13)
6        a = g(a);
7    // stuff here
8  }

9  int g(int z)
10 {
11   int p ,q;
12   // stuff here
13   return q;
14 }
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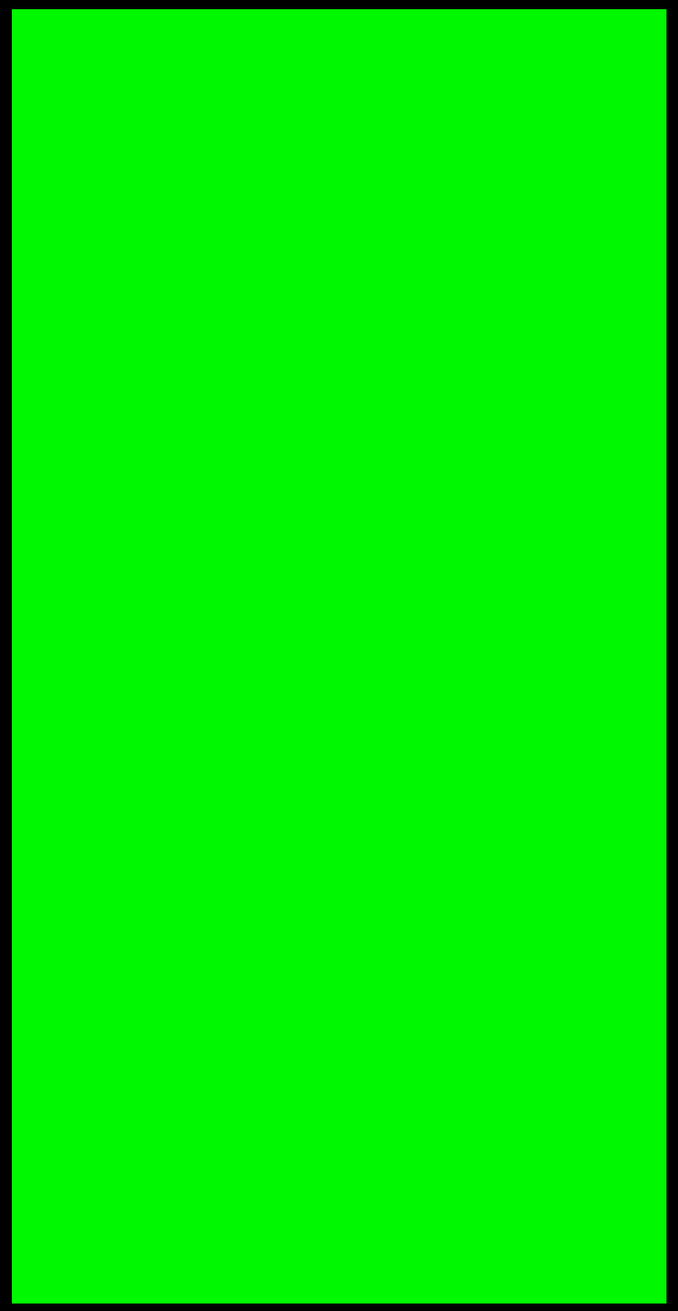

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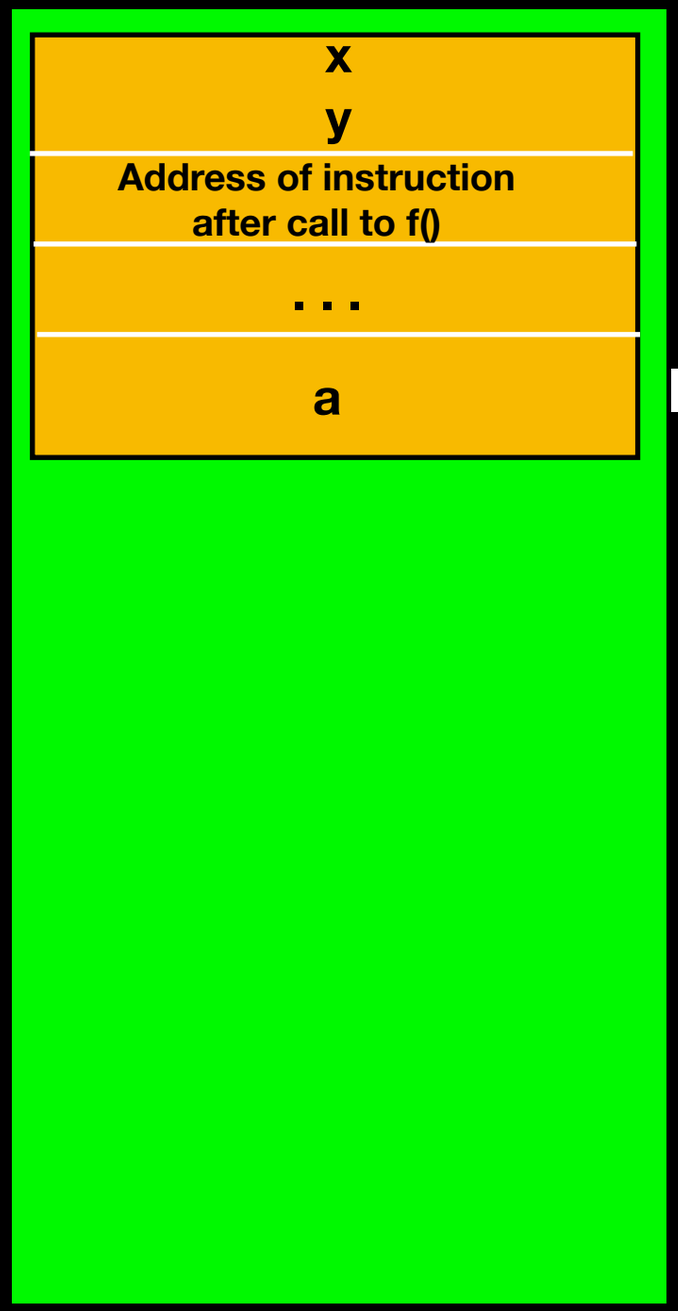
Stack Frame for f()



parameters

return address

local variables

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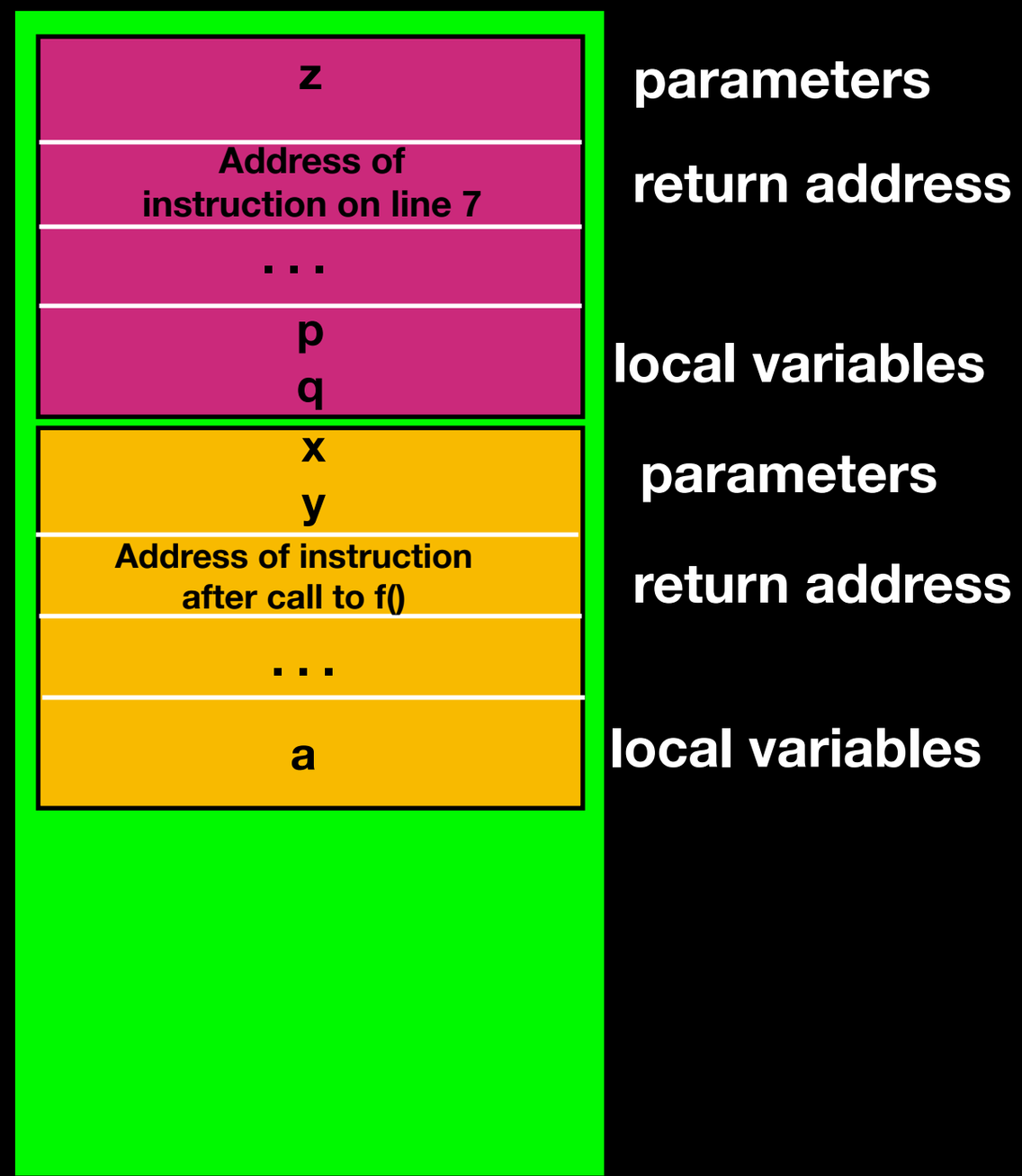

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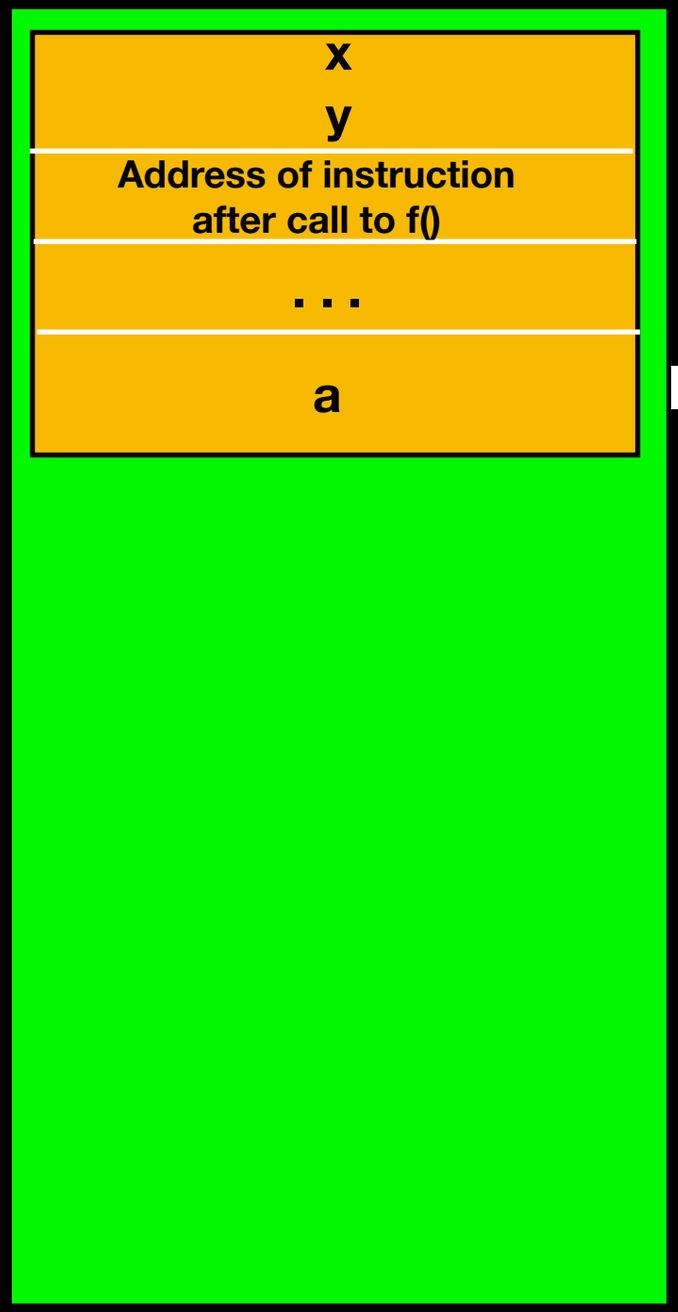

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Balancing Parentheses

Balancing Parentheses

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int f(){if(x*(y+z[i])<47){x += y}}
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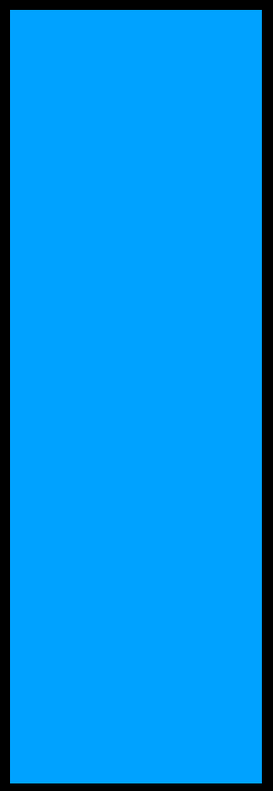

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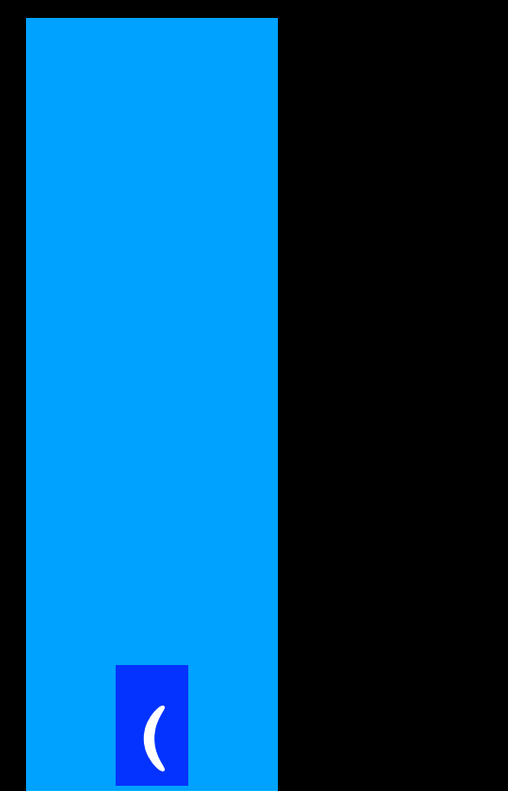

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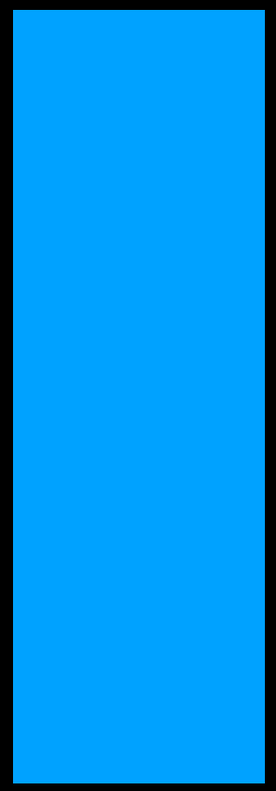

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push

Balancing Parentheses

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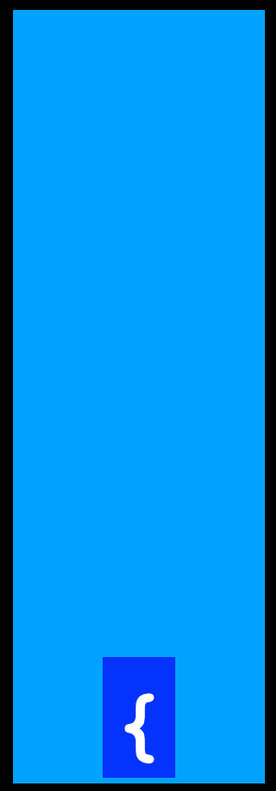

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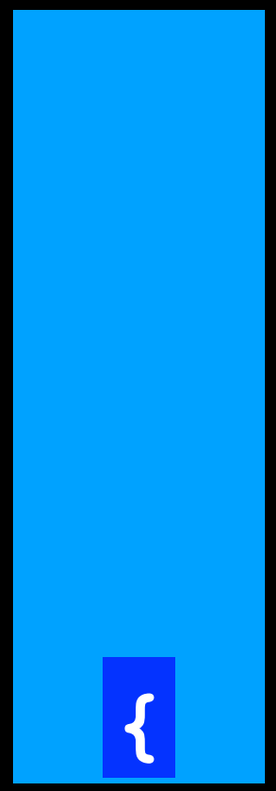

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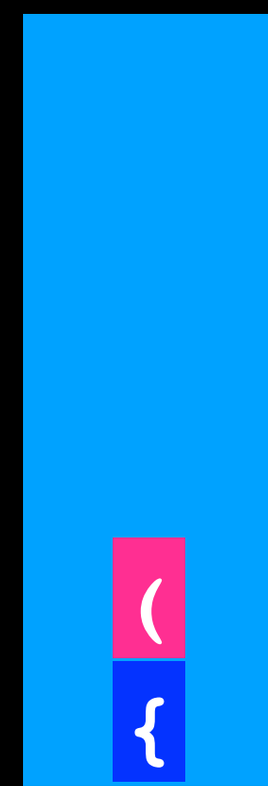

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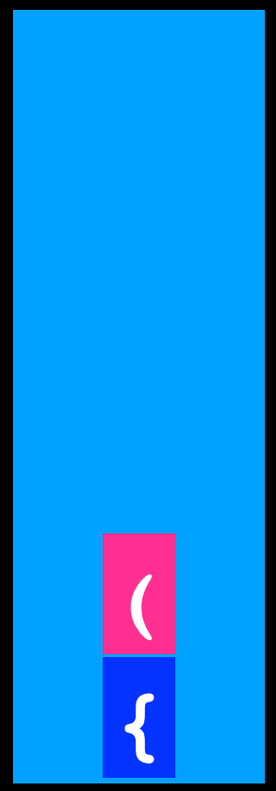

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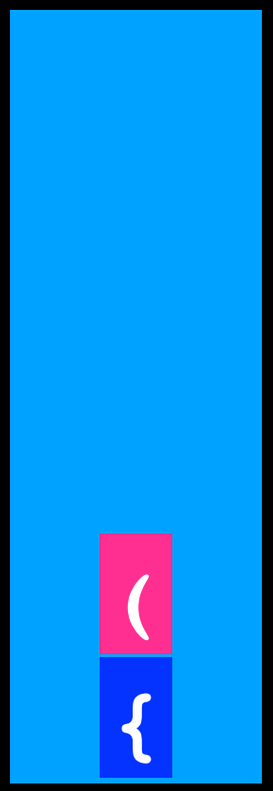

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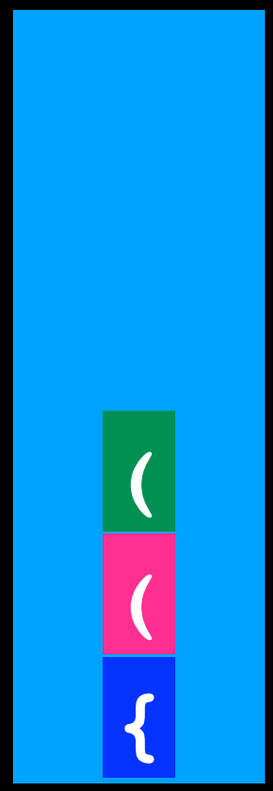

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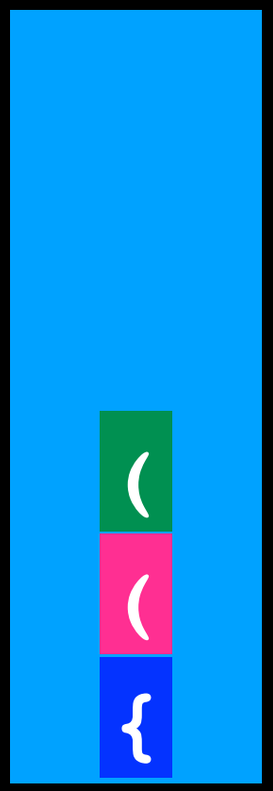

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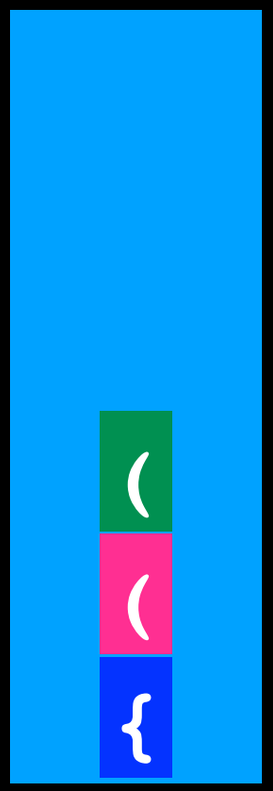

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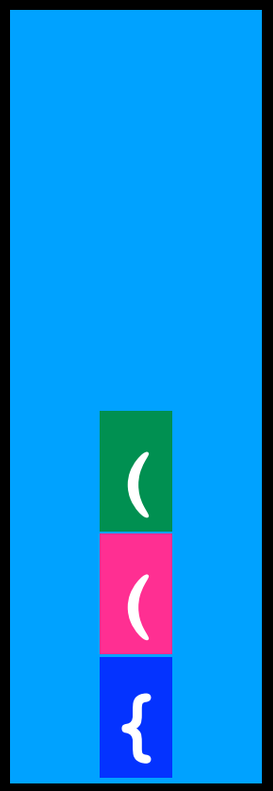

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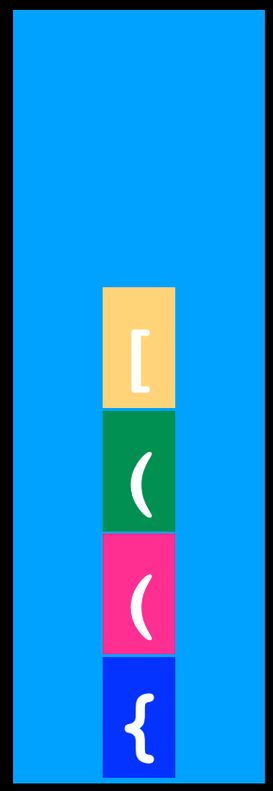

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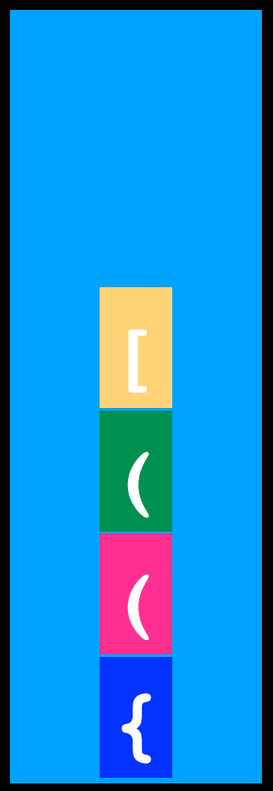

