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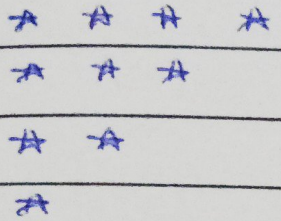
Recursion

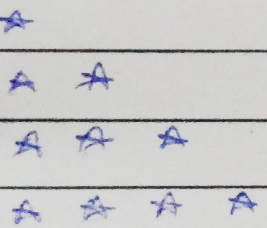
Patterns (triangle , 2)
Bubble sort
Selection sort

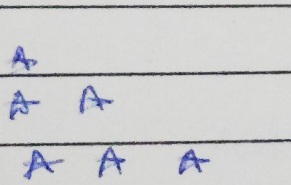


```
triangle ( 4 , 0 )

static void triangle ( int r , int c )
{
    if ( r == 0 )
    return ;
    if ( c < r )
    { sop ("*");
    triangle ( r , c+1 ); }
    else
    { s.o.println( );
    triangle ( r-1, 0 ) ;
} }
```

try





(3 , 1)
(3 , 2) → (2 , 0) (new line)
(2 , 1) → (1 , 0) → (0 , 0) (new line, new line)

dry run

looks like bubble sort

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```
static void bubble ( int[] arr, int r, int c )
{
    if ( r==0 )
        return ;

    if ( c<r )
    {
        swap ( arr , c );
        bubble (arr , r , c+1 );
    }
    else
        { bubble ( arr, r-1 , 0 ); }
}
```

r => outer loop
c => inner loop

Selection Sort - try yourself.

See Kunal's notes

Merge Sort via recursion

you can watch again the vidio

Prefer Kunal's notes

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Quick Sort

watch vidio + Prefer kunal's notes
=
for code also

in compitistive Programming & Interviews use Inbuild sorting algorithms.

Array.sort(arr); // this is much more efficient internally it uses hybrid sorting algorithms
O(nlogn) performence
Faster then the one pivot sort

Recursion - subset questions & String questions

String → Q1. skip 'a' charecter
Q.2. skip a string
Q.3. Skip a string if it's not the required string

- str.substring(1);
- str.isEmpty();
- str.startsWith("abc");

Subset introduction

★ Permutations & combinations
★ subsets → non-adjusent collection

[3,5,9] → [3], [3,5], [3,9], [3,5,9], [5,9], [5], [9]

in sets ordering can not change [3,5] is same as [5,3]

in permutations ordering can be changed

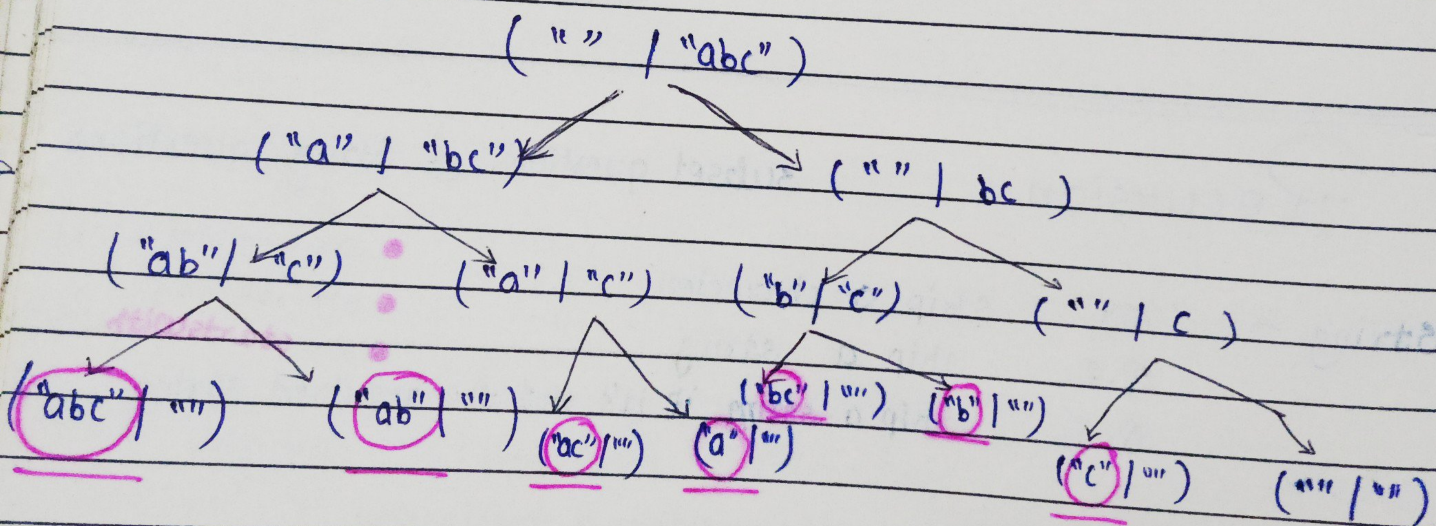
str = "abc"

ans = ["a", "b", "c", "ab", "ac", "bc", "abc"]

we are trying to create subsets

** VVI This pattern of taking some elements & removing some is known as Subset pattern

* (processed , unprocessed)



When in unprocessed → empty, Processed will have answers

Code by yourself for subseq function

subsequence . java

⇒ instead of printing arraylist भी return करवा सकते

⇒ ascii value related q था, इतना imp नहीं लगा

Notes - KUNAL Git

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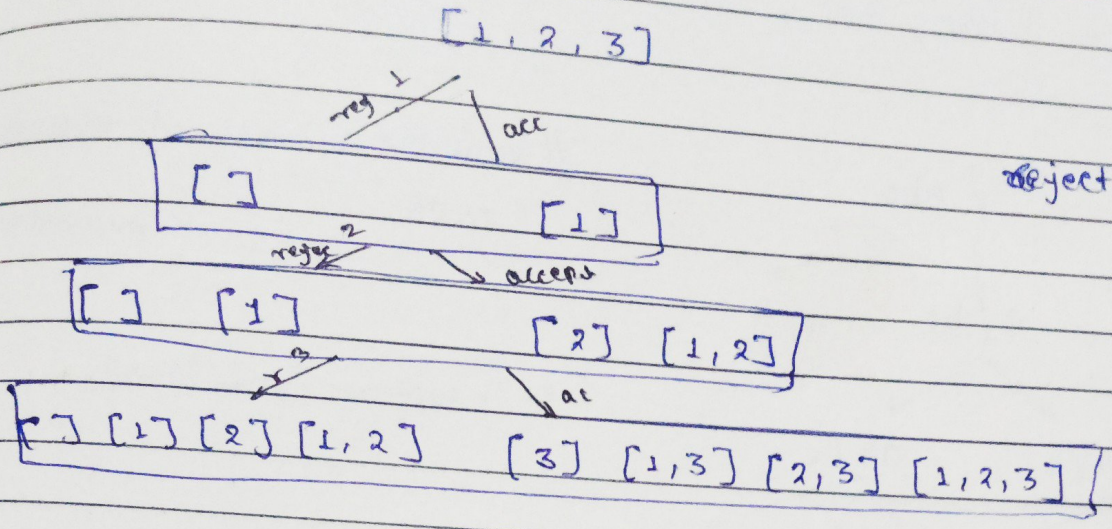
char ch = 'a'
sop(ch+0);
↓
97




```
static List<List<Integer>> subset(int[] arr)
{
    List<List<Integer>> outer = new ArrayList<>();

    outer.add(new ArrayList<>());
for(int num : arr){
    int n = outer.size();
for(int i=0; i<n; i++)
{
    List<Integer> internal = new ArrayList<>(outer.get(i));