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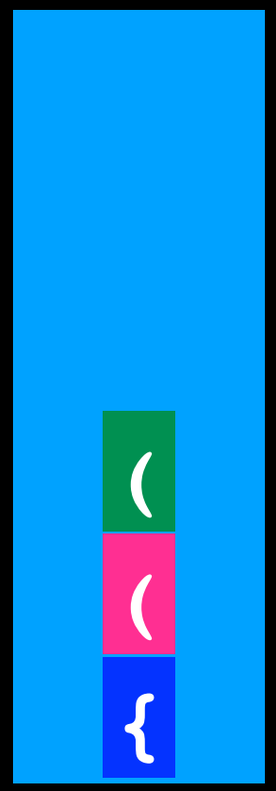
pop



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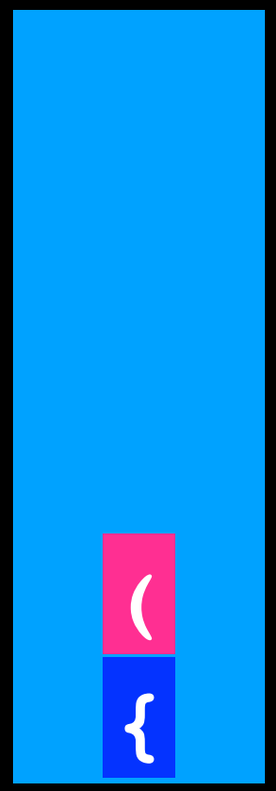

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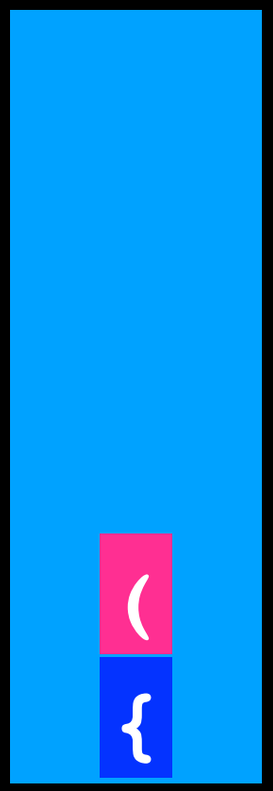

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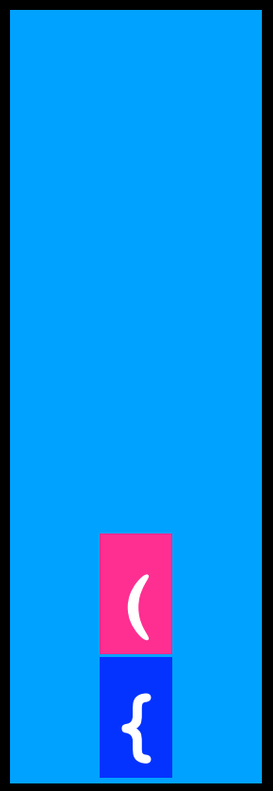

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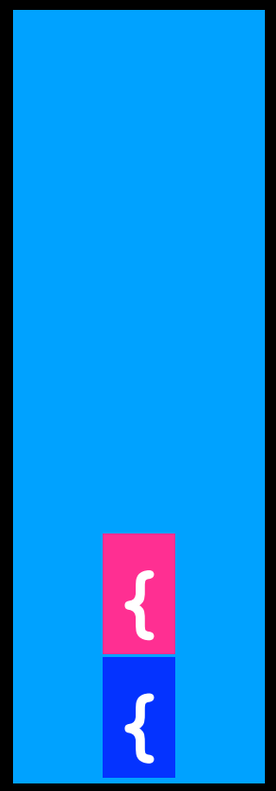

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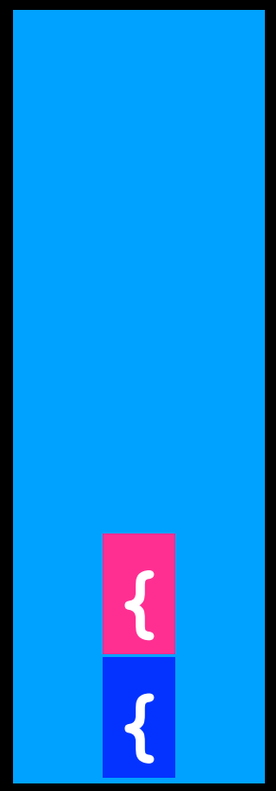

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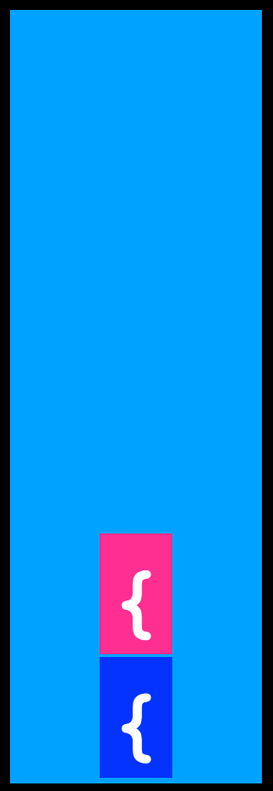

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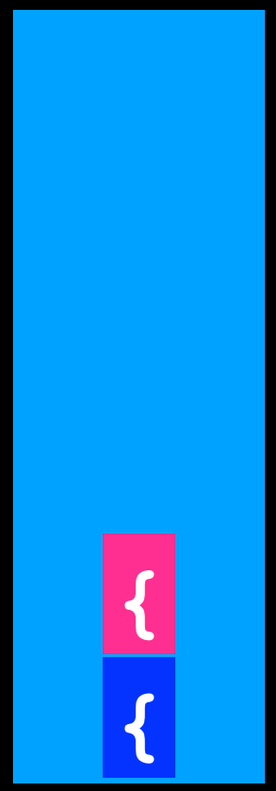

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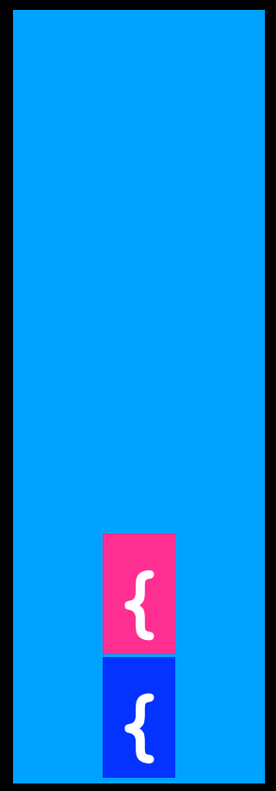

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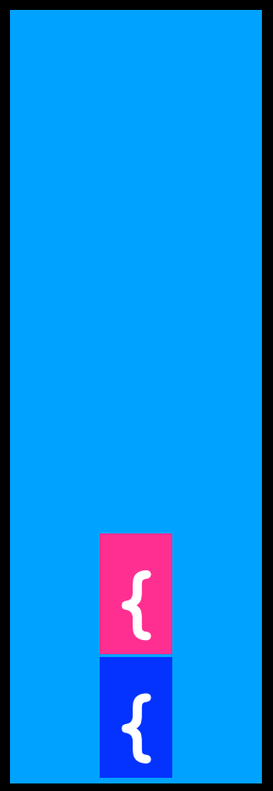

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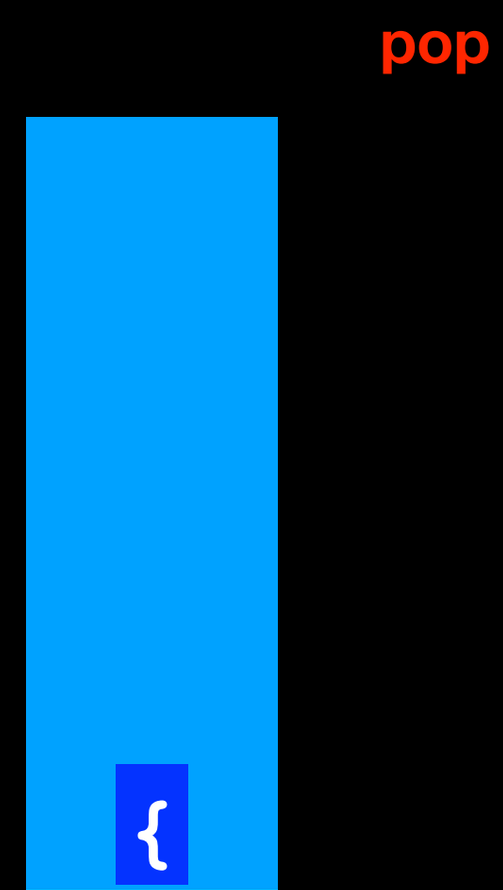

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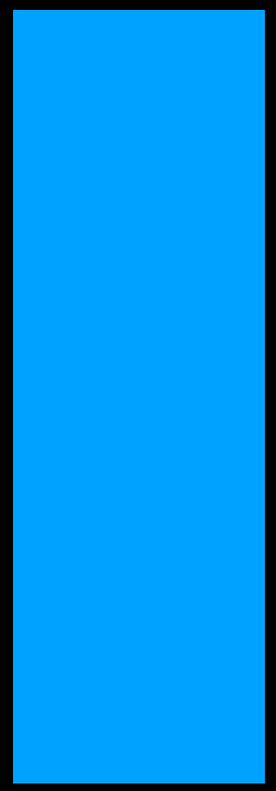
pop



Finished reading
Stack is empty
Parentheses are balanced

Balancing Parentheses

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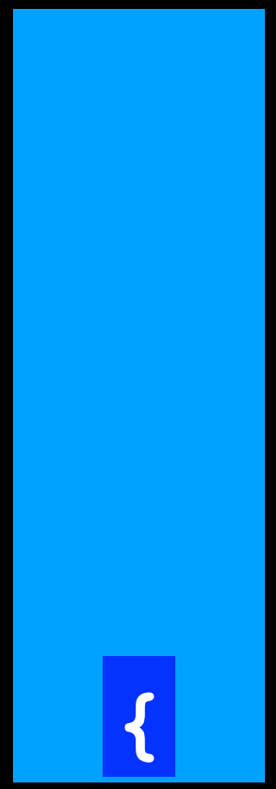


Finished reading
Stack not empty
Parentheses NOT balanced

Balancing Parentheses

```
for(char ch : st)
{
   if ch is an open parenthesis character
      push it on the stack
   else if ch is a close parenthesis character
      if it matches the top of the stack
      pop the stack
      else
         return unbalanced
   // else it is not a parenthesis
}

if stack is empty
   return balanced
else
   return unbalanced
```

Evaluating Postfix Expressions

Postfix Expressions

Operator applies to the two operands immediately preceding it

Infix:	Postfix:
2 * (3 + 4)	2 3 4 + *
2 * 3 + 4	2 3 * 4 +

Evaluating Postfix Expressions

Operator applies to the two operands immediately preceding it

Postfix:

2 3 4 + *

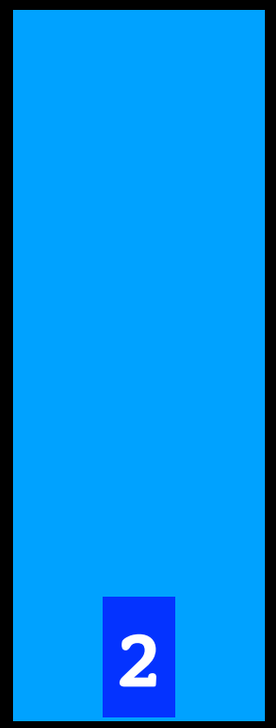
Assumptions / simplifications:

- String is syntactically correct postfix expression
- No unary operators
- No exponentiation operation
- Operands in string are single integer values

Evaluating Postfix Expressions

Postfix:

2 3 4 + *



Evaluating Postfix Expressions

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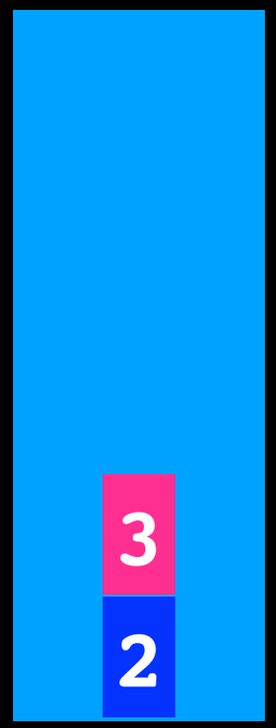

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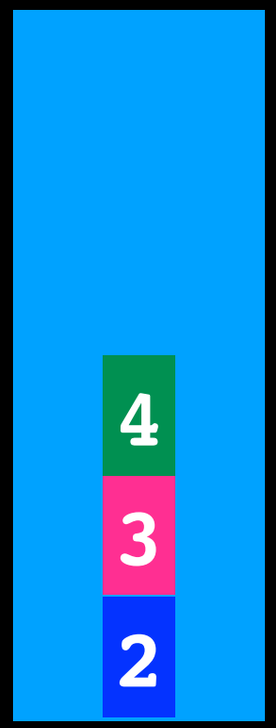

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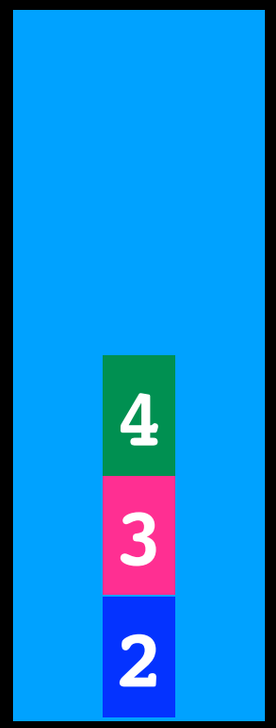

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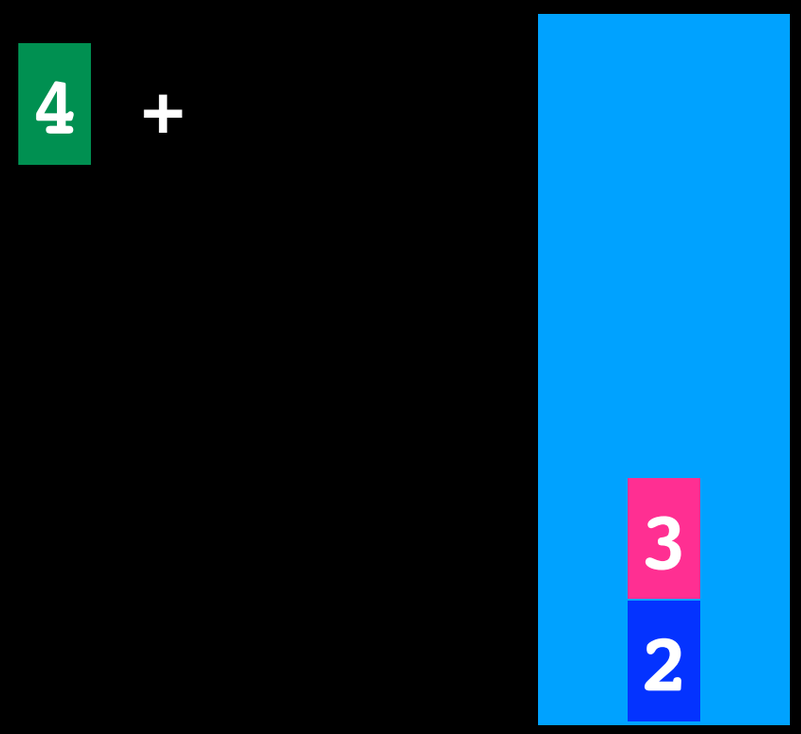

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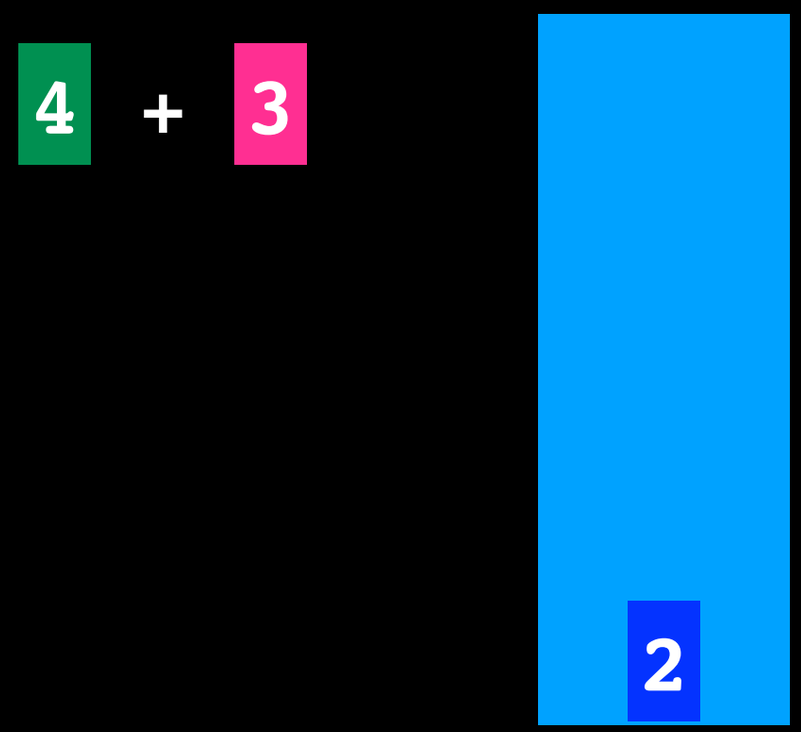
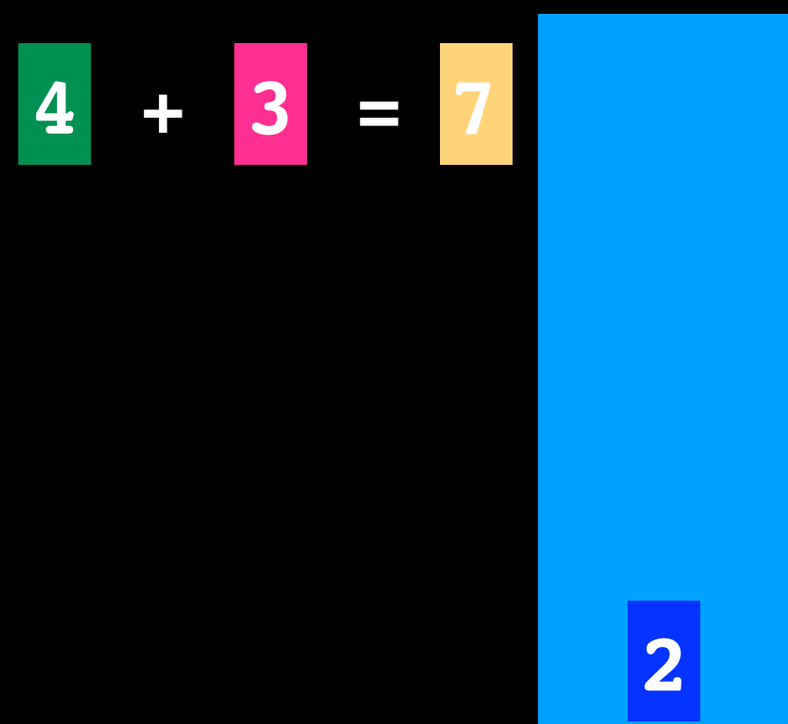


Evaluating Postfix Expressions

Postfix:

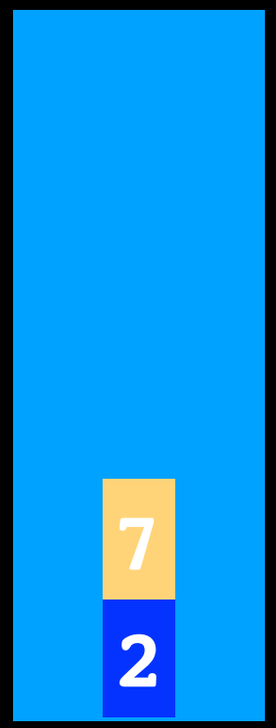
2 3 4 + *



Evaluating Postfix Expressions

Postfix:

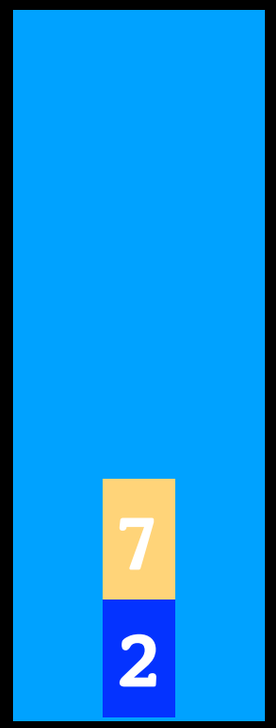
2 3 4 + *



Evaluating Postfix Expressions

Postfix:

2 3 4 + *



Evaluating Postfix Expressions

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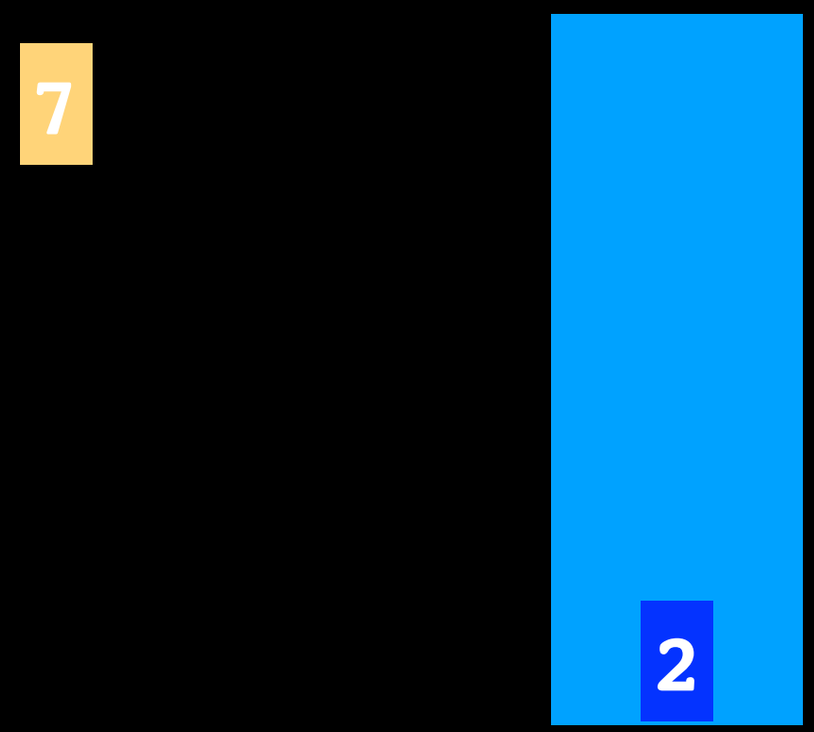
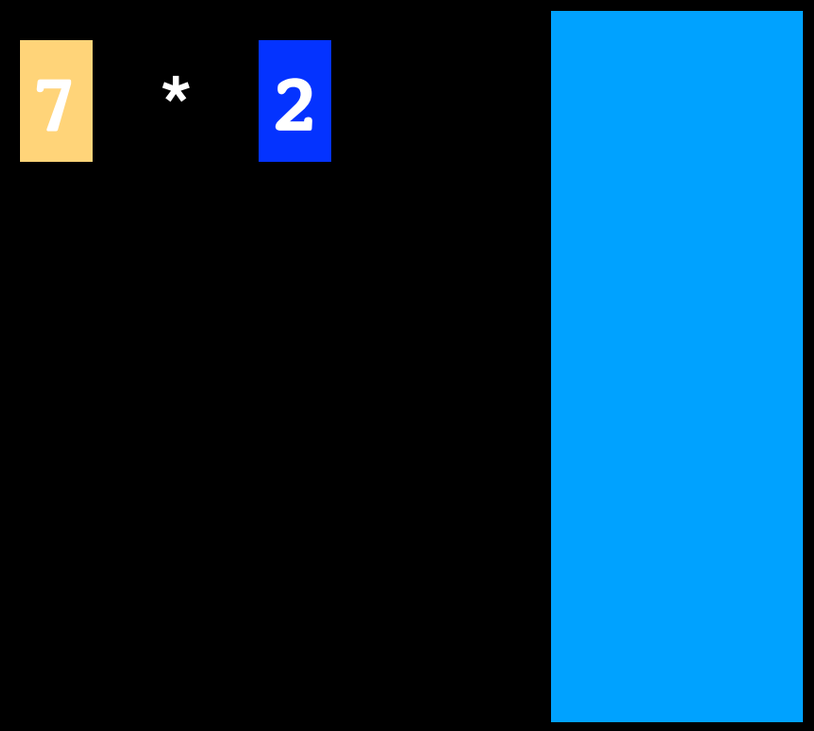


Evaluating Postfix Expressions

Postfix:

2 3 4 + *



Evaluating Postfix Expressions

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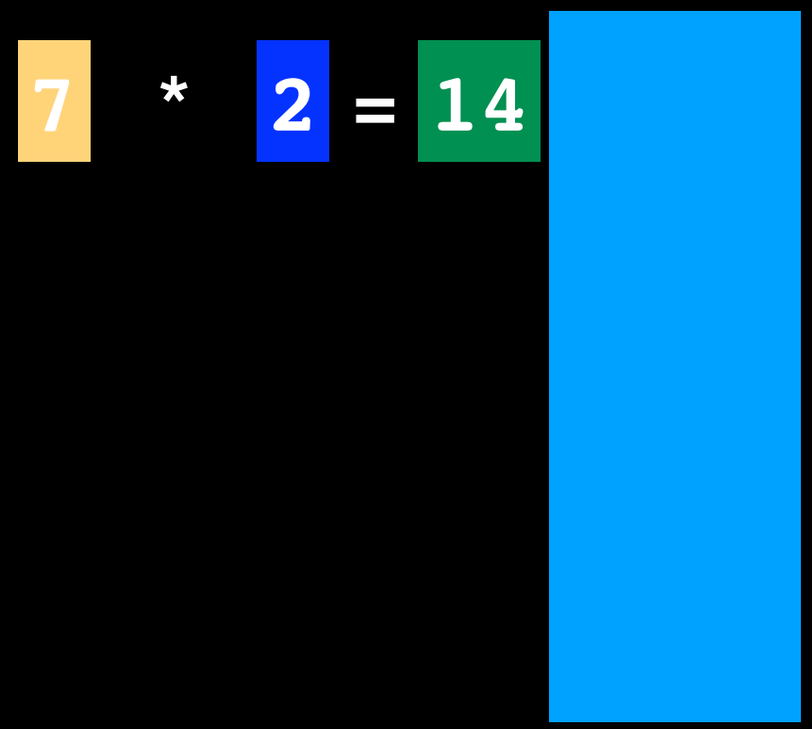
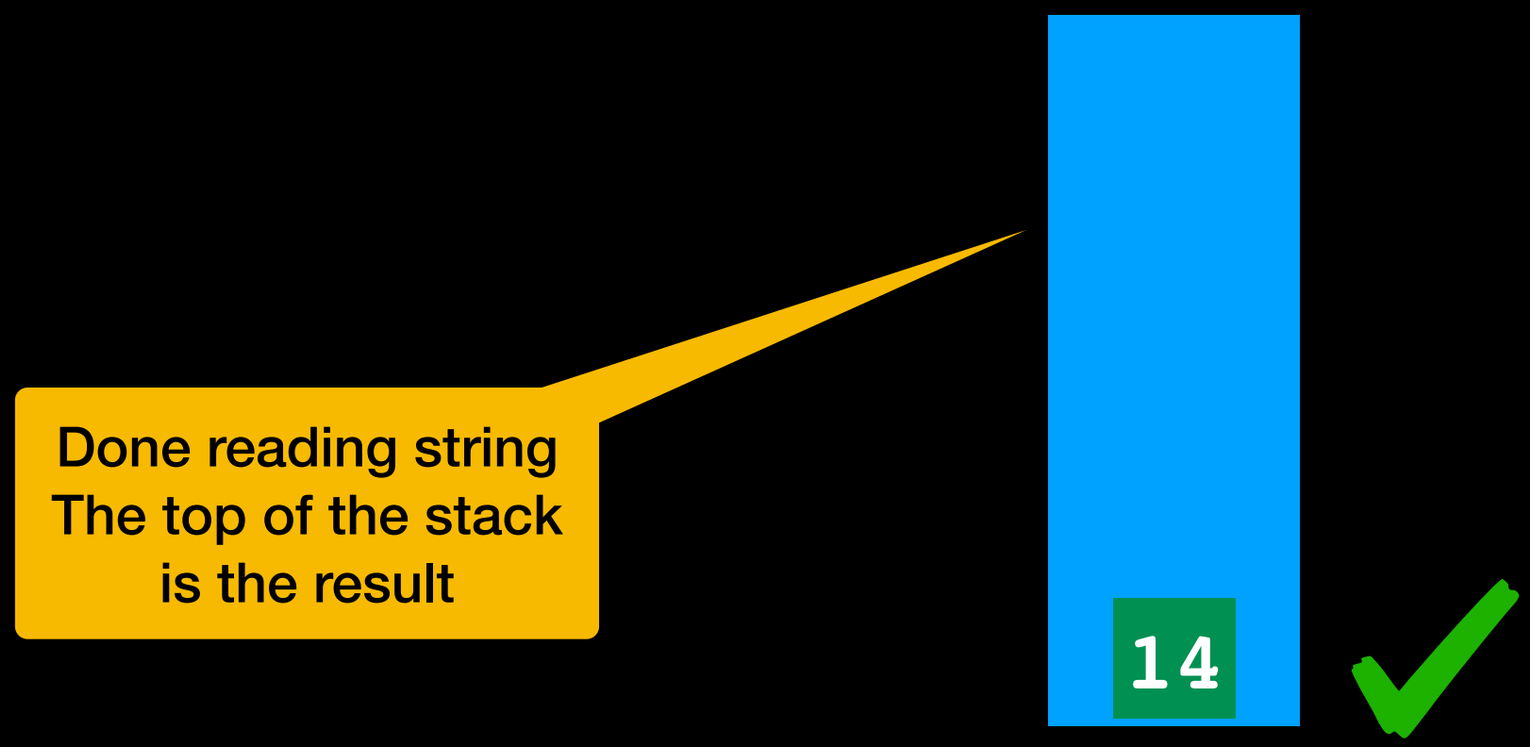
2 3 4 + *



Evaluating Postfix Expressions

Postfix:

2 3 4 + *



Evaluating Postfix Expressions

Operator applies to the two operands immediately preceding it

Postfix:

2 3 * 4 +

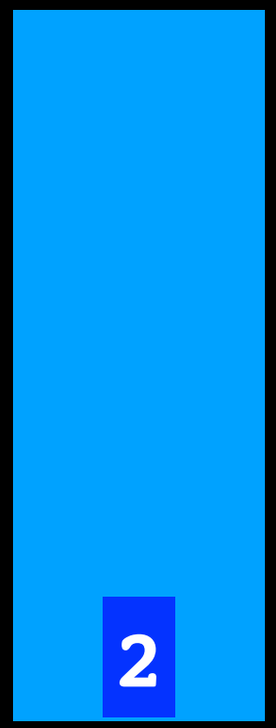
Assumptions / simplifications:

- string is syntactically correct postfix expression
- No unary operators
- No exponentiation operation
- Operands in string are single integer values

Evaluating Postfix Expressions

Postfix:

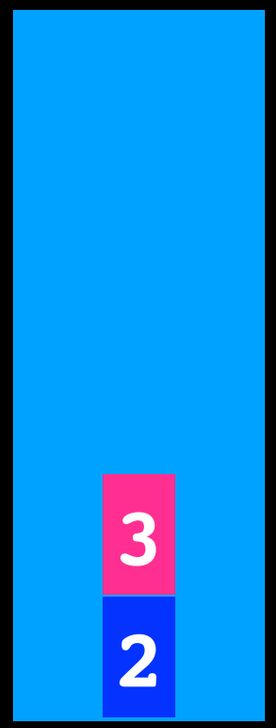
2 3 * 4 +



Evaluating Postfix Expressions

Postfix:

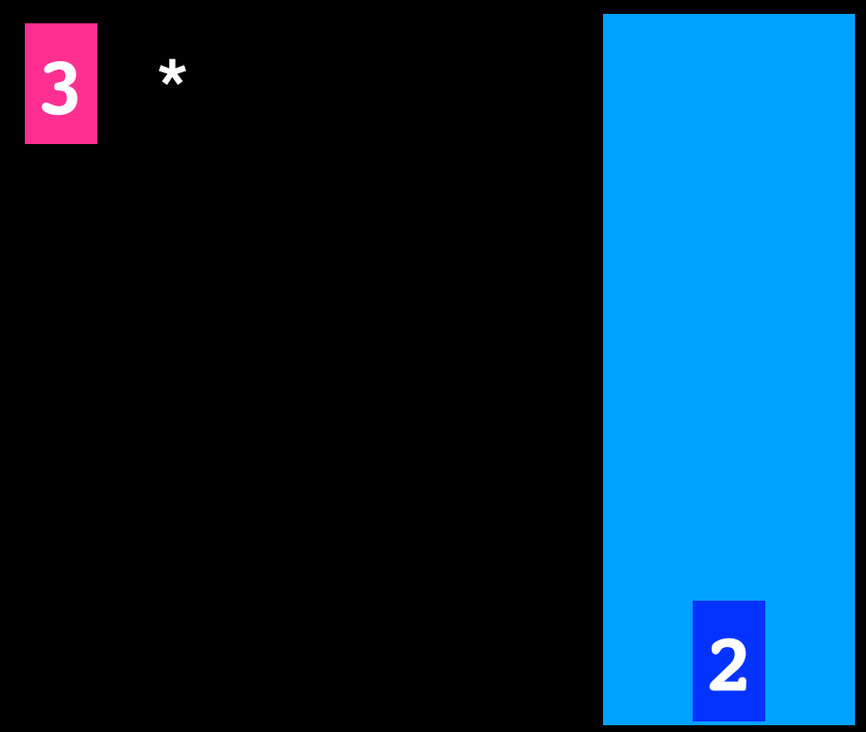
2 3 * 4 +



Evaluating Postfix Expressions

Postfix:

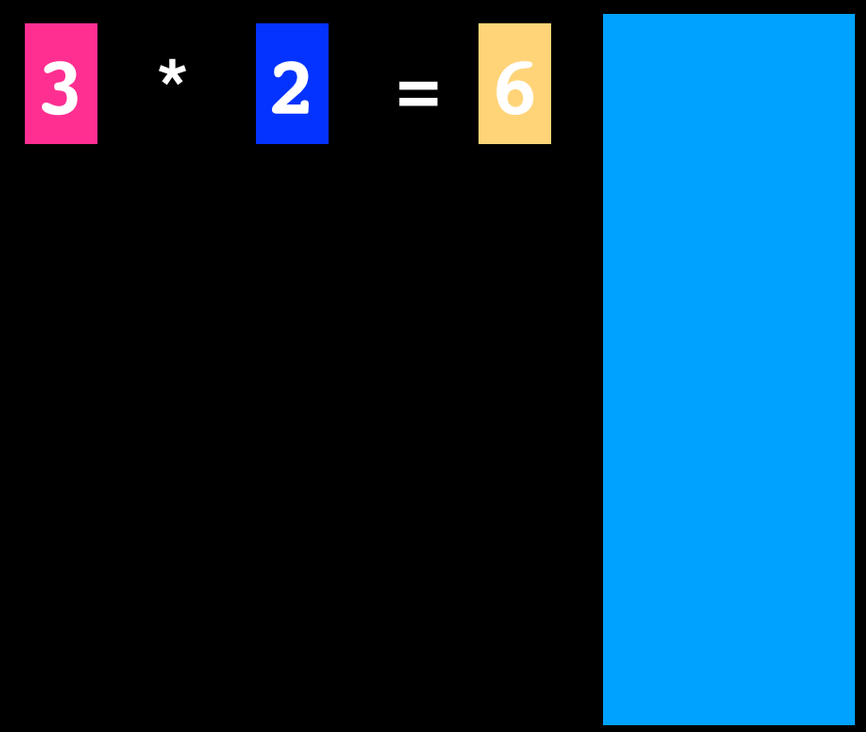
2 3 * 4 +



Evaluating Postfix Expressions

Postfix:

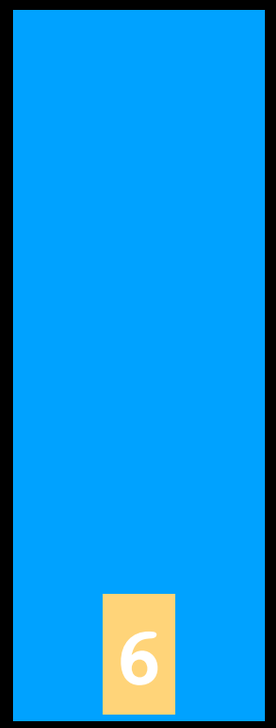
2 3 * 4 +



Evaluating Postfix Expressions

Postfix:

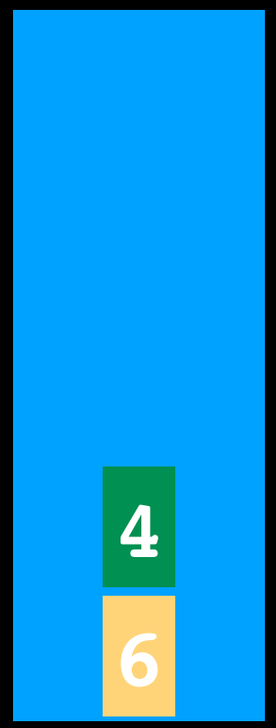
2 3 * 4 +



Evaluating Postfix Expressions

Postfix:

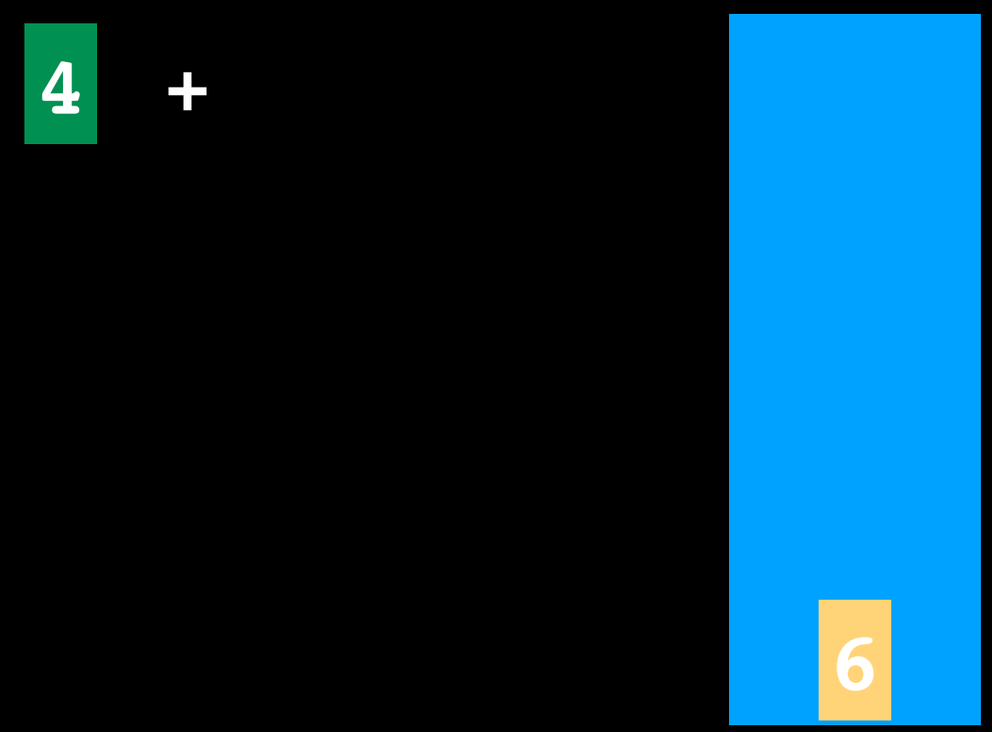
2 3 * 4 +



Evaluating Postfix Expressions

Postfix:

2 3 * 4 +

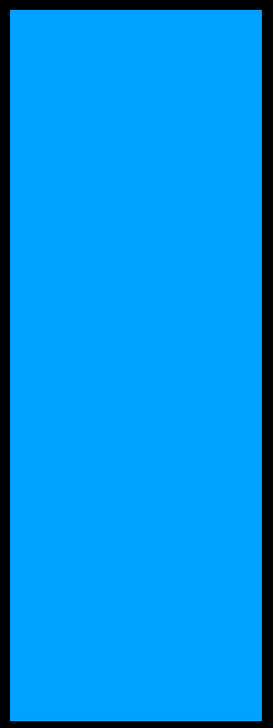


Evaluating Postfix Expressions

Postfix:

2 3 * 4 +

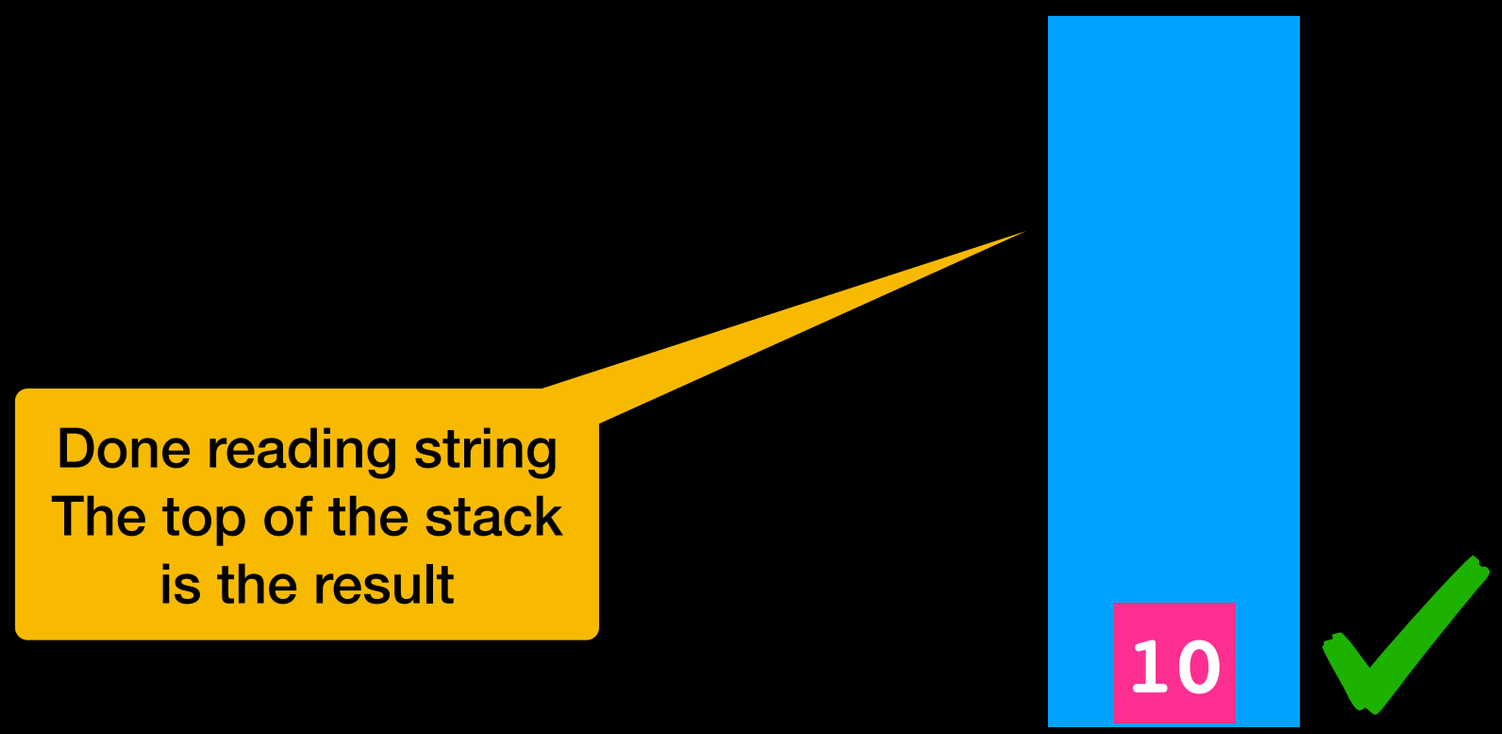
4 + 6 = 10



Evaluating Postfix Expressions

Postfix:

2 3 * 4 +



Evaluating Postfix Expressions

```
for(char ch : st)
{
   if ch is an operand
       push it on the stack
   else // ch is an operator op
   {
       //evaluate and push the result
     operand2 = pop stack
     operand1 = pop stack
     result = operand1 op operand2
     push result on stack
    }
}
```

Lecture Activity

Describe an algorithm that translates the infix expression below into postfix (you can use drawings to explain):

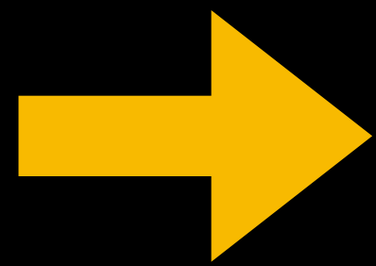
Infix:
2 * (3 + 4)

Postfix:
2 3 4 + *

Hint: use 2 stacks, one for operators and parentheses another one for the operands and postfix expression. Once converted use the empty stack to invert the order

Infix:

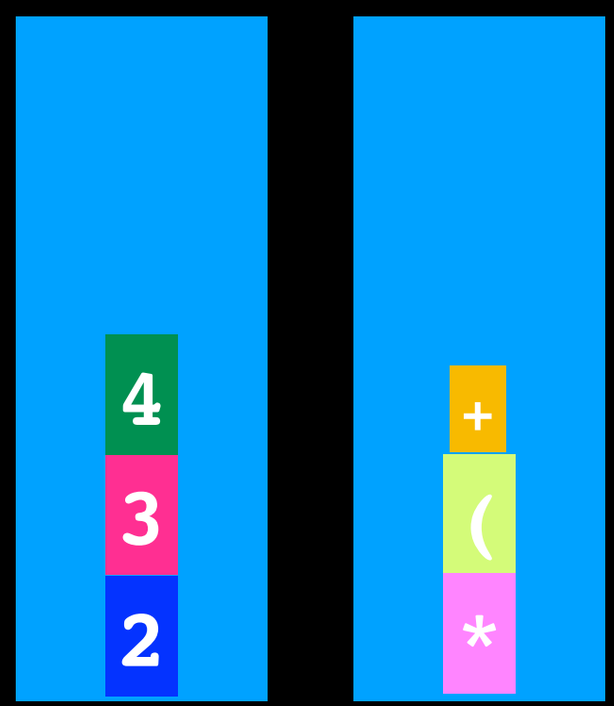
2 * (3 + 4)



Postfix:

2 3 4 + *

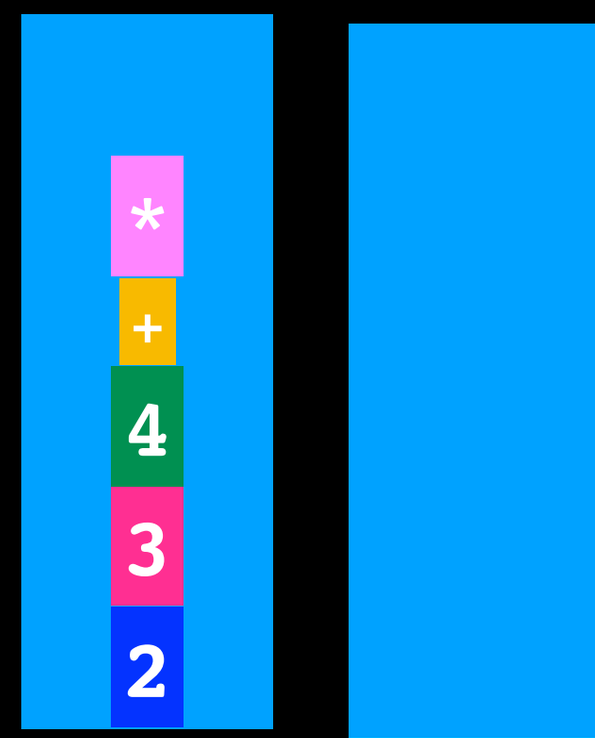
1. Read characters onto corresponding stack until ')'



Postfix Stack

Operator Stack

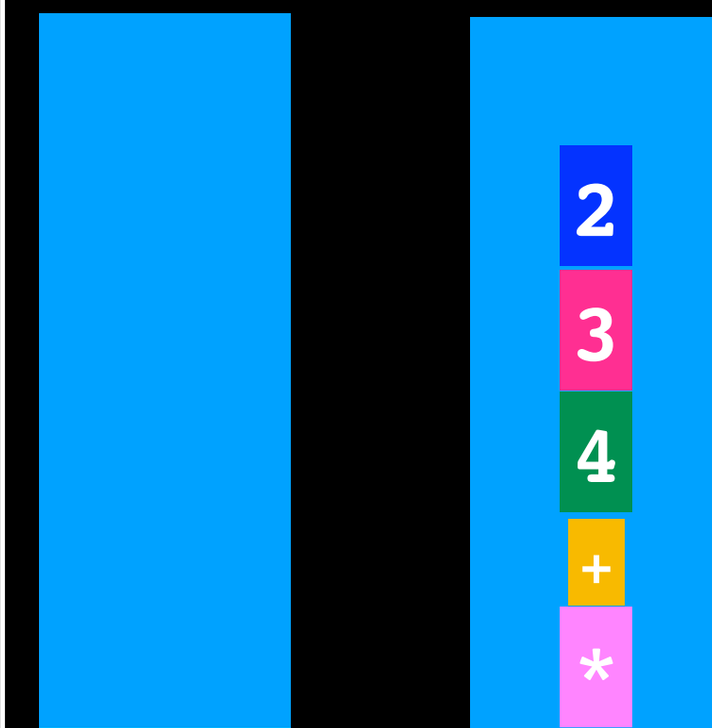
2. Pop operator stack and push it onto postfix stack ignoring '('



Postfix Stack

Operator Stack

3. Push everything onto empty stack to invert
Then read pop and print.

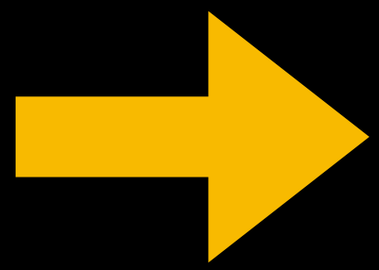


Postfix Stack

Operator Stack

Infix:

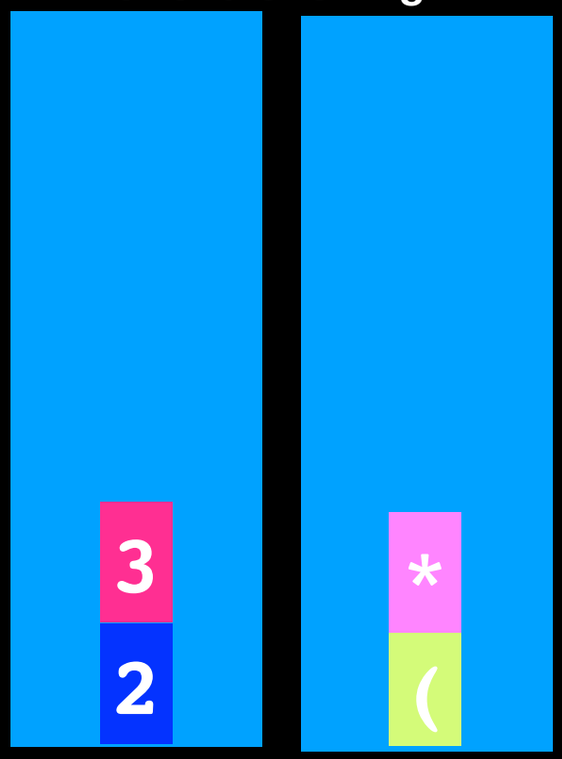
(2 * 3)+ 4



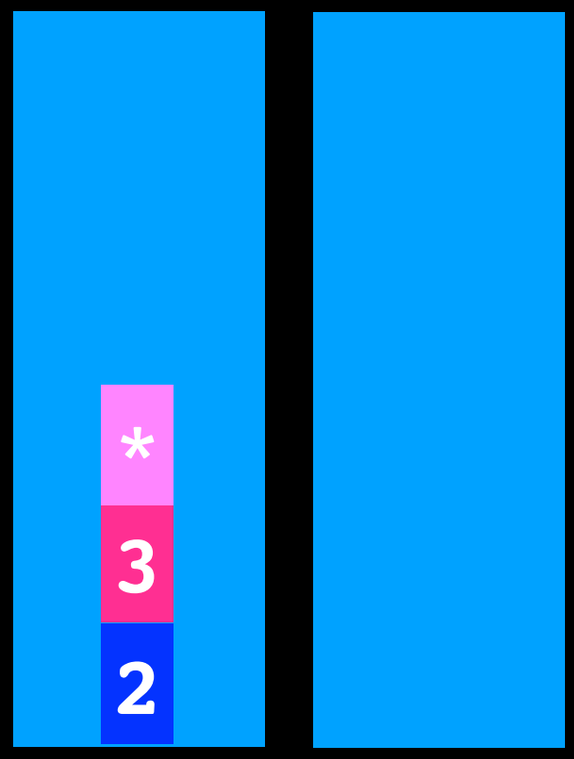
Postfix:

2 3 *4 +

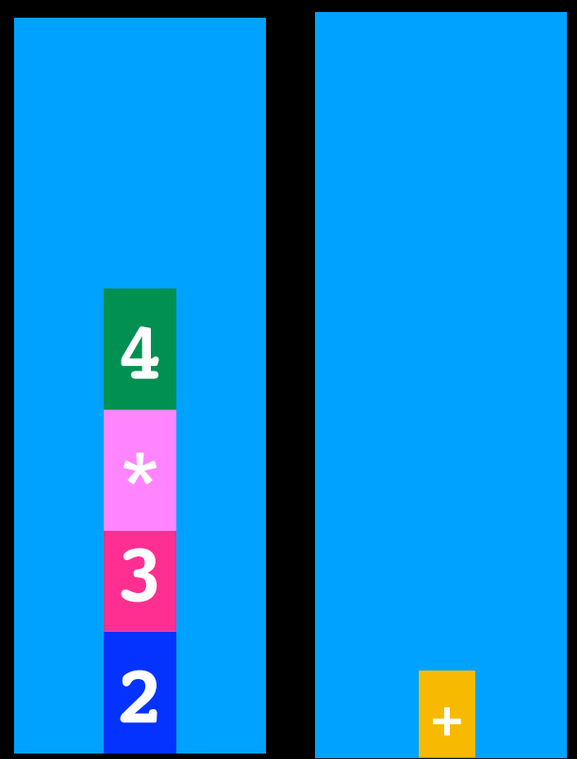
1. Read characters onto corr. stack until ')' or end of string



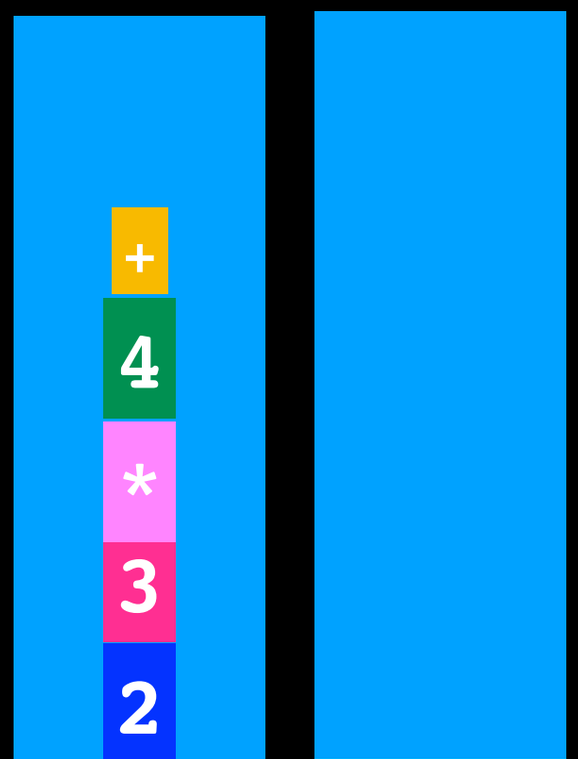
2. If reading a ')', move operators to Postfix Stack until a '(' discard it and continue reading string



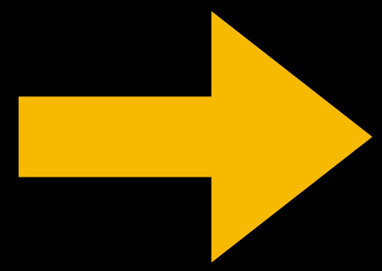
3. Keep reading until ')' -> 2. or end of string -> 4.



4. Move operators to Postfix Stack

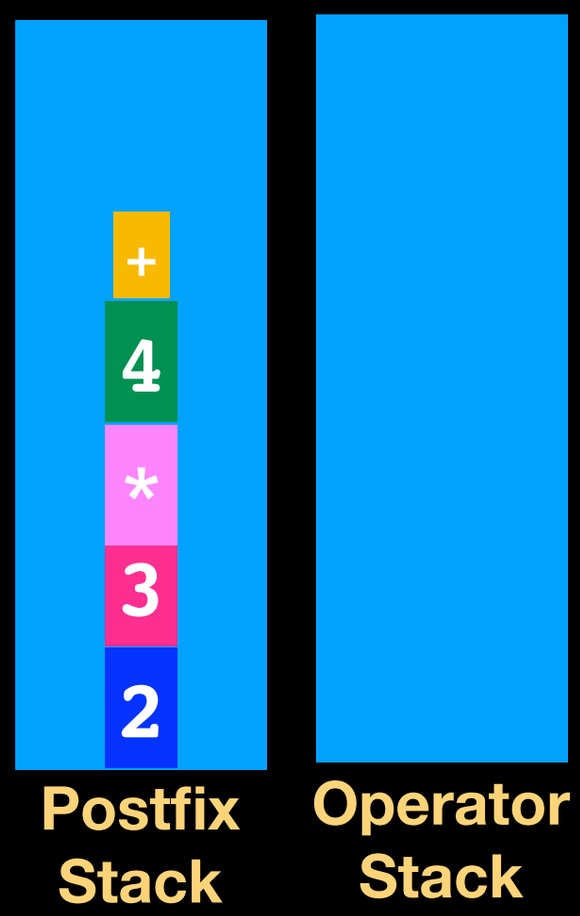


Infix:
(2 * 3)+ 4

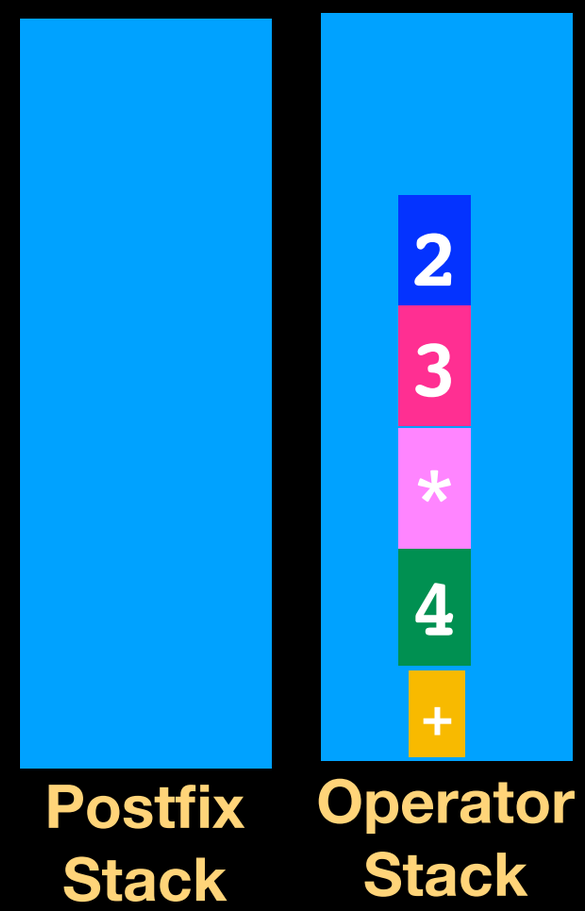


Postfix:
2 3 *4 +

4. Move operators to Postfix Stack



5. Pop and push onto empty stack to invert, then print



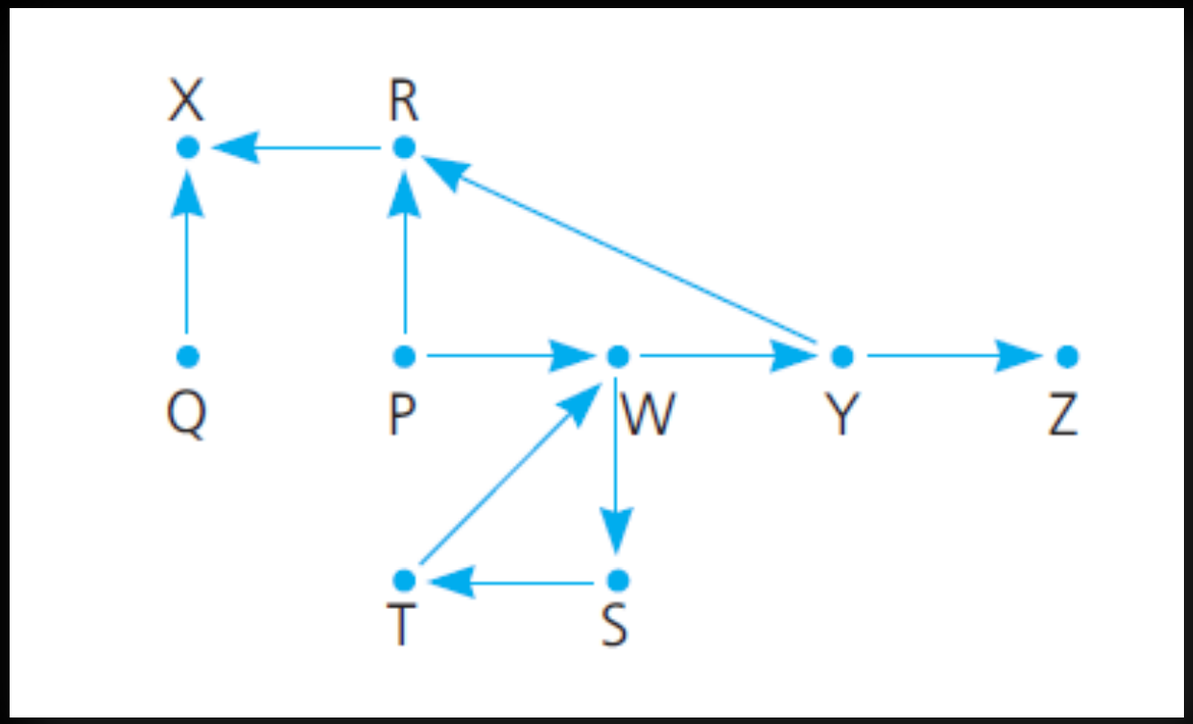
Search a Flight Map

Fly from Origin to Destination following map

1. Reach destination

2. Reach city with no departing flights (dead end)

3. Go in circles forever



Backtracking

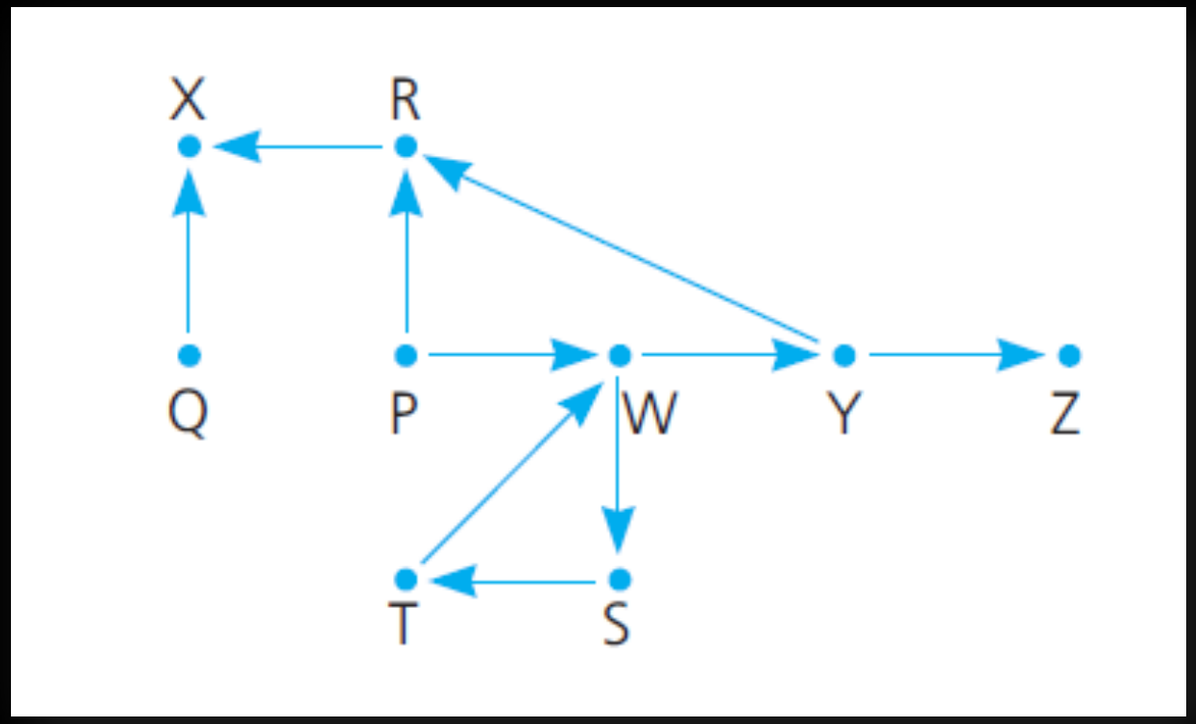
C = visited

C = backtracked

Avoid dead end by backtracking

Avoid traveling in circles by marking visited cities

Origin = P , Destination = Z



P

Backtracking

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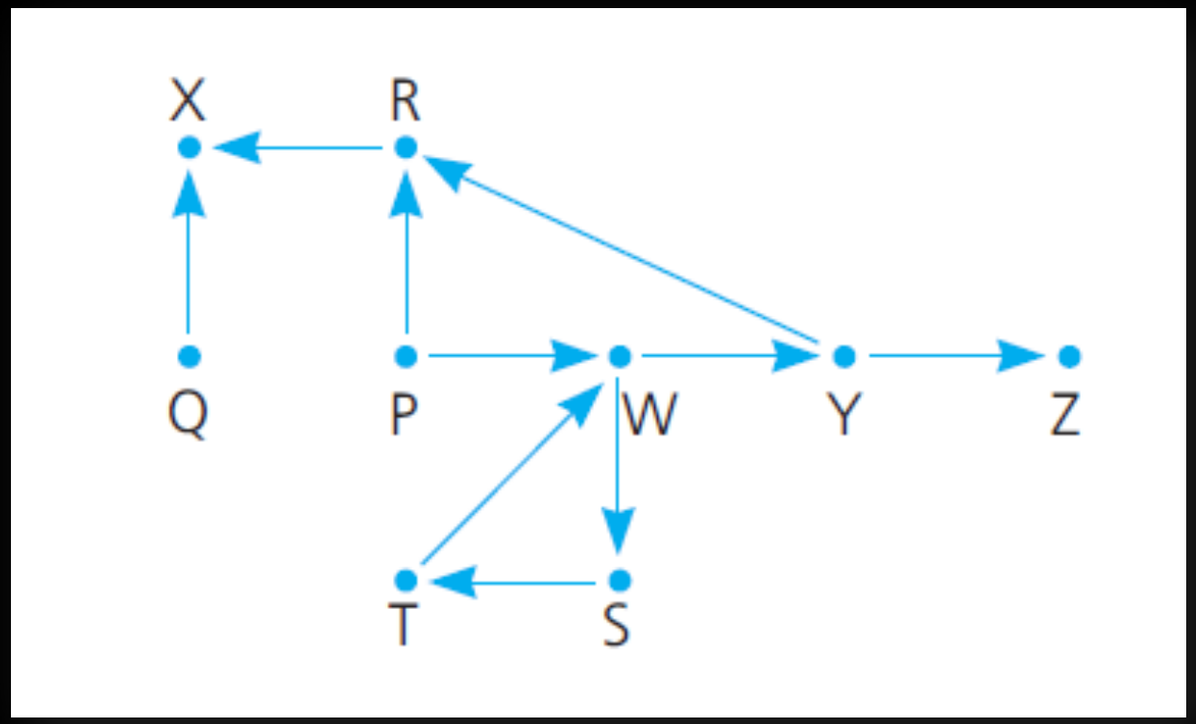