    internal.add(num);
    outer.add(internal);
    }
}
return outer;
}
```

O(N * 2^n) time complexity

Space O(2^n * N) → space take by each subset
(2^n → total subset)

#subset.java

notes after 2 page →

for dublicates

cheak ⇒ kk vidio
10 minuts

#SubsetDub.java

n! permutations you can have
n=3 3! ⇒ 6

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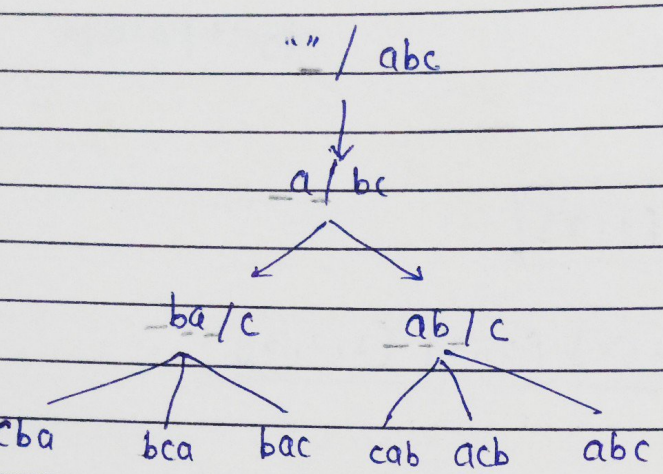
str = abc

permutations = [abc, bac, cab, bca, acb, cba ...]



// Variable number of recursive calls.

p + 1 (processed + 1)

Program from kunal

[ ) inclusive exclusive

PerRec.java

```
static void permutations ( String p , String up )
{
    if ( up.isEmpty() )
    {   System.out.println(p);
        return;
    }

    char ch = up.charAt(0);

for( int i=0; i<=p.length ; i++ )
    {
        String f = p.substring(0, i)
        String s = p.substring (i, p.length() );
        permutations ( f+ch+s , up.substring(1) );
    }
}
```

PerRecRet.java

Try code for returning arraylist & count the permutati code or watch again Kunal's code

returning no. of permutations - we can return by formula but using permutations fun. also we can do, without p count in

// not getting all the thing
// Give it a try letter

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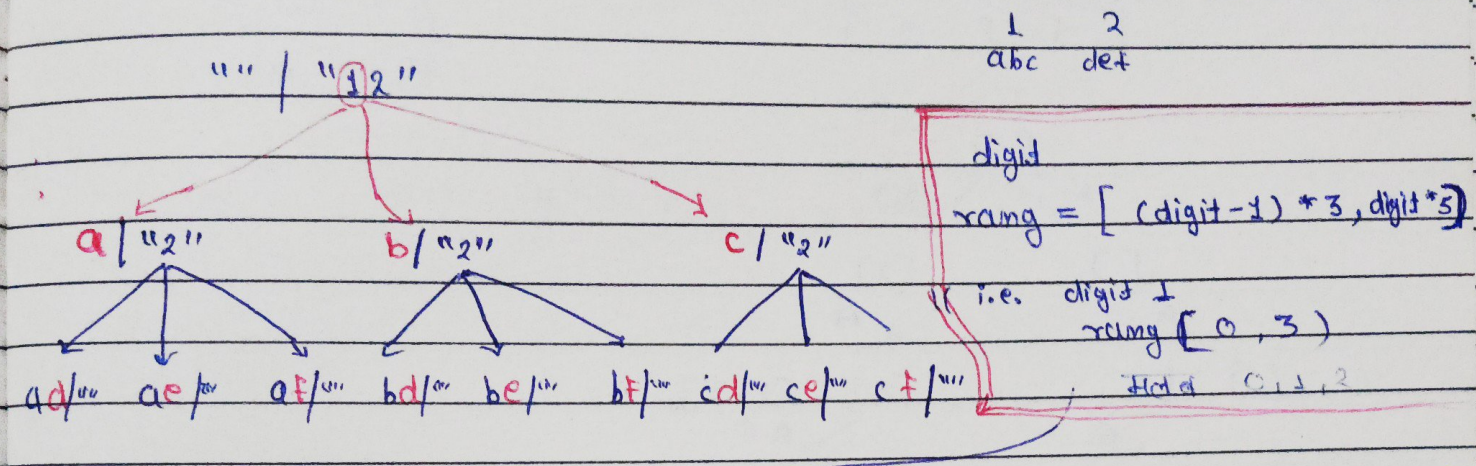
Recursion (4) vidios ↳ बाद मे

Coming back

13 jan 2024

Combination questions

leet 17. Letter combinations of a phon number



1 2
abc def

digit
rang = [(digit-1) * 3, digit * 5)

i.e. digit 1
rang [0, 3)

Hold 0, 1, 2

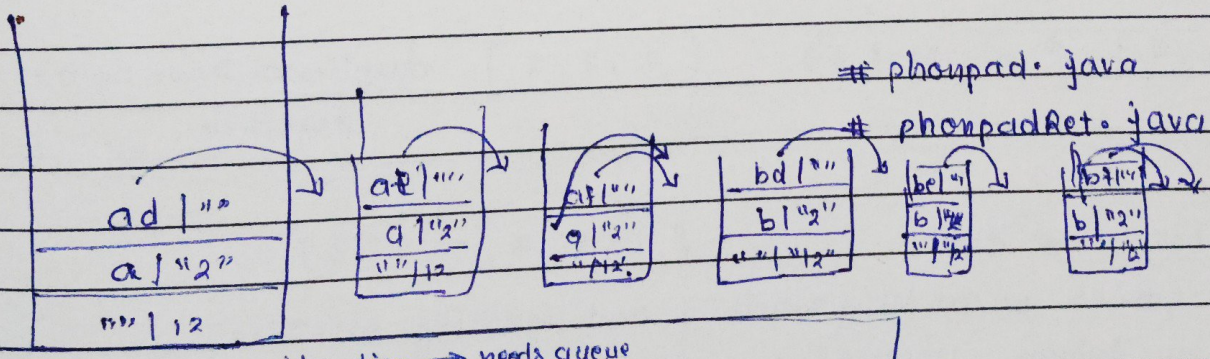
↳ for loop (0, 1, 2 (means a, b, c))

digit 2, rang [3, 6)
(3, 4, 5)
d e f

a + index(3) = d

a + 1 = b

charecter to add in processed = 'a' + index



phonpad.java
phonpadRet.java

permutation using iteration → needs queue

Adv. sliding window, two pointe → hashmap, heaps

Recurtion is used everywhere - arrays strings, recur linkedlist, trees, graph dp

Tackv Forward Complexity tip | if constraint 10^5 & we use $O(n^2)$ मतलब $(10^5)^2 \rightarrow (10)^{10}$ operation → TLE

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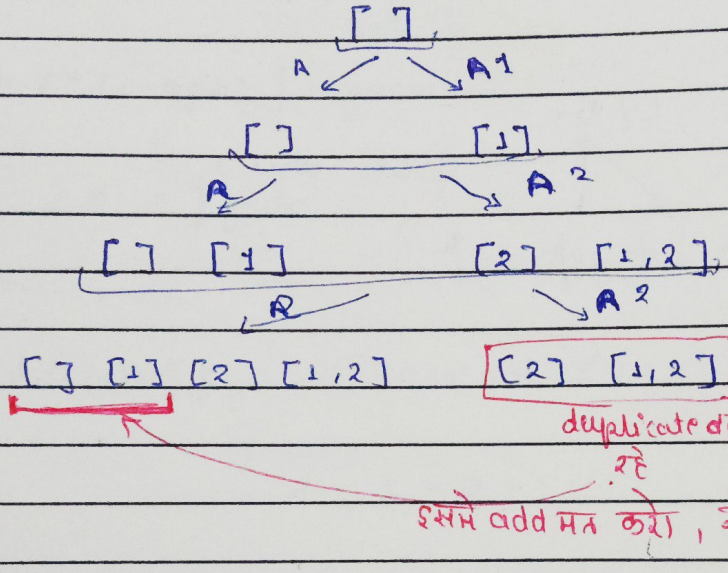
Subset with duplicate value

[1, 2, 2]

A - accept
R → reject



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

duplicate है इसमें add मत करो, नहीं होगा।

* when you find a duplicate element only add it in the newly created subset of previous step.

* [2, 1, 2] हैं तो sort करो [1, 2, 2] duplicates have to be together.

---

you have some data [1, 2, 3, 4, 5, 6]

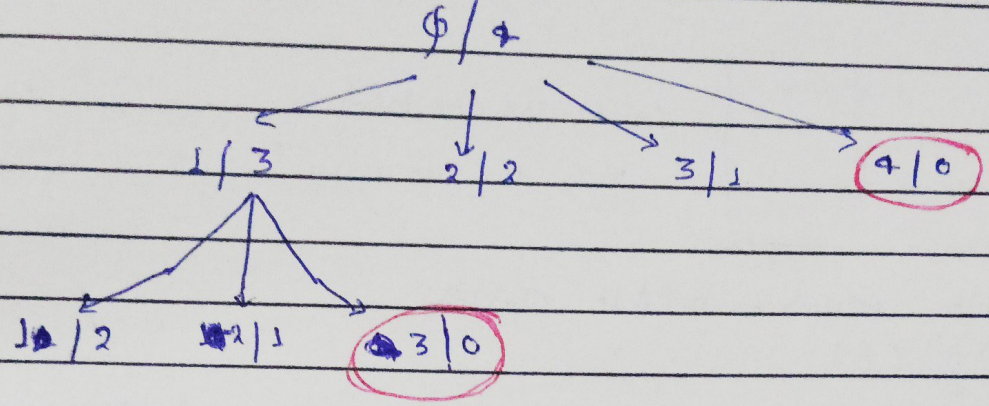
in the answer you are taking something and ignoring something

This follows processed and unprocessed

dice [1, 2, 3, 4, 5, 6] , possible combinations for making 4

Ans [4, 31, 211, 1111, 22 . . .]

Q. 204 bitwise