P

R

Backtracking

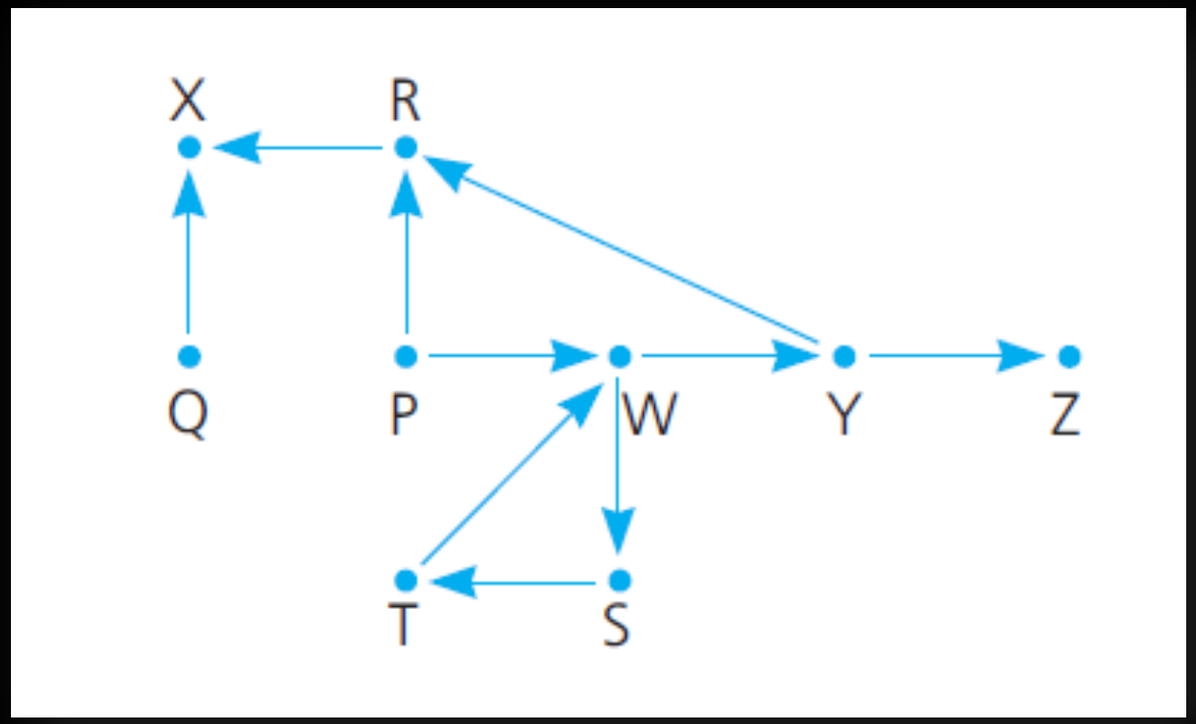
C = visited

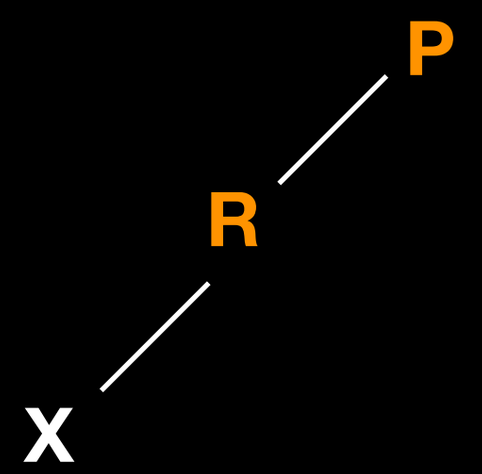
C = backtracked

Avoid dead end by backtracking

Avoid traveling in circles by marking visited cities

Origin = P , Destination = Z





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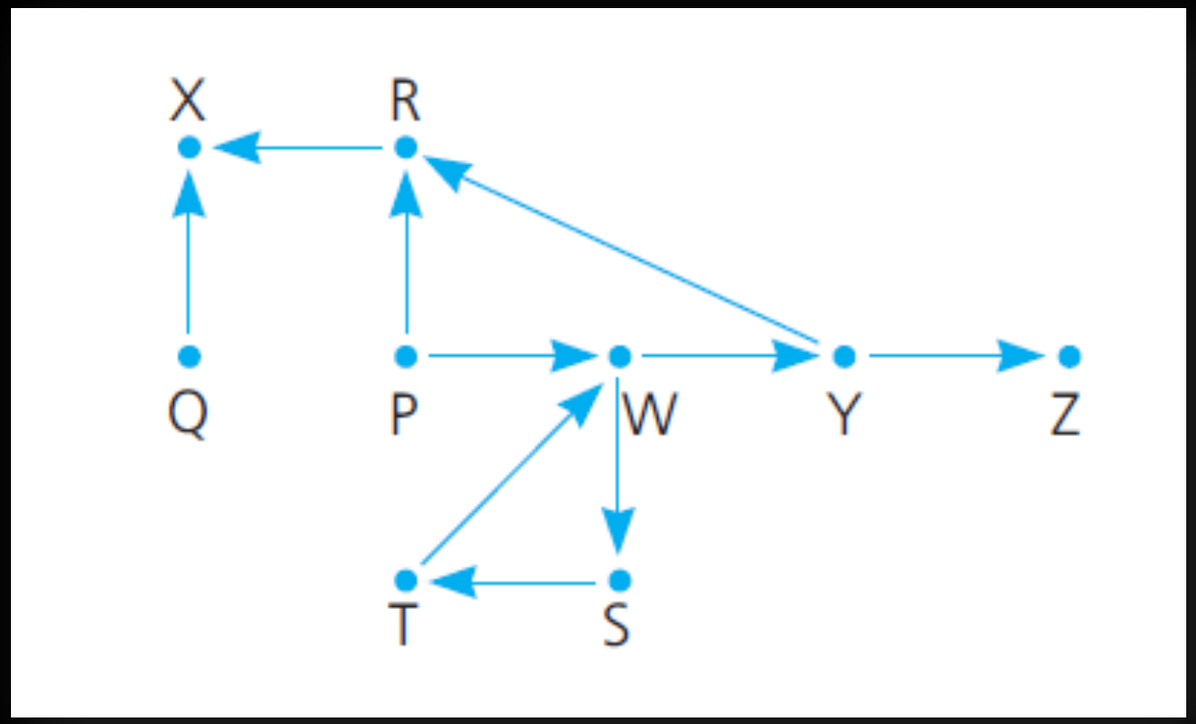

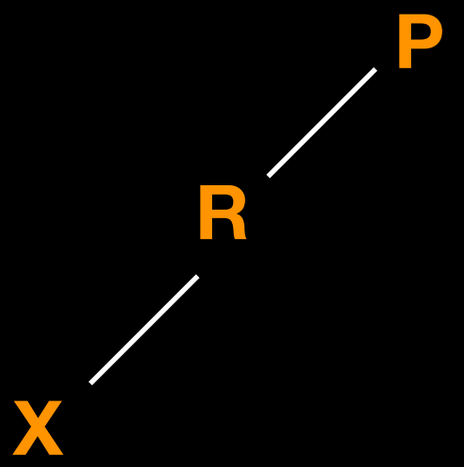

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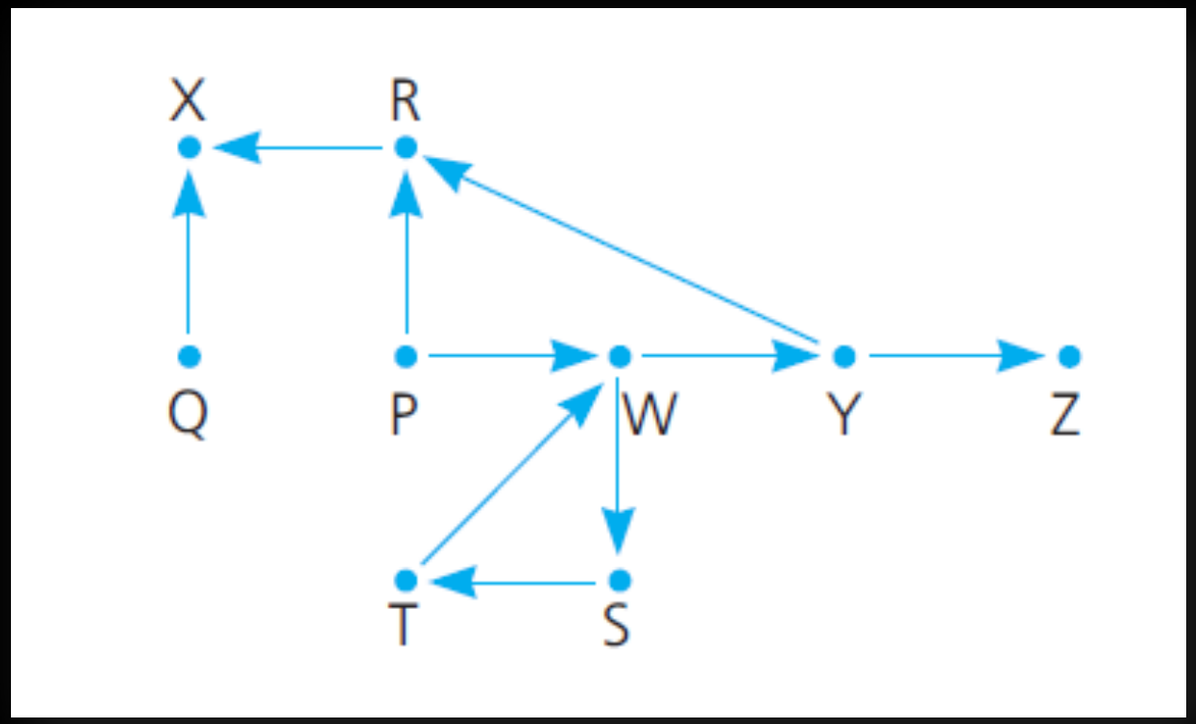

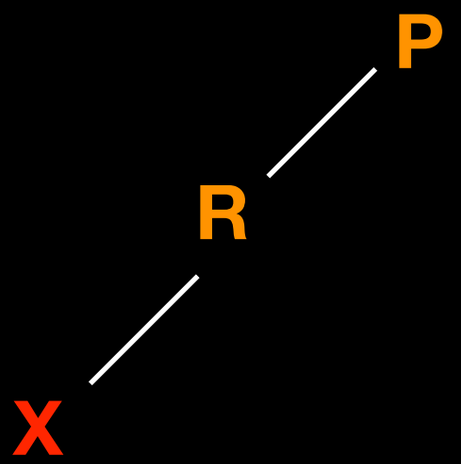

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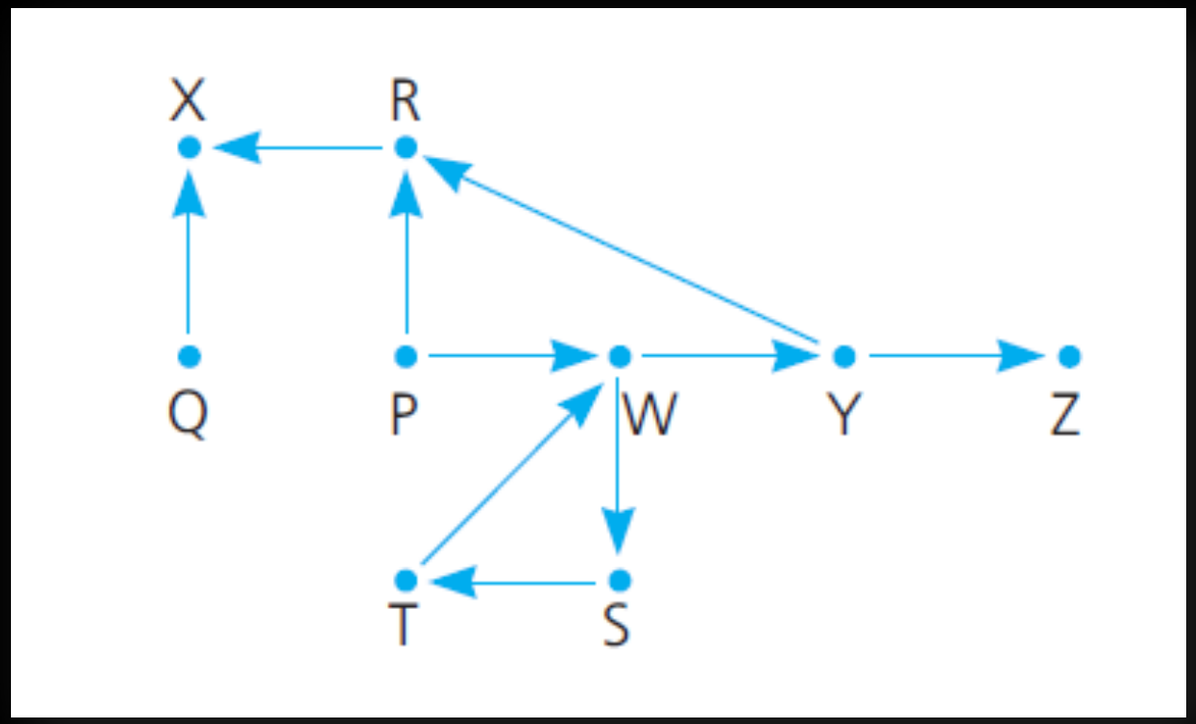

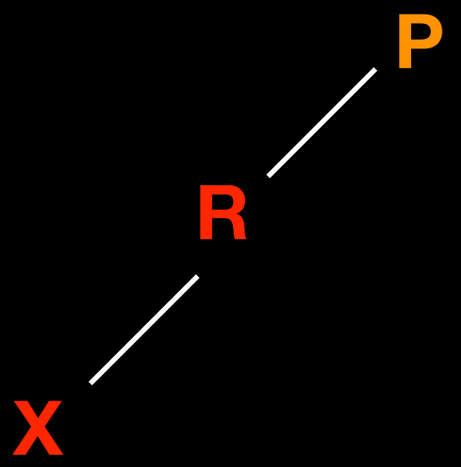

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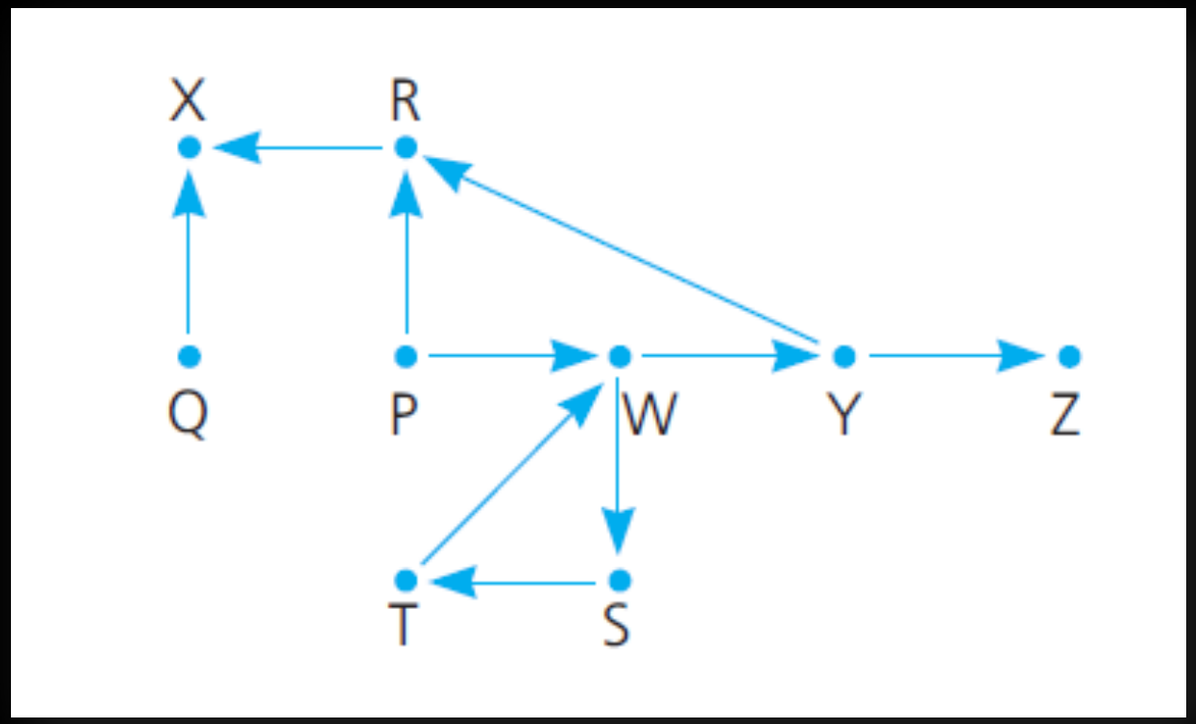

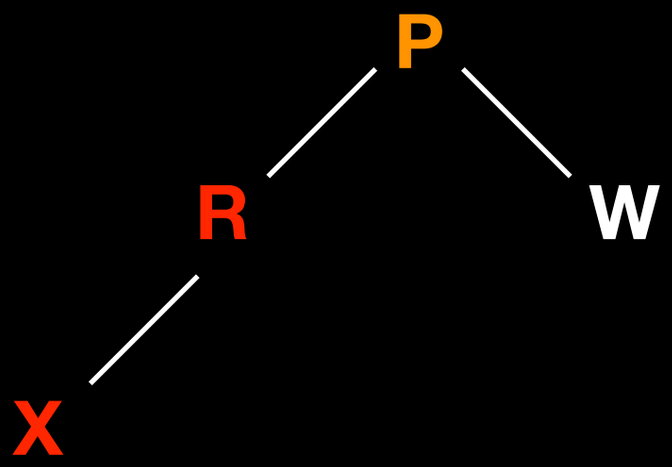

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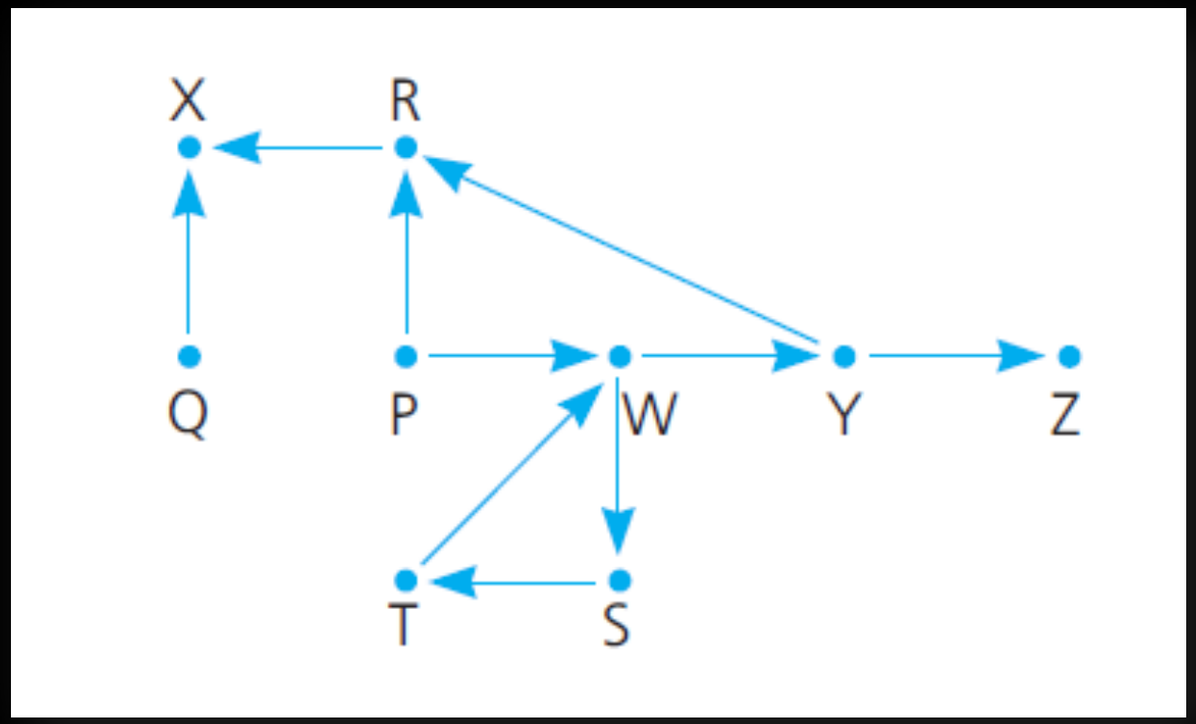

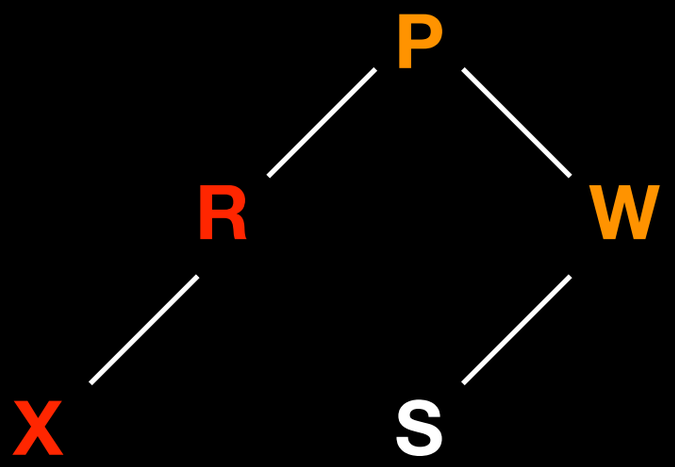

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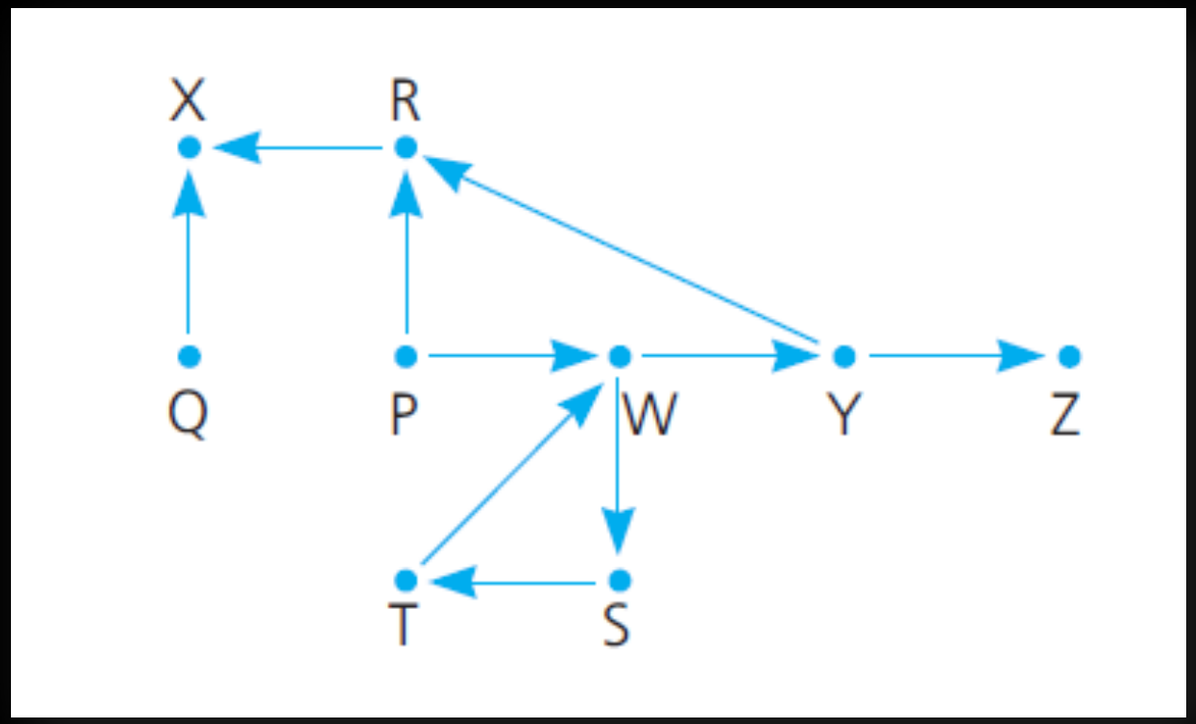