```
static ArrayList<String> diceRet (String p , int target )
{
    if (target == 0)
  { ArrayList<String> list = new ArrayList<>();
      list.add(p);
       return list;
    }

ArrayList<String> list = new ArrayList<>();

for (int i=1 ; i<=6 && i<= target ; i++ )
  {     list.addAll(diceRet( p+i , target-i);
  }
  return list ;
}
```

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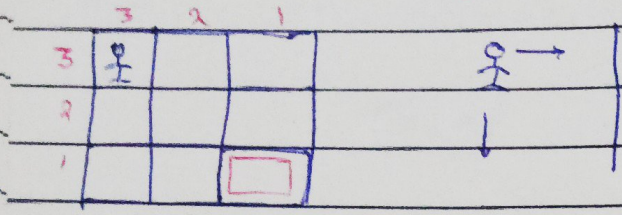
Backtracking + Maze Problems - Theory + code + Tips

why backtracking, how to know backtracking will be used

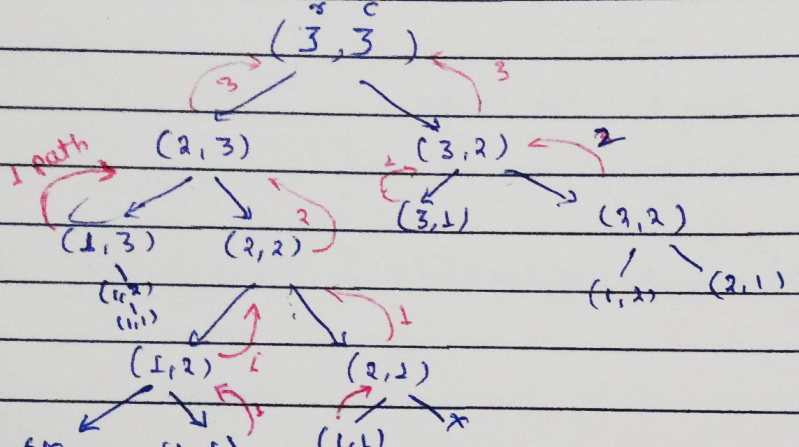


what we are doing ?

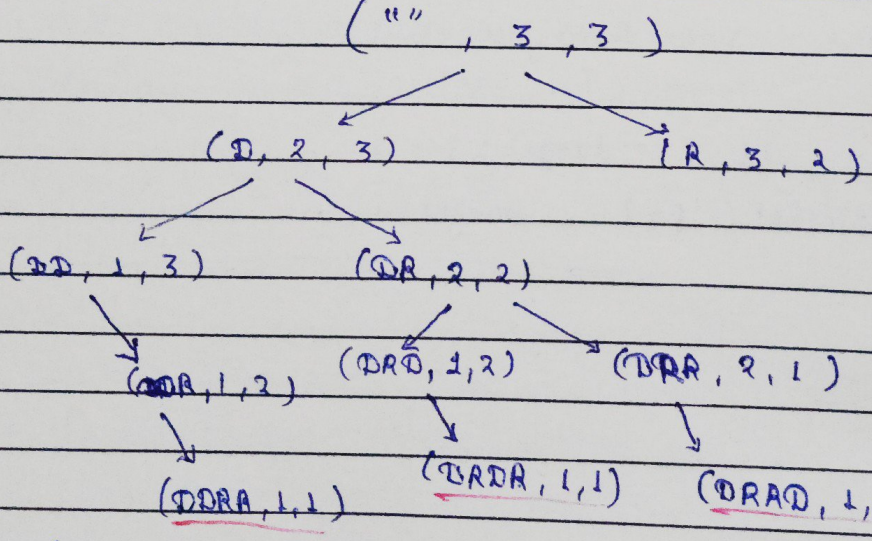
How we are doing ?

Ans → RRDD DDRR RDDR RDRD DRDR

O/p → no of paths (6)




```
int count (int r, int c)
{
    if (r==1 || c==1)
        return 1;
    int left = count(r-1, c);
    int right = count (r, c-1);
    return left+right;
}
```




```
void printp(String p, int r, int c)
{   if (r==1 && c==1) {s.o.p(p); return;}
    if (r>1) { printp (p+'D', r-1, c); }
    if (c>1) { printp (p+'R', r, c-1); }
}
```

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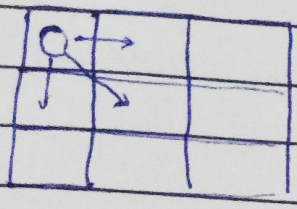
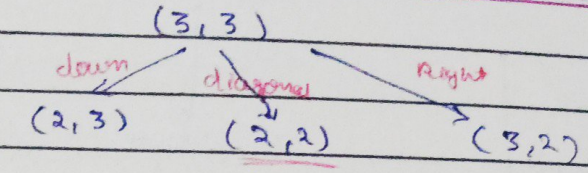
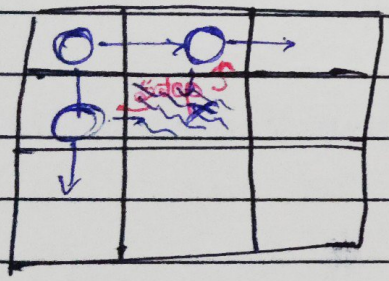




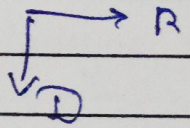
condition returning