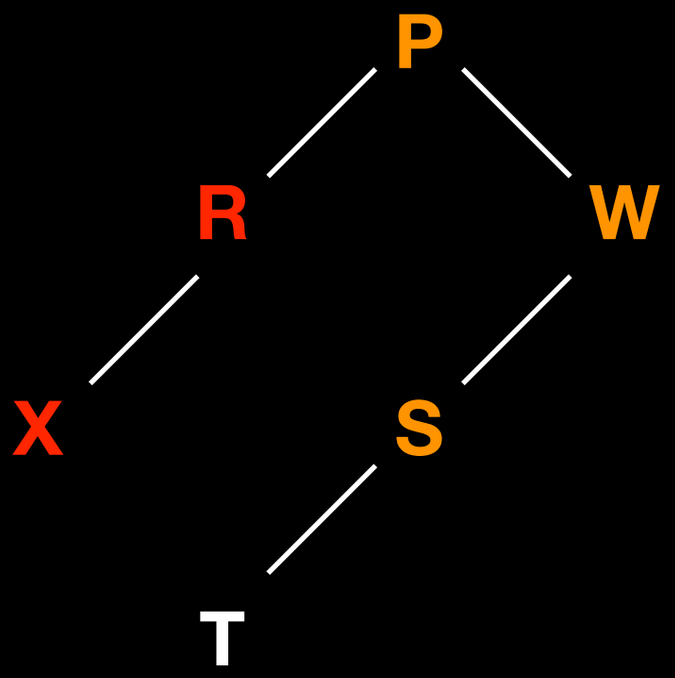

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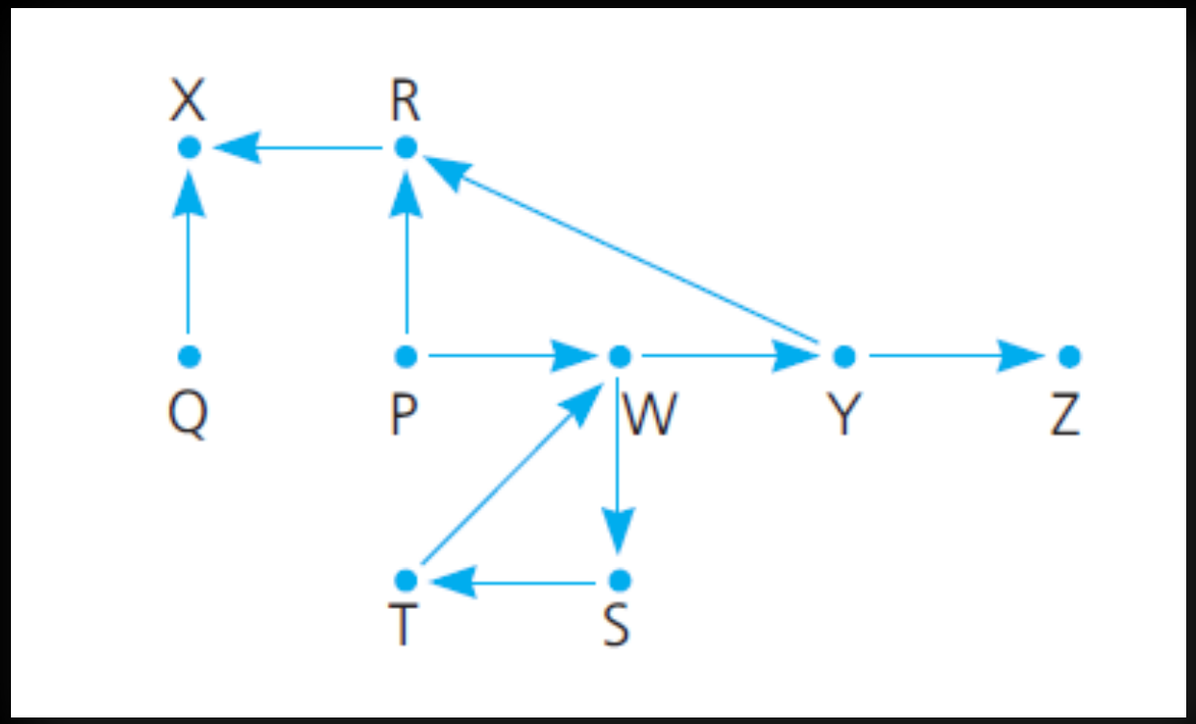

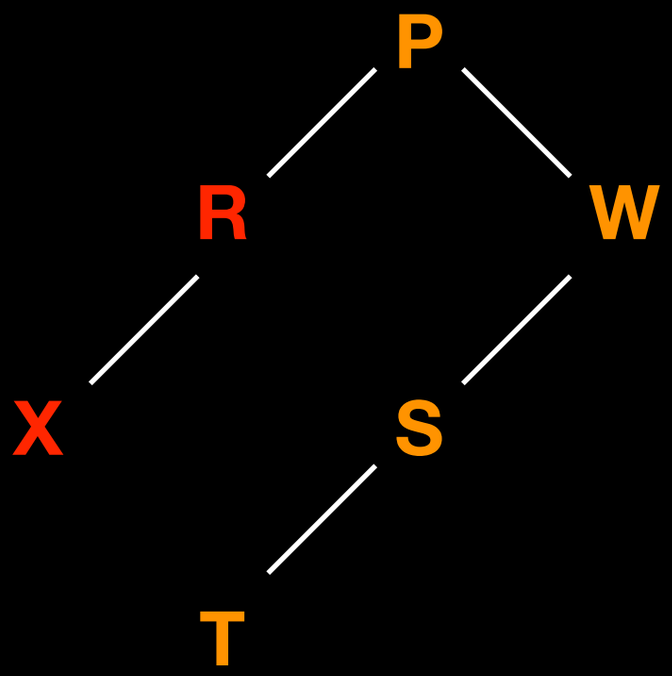

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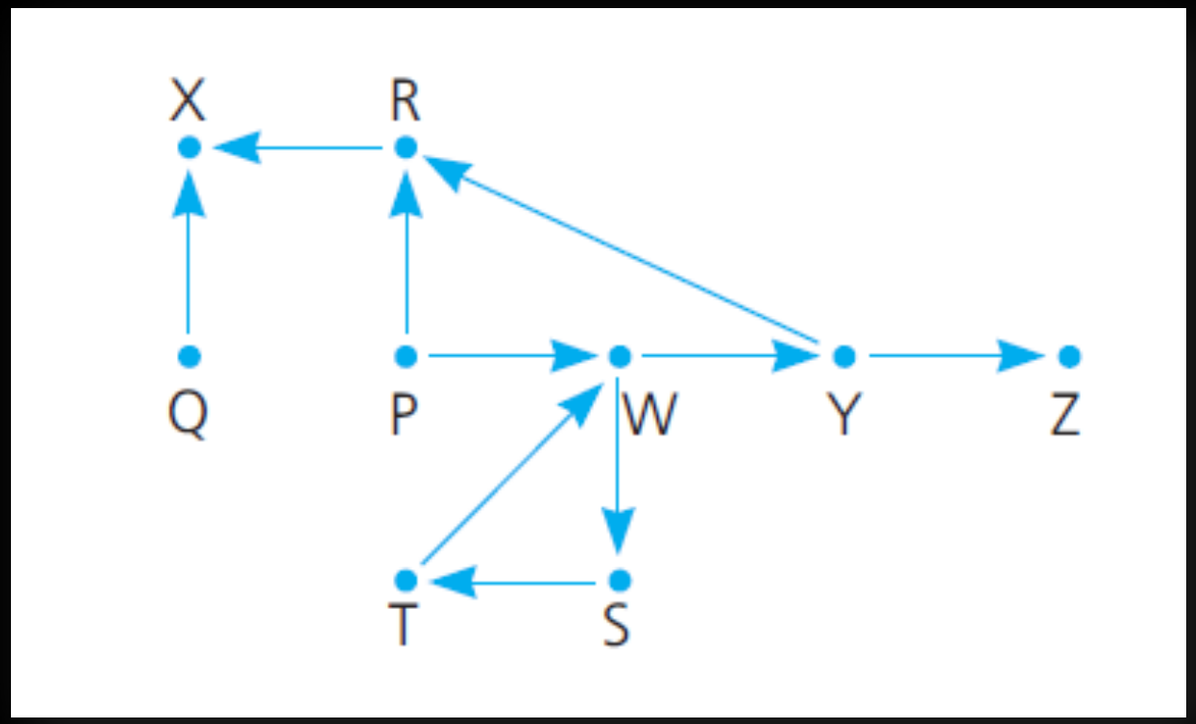

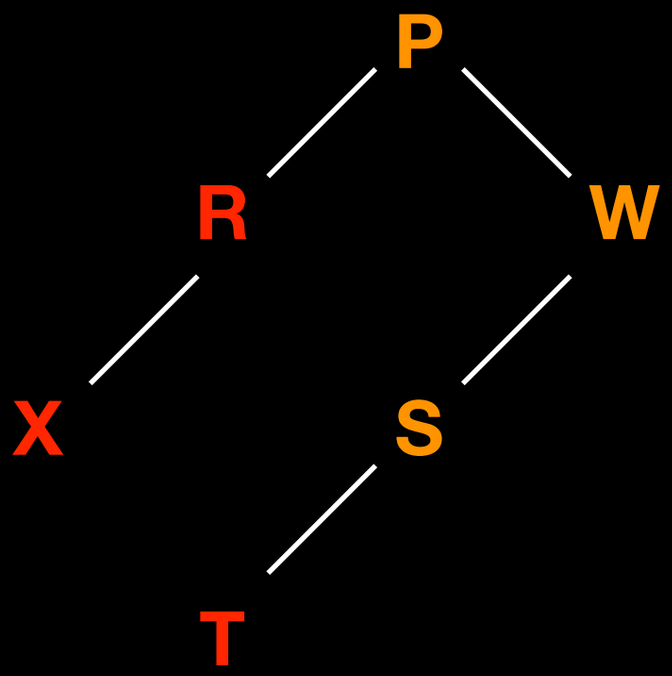

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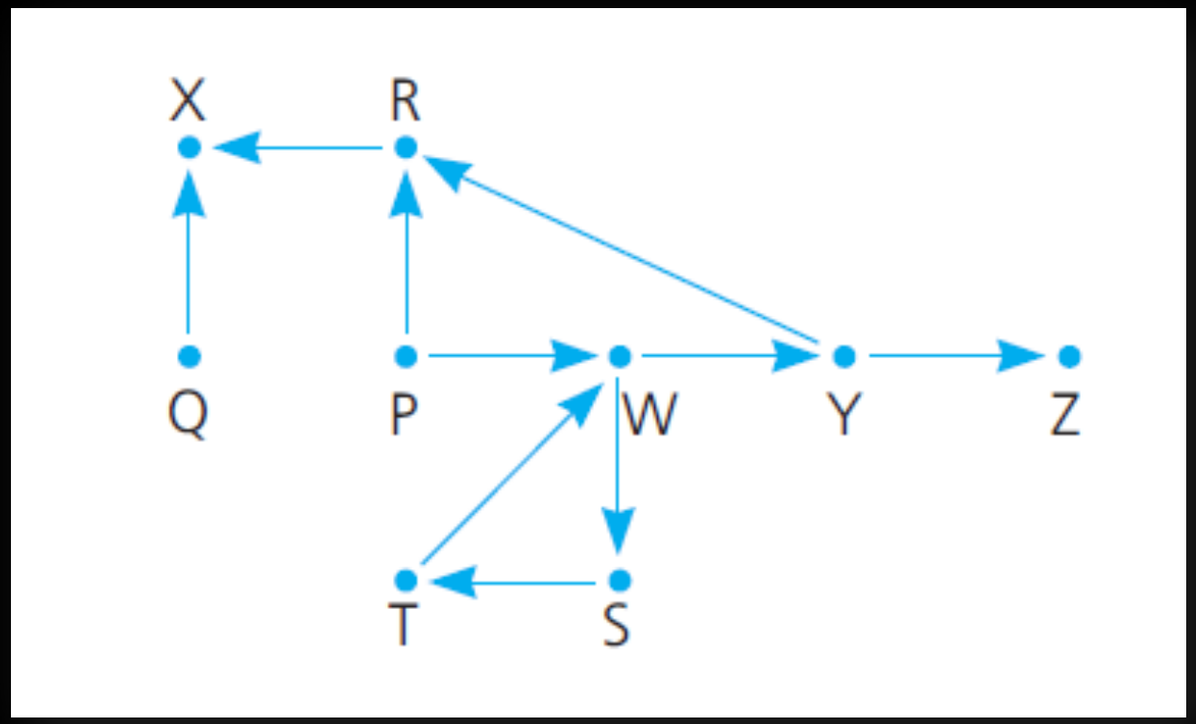

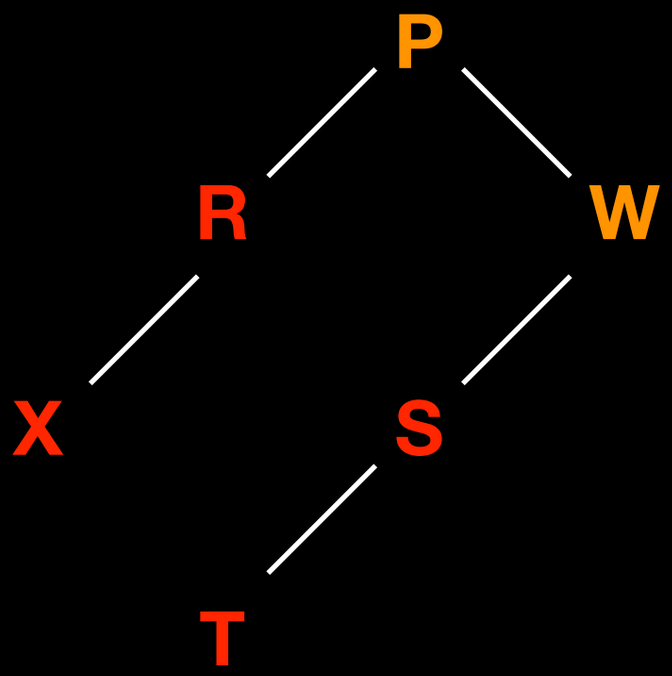

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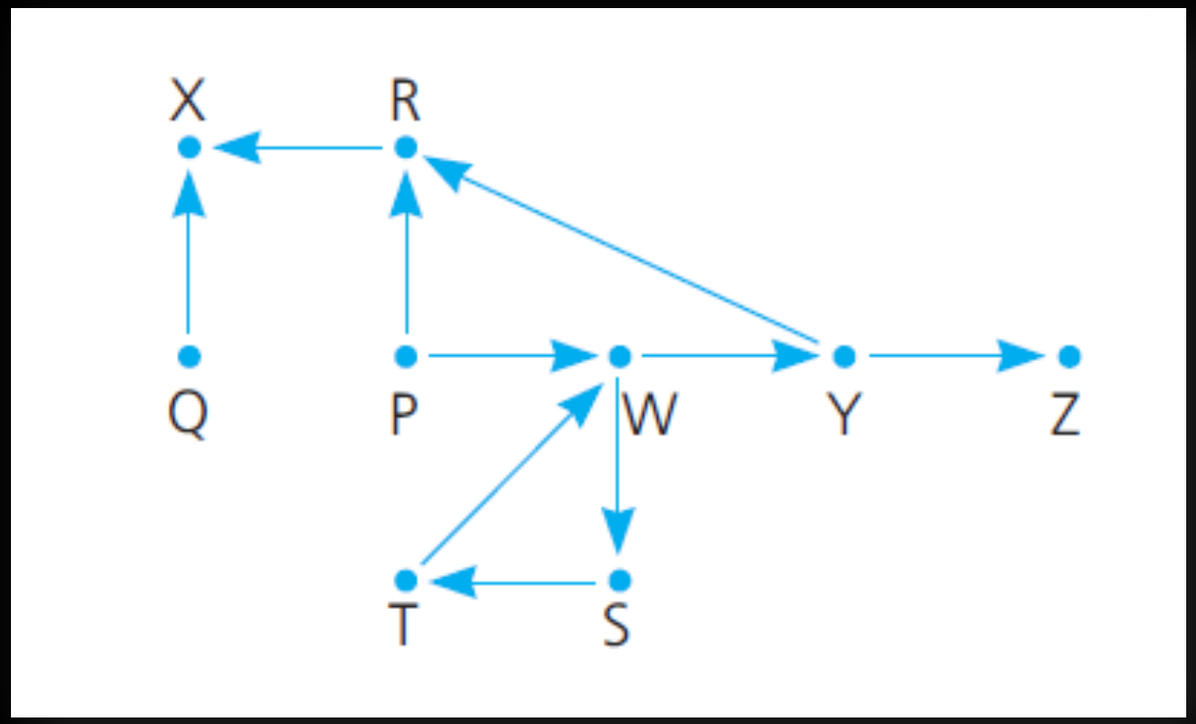
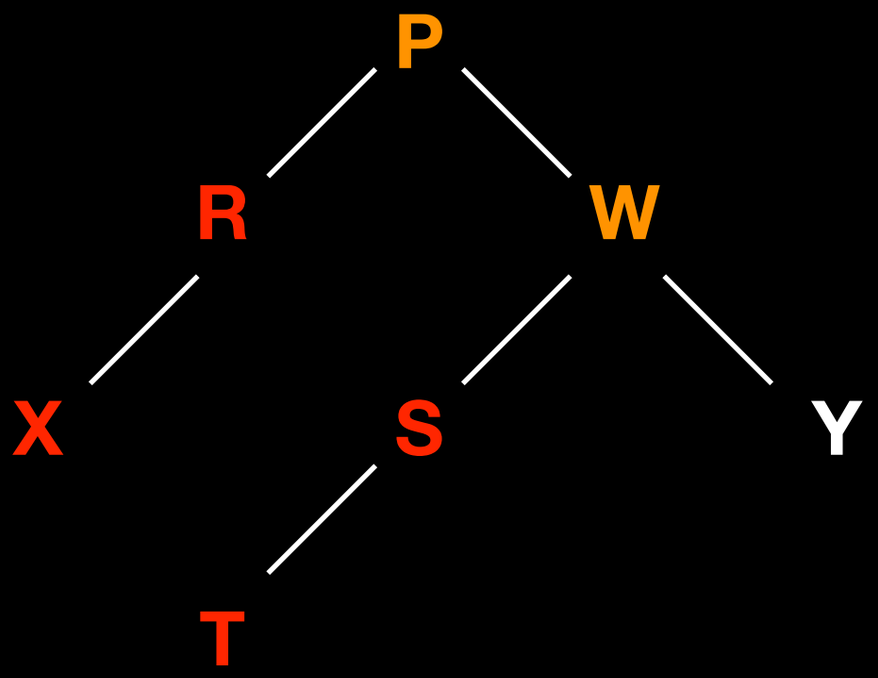
Origin = P , Destination = Z





Backtracking

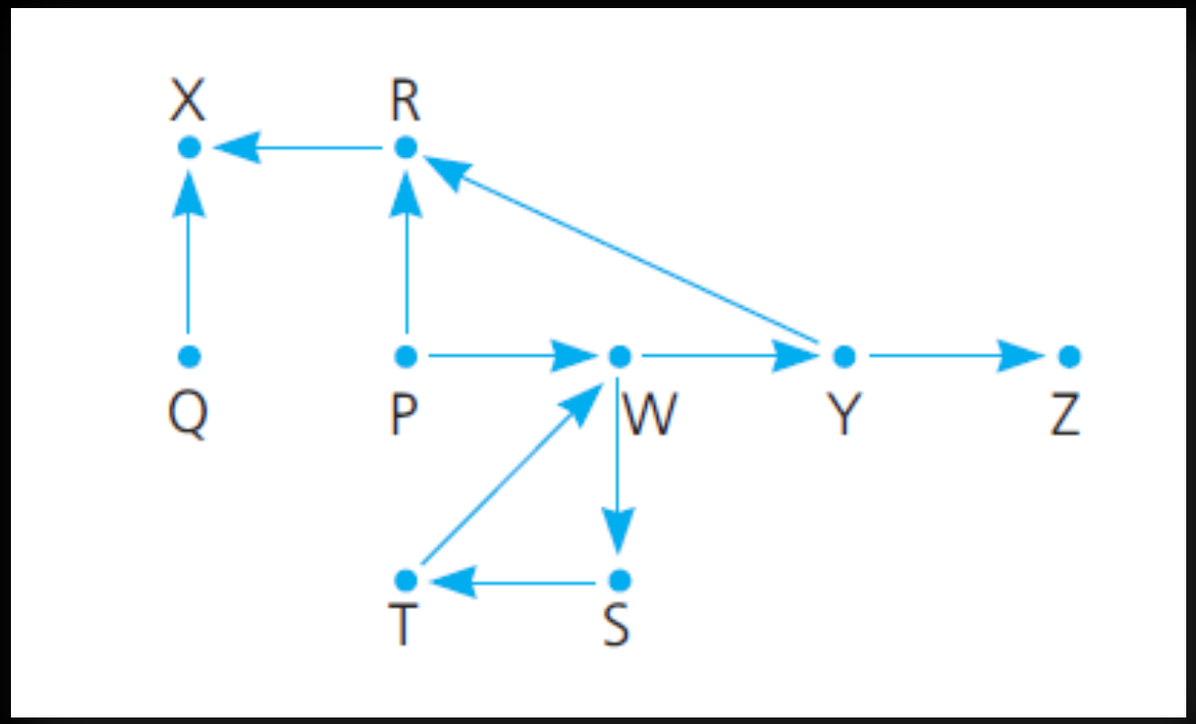
Avoid dead end by backtracking

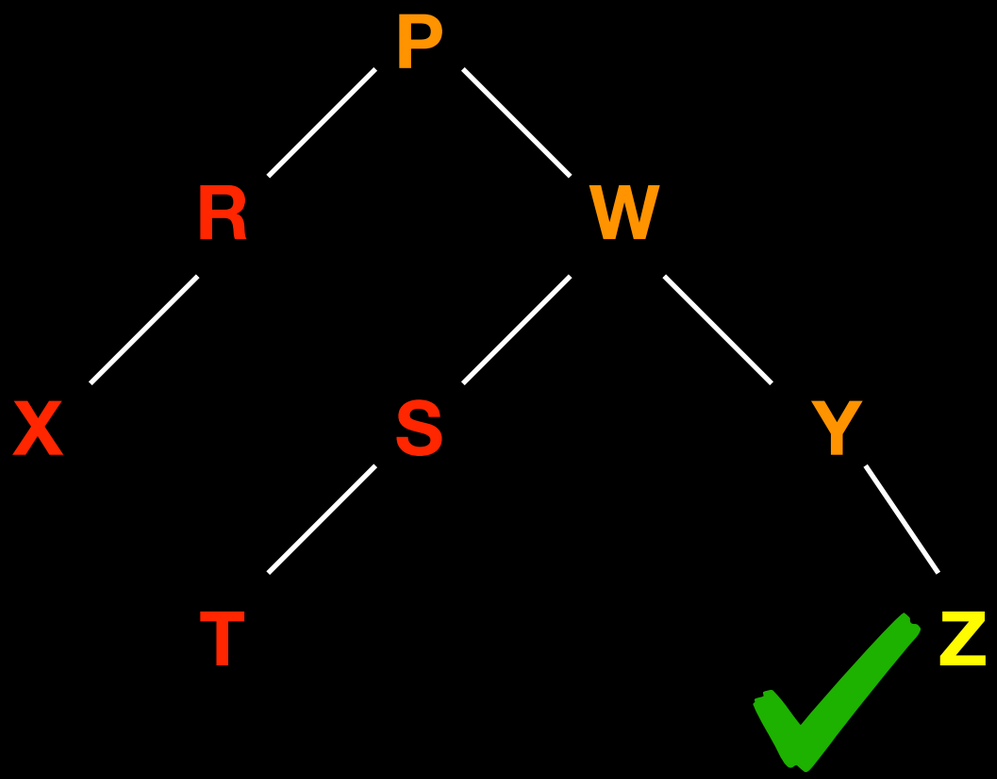
C = visited

C = backtracked

Avoid traveling in circles by marking visited cities

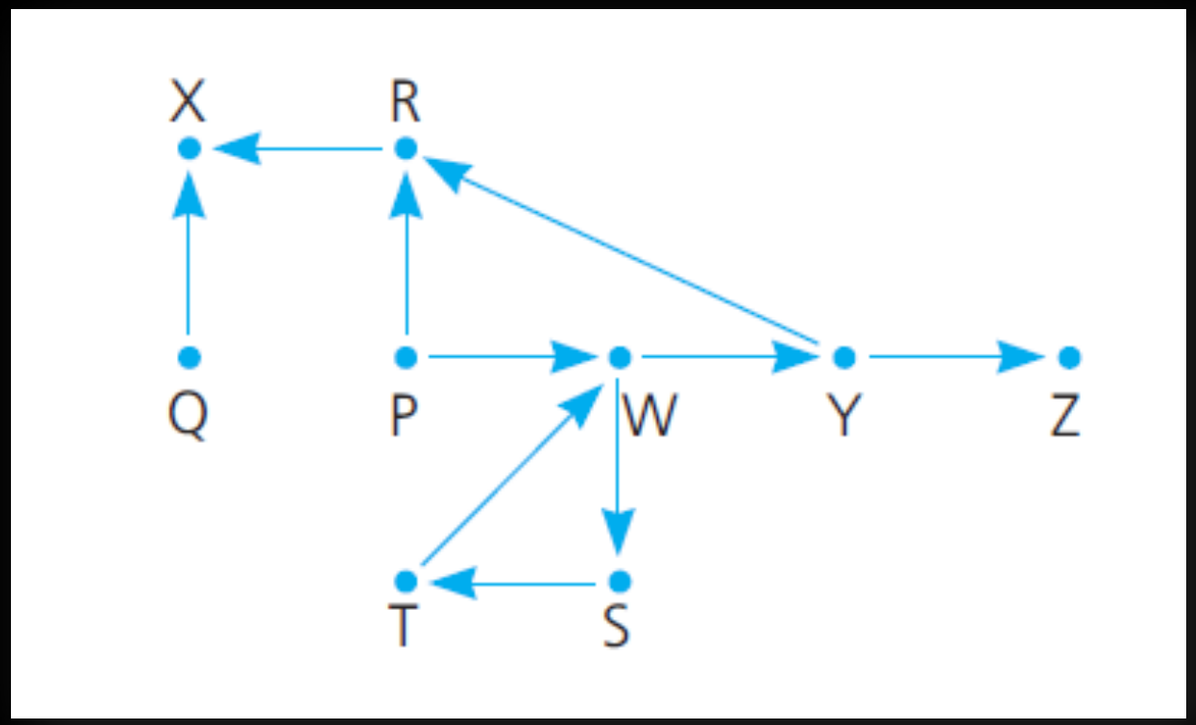
Origin = P , Destination = Z

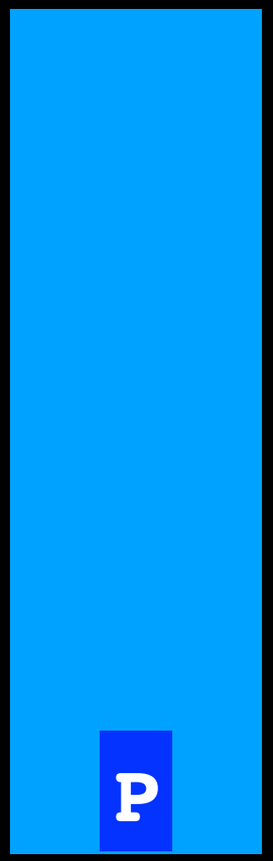




Backtracking

Origin = P , Destination = Z





Backtracking

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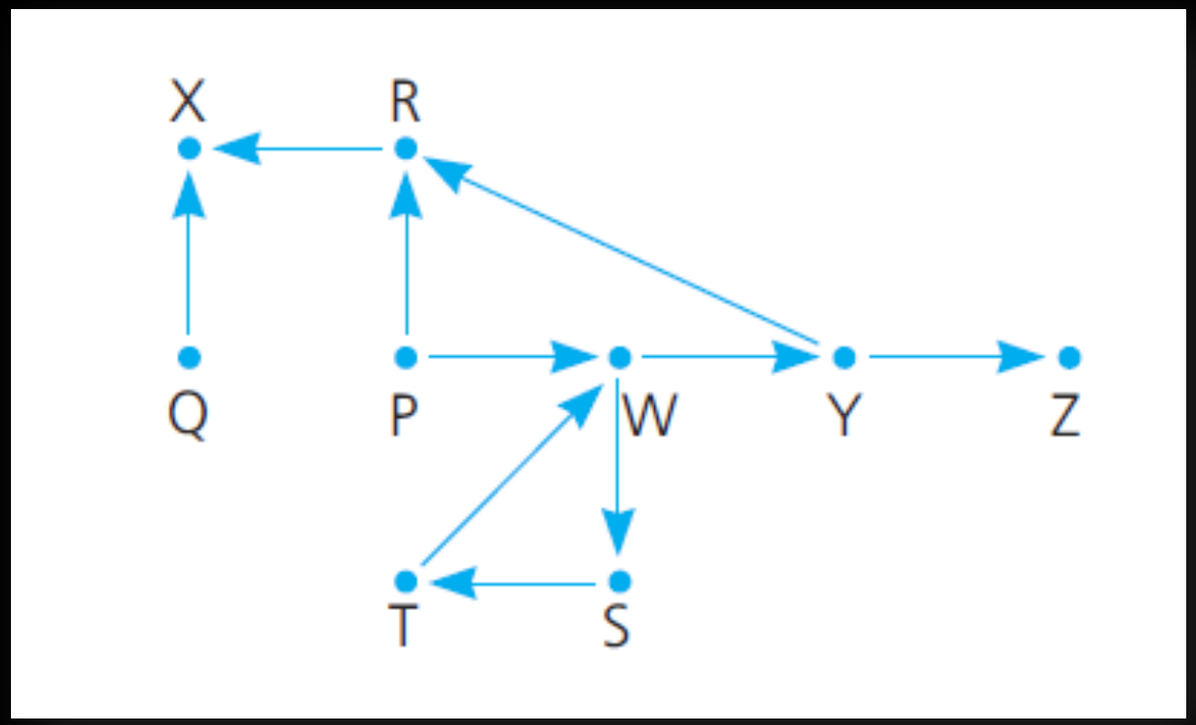

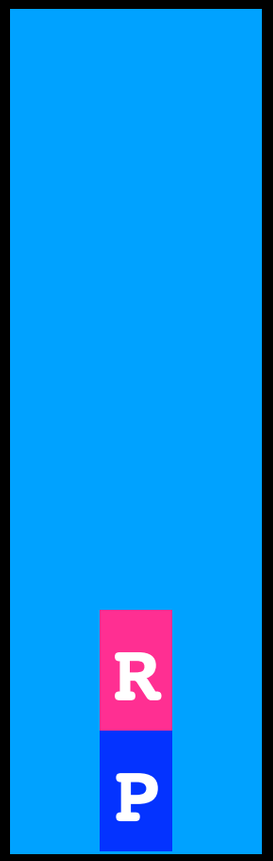

Backtracking

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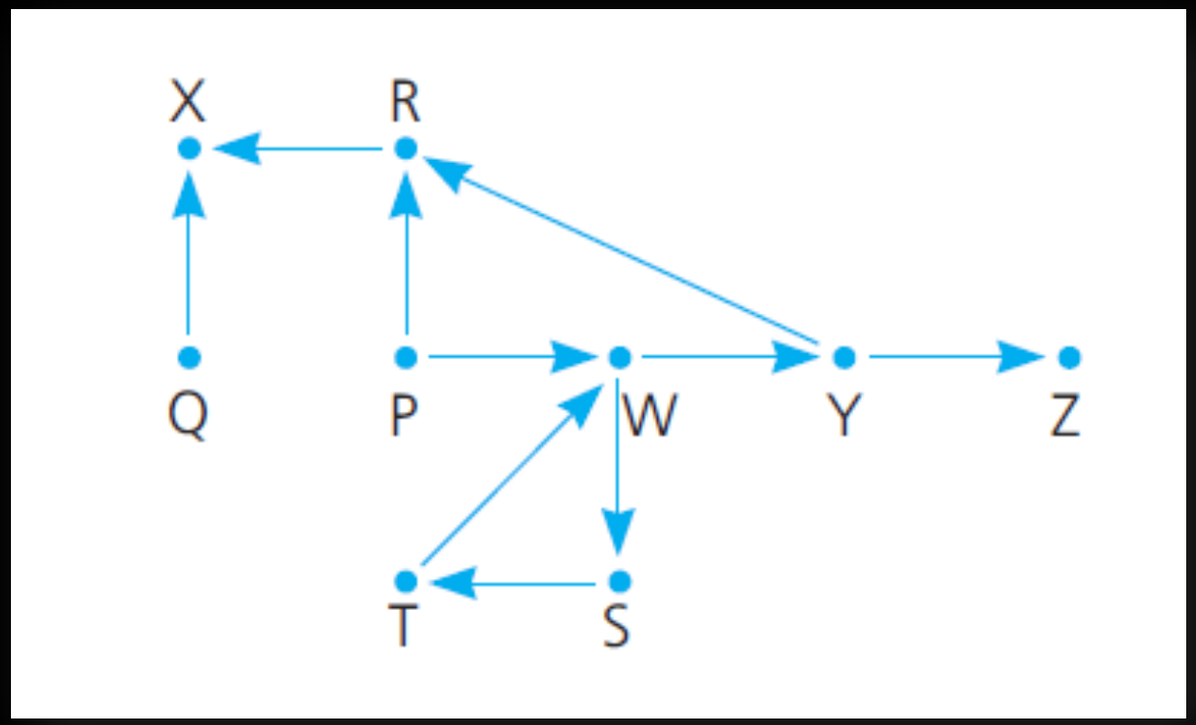

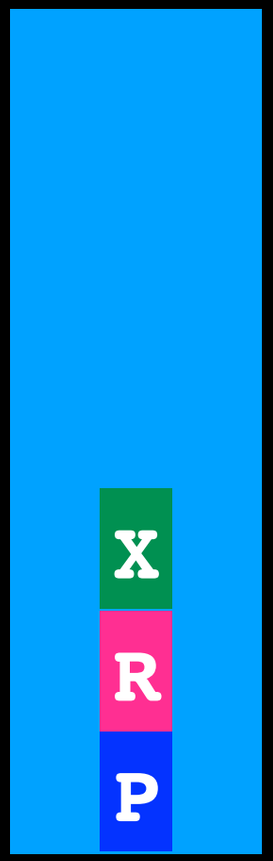

Backtracking

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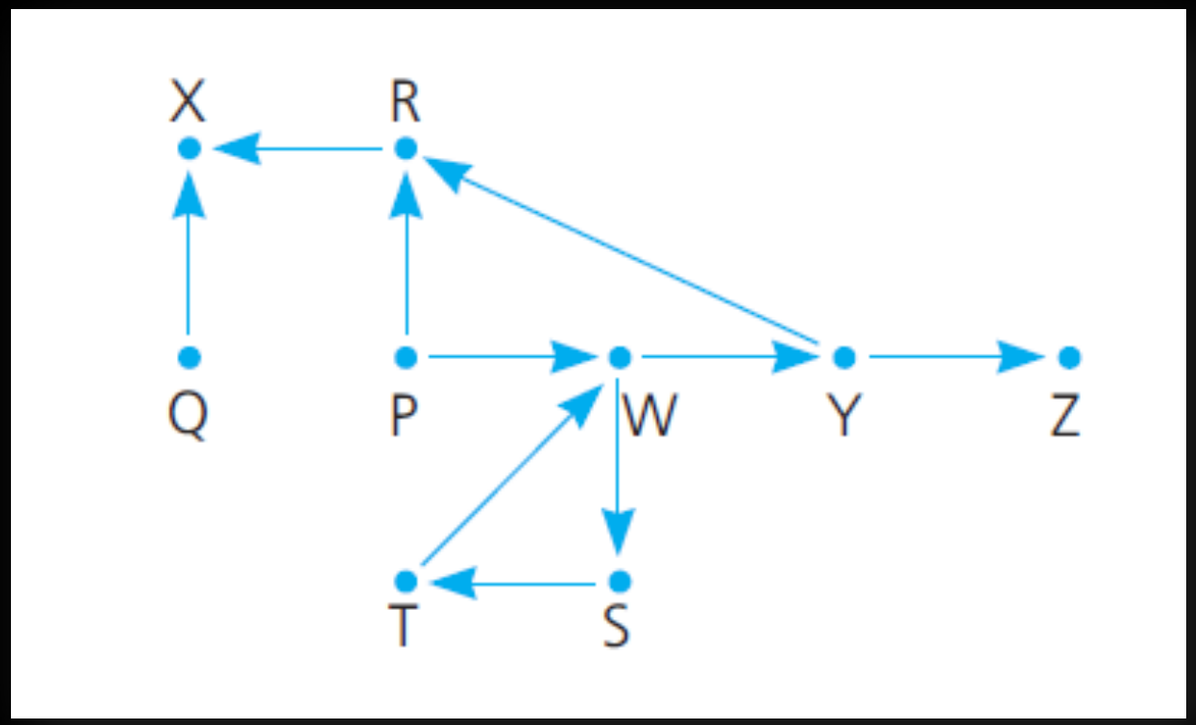

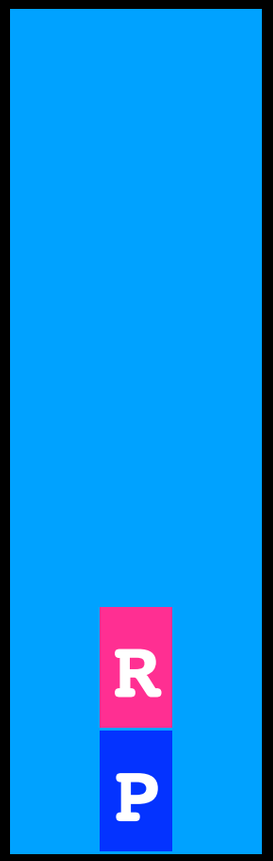

Backtracking

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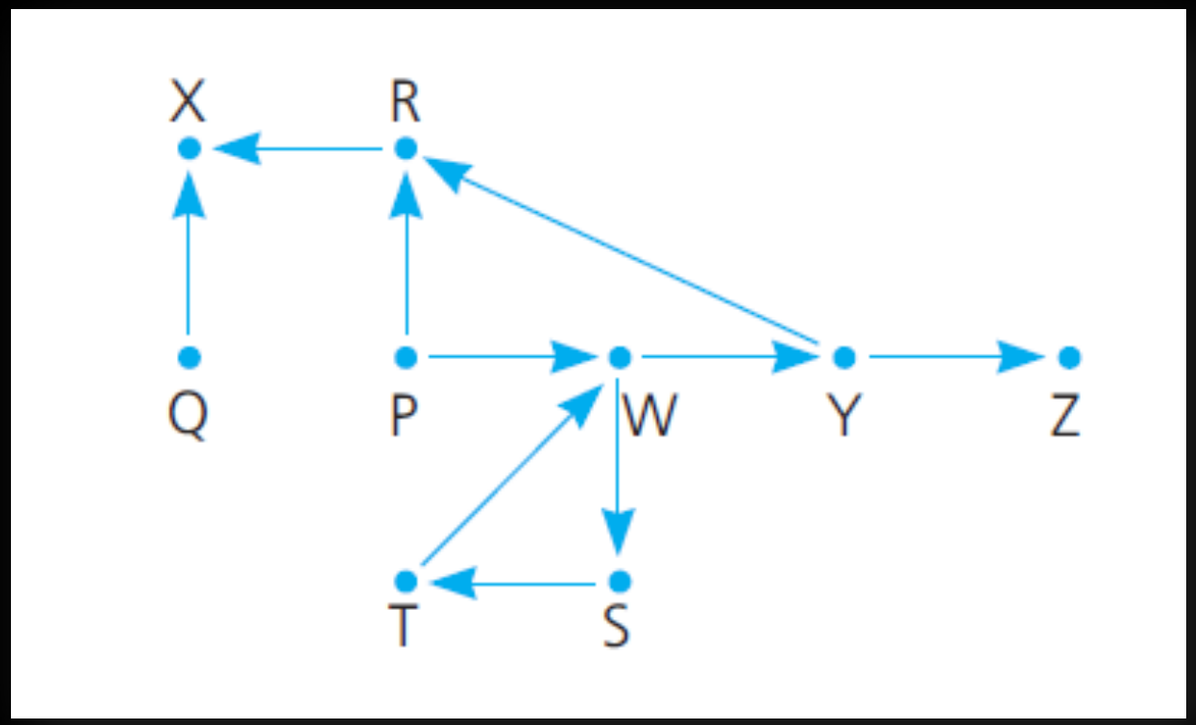
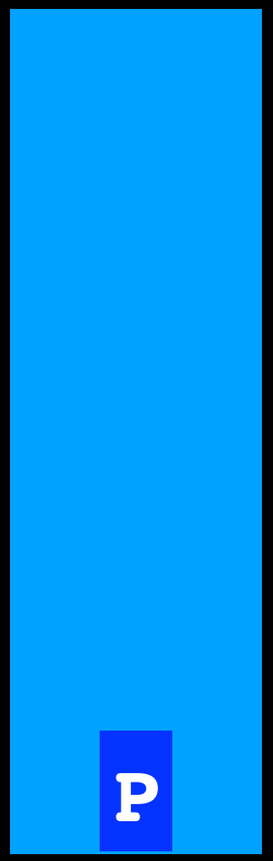
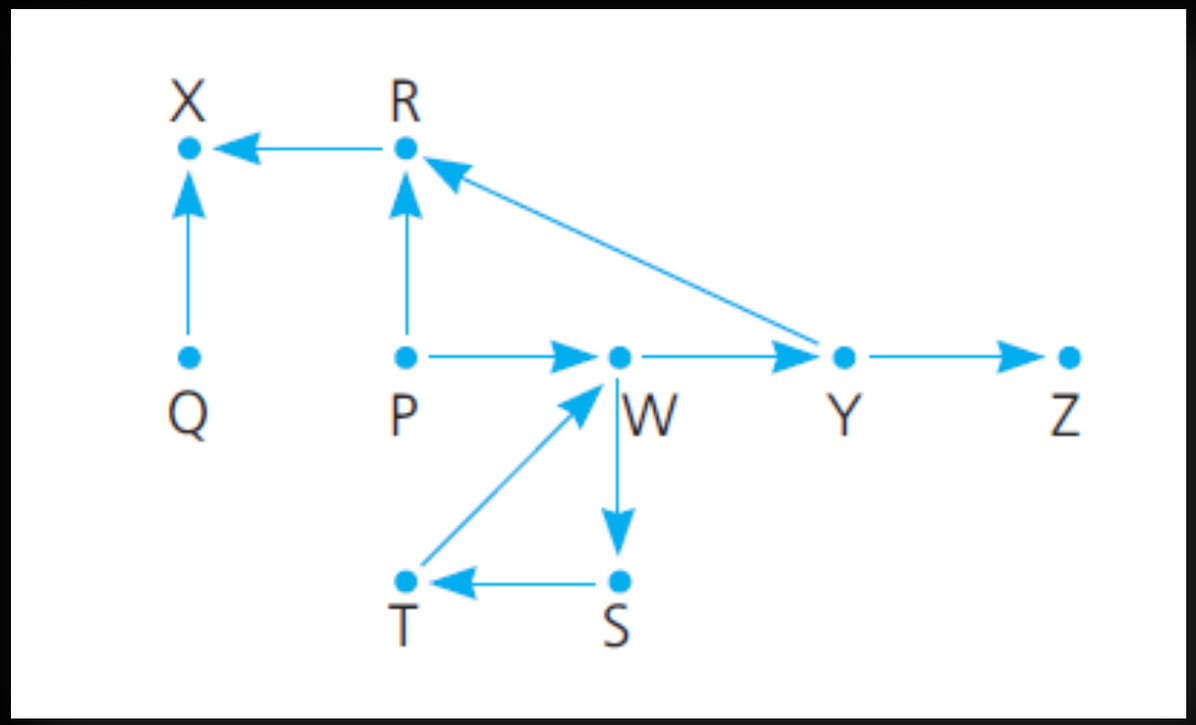
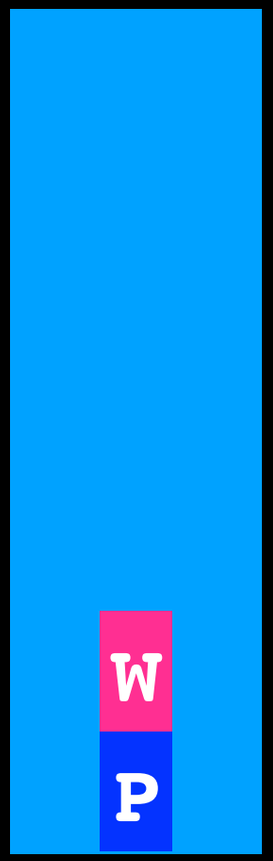




Backtracking

Origin = P , Destination = Z





Backtracking

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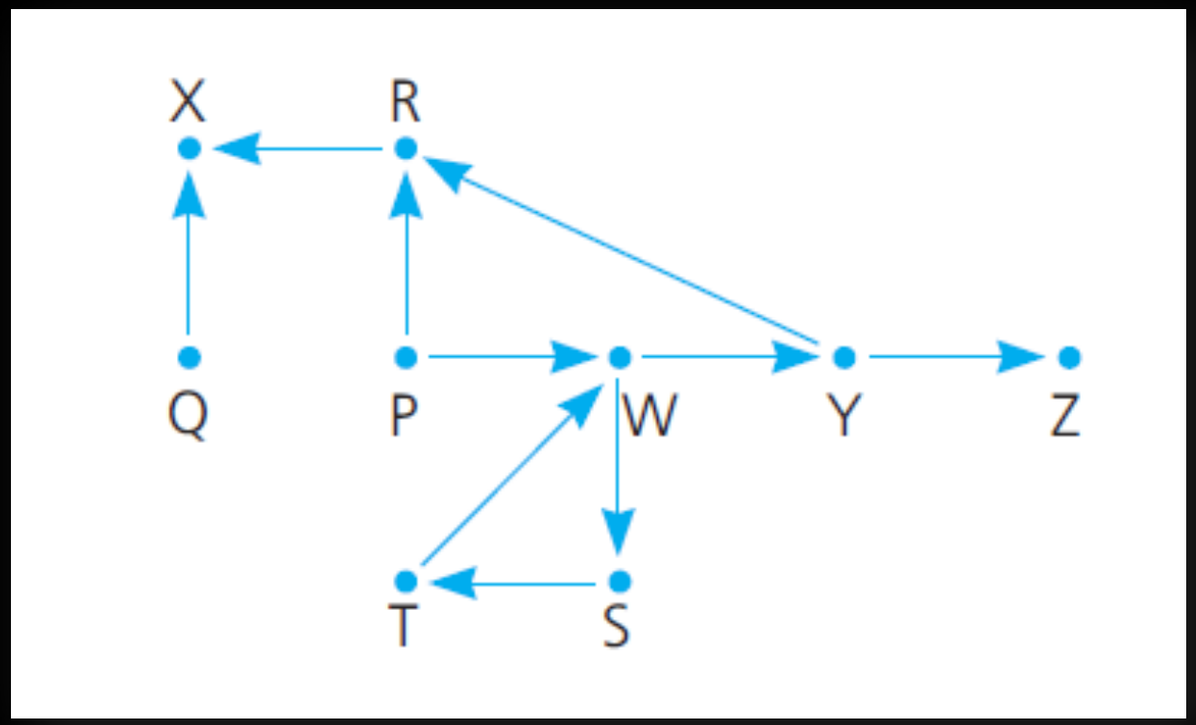
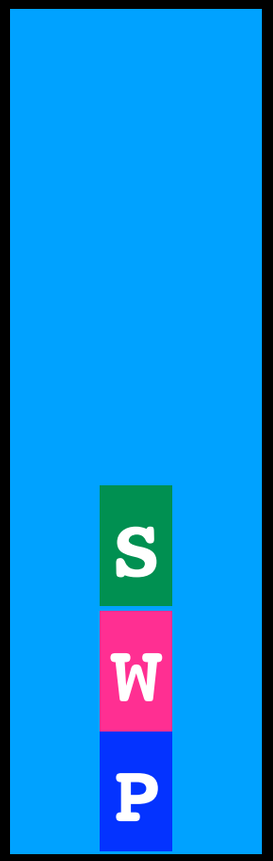
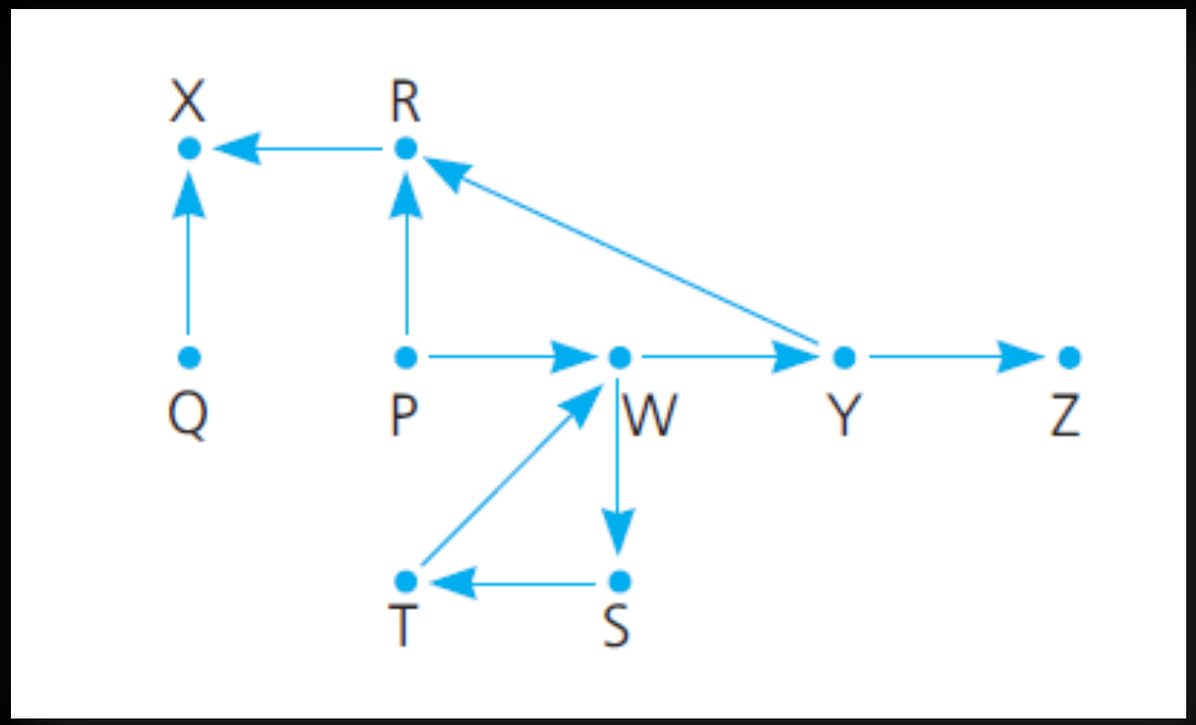
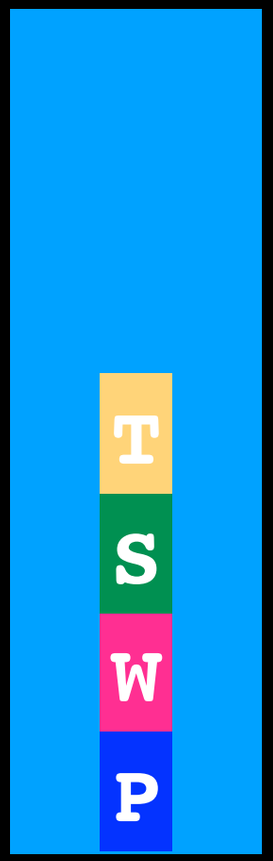




Backtracking

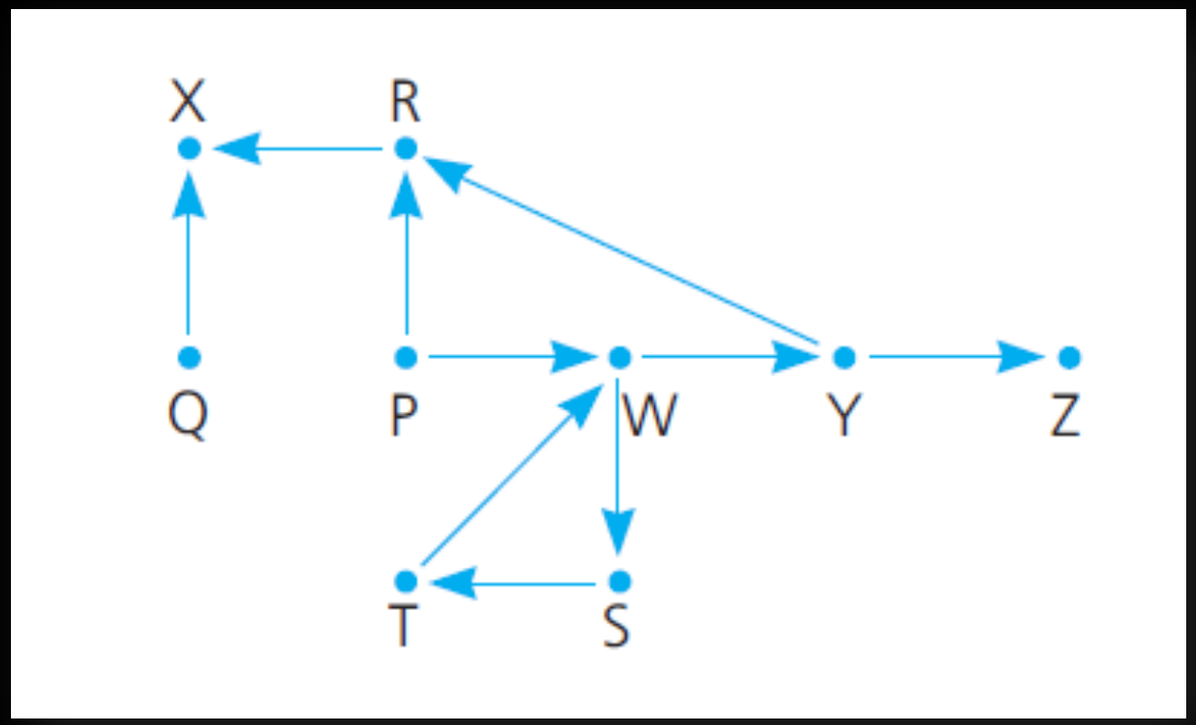
Origin = P , Destination = Z

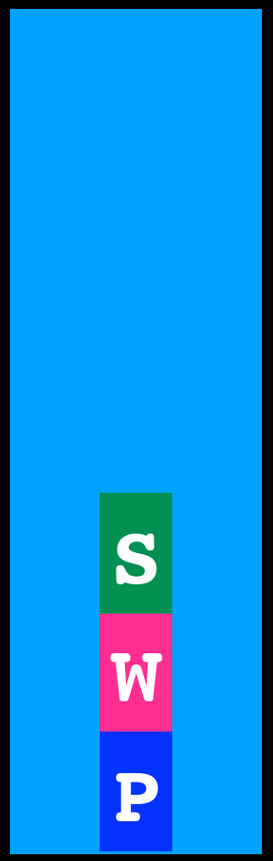




Backtracking

Origin = P , Destination = Z





Backtracking

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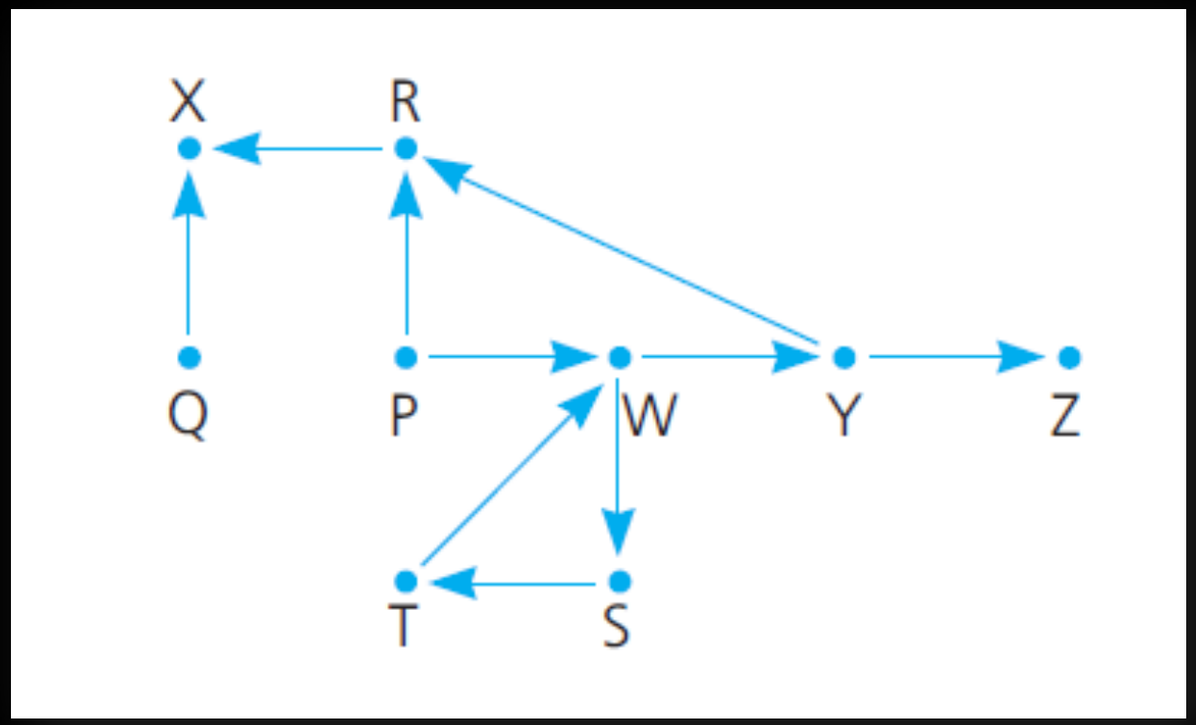
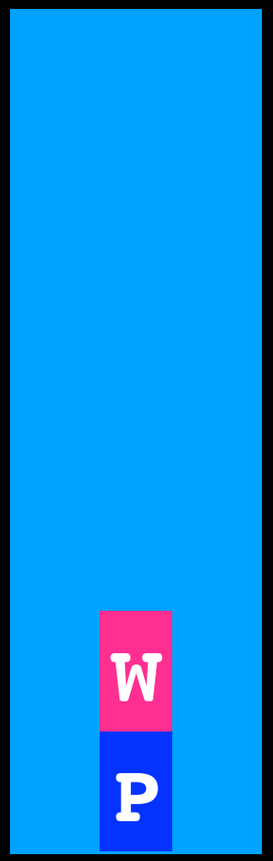
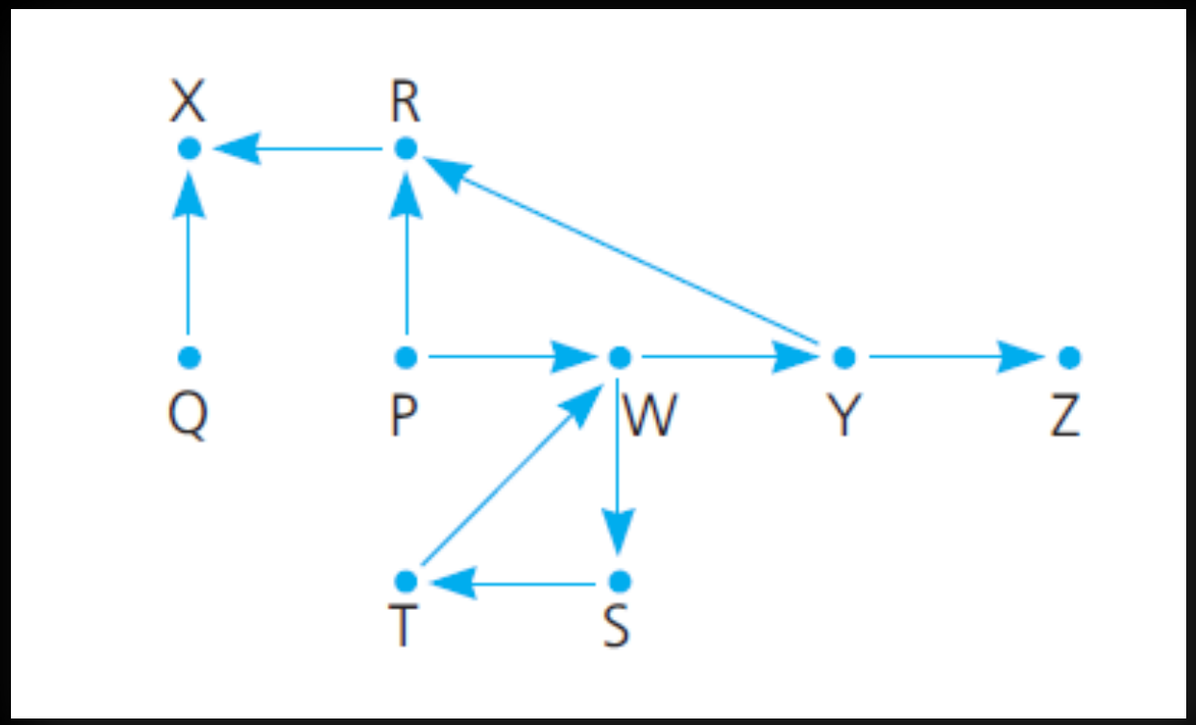
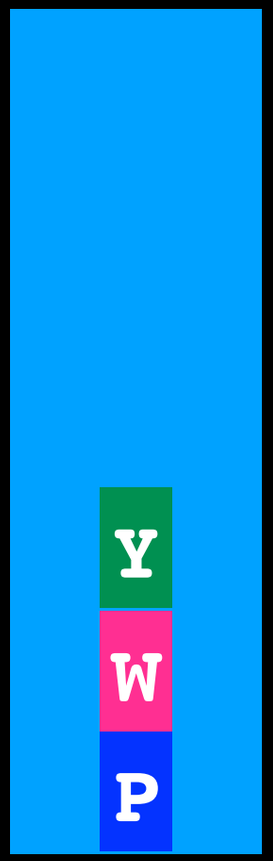




Backtracking

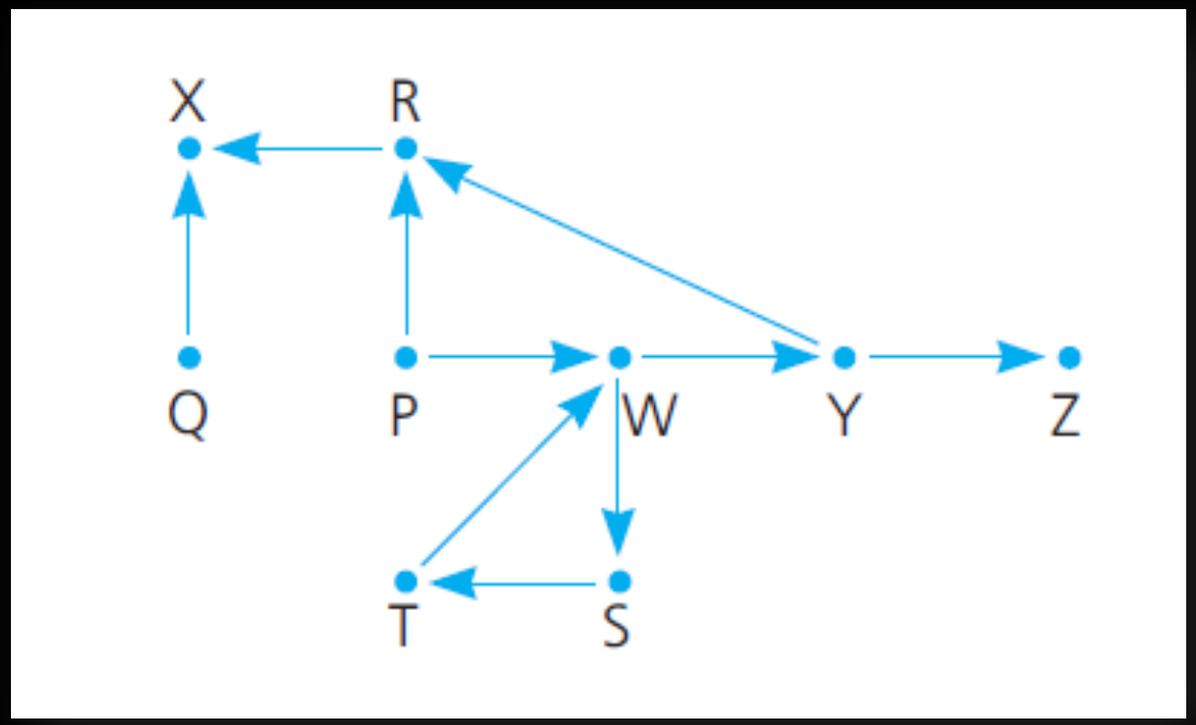
Origin = P , Destination = Z

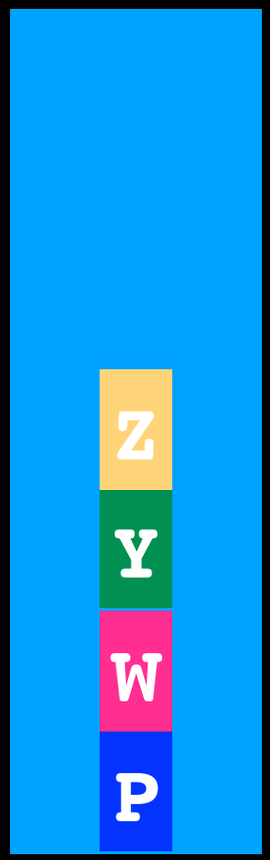




Backtracking

Origin = P , Destination = Z





Backtracking

```
while(not found flights from origin to destination)
{
   if no flight exists from city on top of stack to
   unvisited destination
       pop the stack //BACKTRACK
   else
   {
       select an unvisited city C accessible from city
       currently at top of stack
       push C on stack
       mark C as visited
    }
}
```

Program Stack and Recursion

Recursion works because function waining for result/ return from recursive call are on program stack

Order of execution determined by **stack**

More Applications

Balancing anything!

-html tags (e.g matches

Reverse characters in a word or words in a sentence

Undo mechanism for editors or backups

Traversals (graphs / trees)

. . .

Stack ADT

```
#ifndef STACK_H_
#define STACK_H_

template<<typename ItemType>
class Stack
{

public:
    Stack();
    void push(const ItemType& new_entry); //adds an element to top of stack
    void pop(); // removes element from top of stack
    ItemType top() const; // returns a copy of element at top of stack
    int size() const; // returns the number of elements in the stack
    bool isEmpty() const;//returns true if no elements on stack, else false

private:
          //implementation details here


};    //end Stack

#include "Stack.cpp"
#endif // STACK_H_`
```