```
{ r>=1 && c>=1
  if ( r>1 && c>1 )
  { list.addAll(pathRetDiagonal ( p+'D', r-1 , c-1 )); }
  if ( r>1 )
  { list.addAll ( pathRetDiagonal ( p+'V', r-1 , c )); }
  if ( c>1 )
  { list.addAll ( pathRetDiagonal ( p+'H', r , c-1 ); }
```

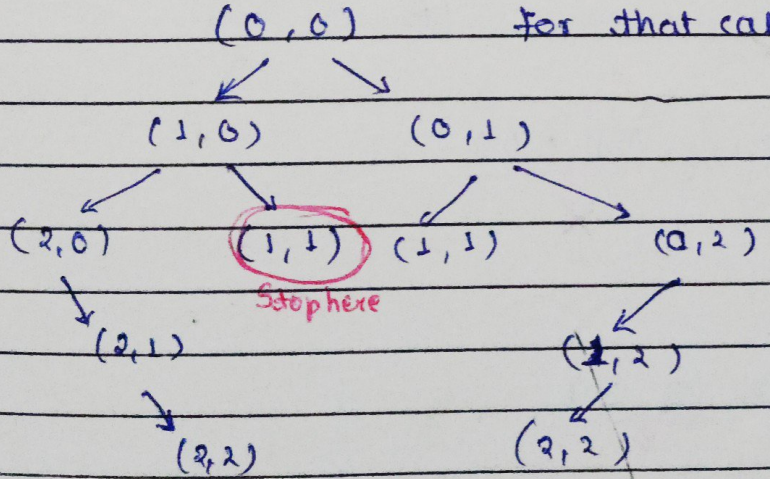
Maze with Opticals



false → river Boolean metrix



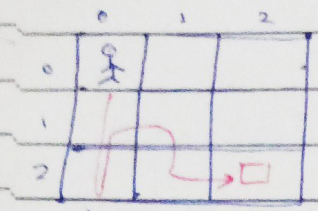
Note - check, when you land on a new cell, check whether is river or not if you land on river, stop recursion for that call.

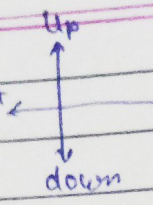


in javafolder
pathRestrictions.java

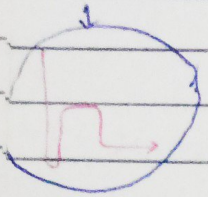
Bolleam matrix

Problem





all directions are allowed



("", 0, 0)

pathAll

(D, 1, 0) (R, 0, 1)

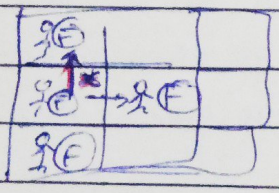
(DD, 2, 0) (DR, 1, 1) (DU, 0, 0)

Can not be an answer.

Do not move back the same path. This is known as backtracking problem.

It's coming back to the same point where it was started, here it's stucking in endless loop.

How to solve All cells that are visited mark those as false. So that it does not go there



("", 0, 0)

(D, 1, 0) (R, 0, 1)

(DD, 2, 0) (DR, 1, 1) (DU, 0, 0)

(DDR, 2, 1) (DDU, 1, 0)

(DDRR, 2, 2) (DDRU, 1, 1) (DDRL, 2, 0)

(DDRUR, 1, 2)

(DDRURD, 2, 2)

marking false == I have that cell in my current path.

So, when that path is over. ex: you are in another recursion call, those cells should not be false.

* while you are moving back, you restore the maze at it was.

when do we go back ⇒ happens when function is returned.

When you come out of the recursive function → you are now in above recursion call. Hence re-mark the cell as true.

→ This is known as Backtracking

When the function is return change the changes that you made previously

Backtracking # allpath.java

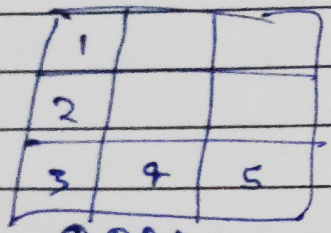
~~# allpathPrint.java~~

Backtracking -

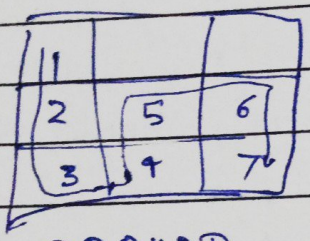
you are making some changes while going in the bellow recursion calls, So when you go outside of those recursion calls the changes that made by those recursion calls should also not be available

thought process - make a change, reverse the change, when that work is done

Q. give the o/p of previous problem, as print the path in the matrix formate. matrix and the path



DDRA



DDRIAD

- Take a step variable
- update the path array
- print it in base condition
- Backtrack

~~allpathprint~~
#pathAllMatPrint.java
in javafolder

queen (8)

N-queens, N-knights, Sudoku solver

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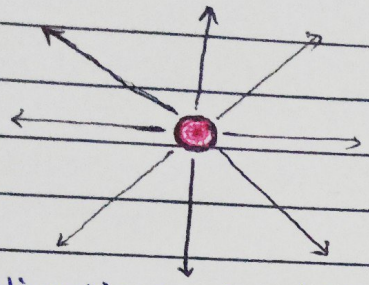
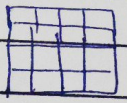


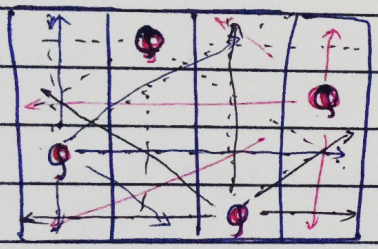
directions - in which queen can attack

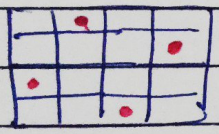
n = 4, means the question says you are given a n×n board and you have to place N queens on it.

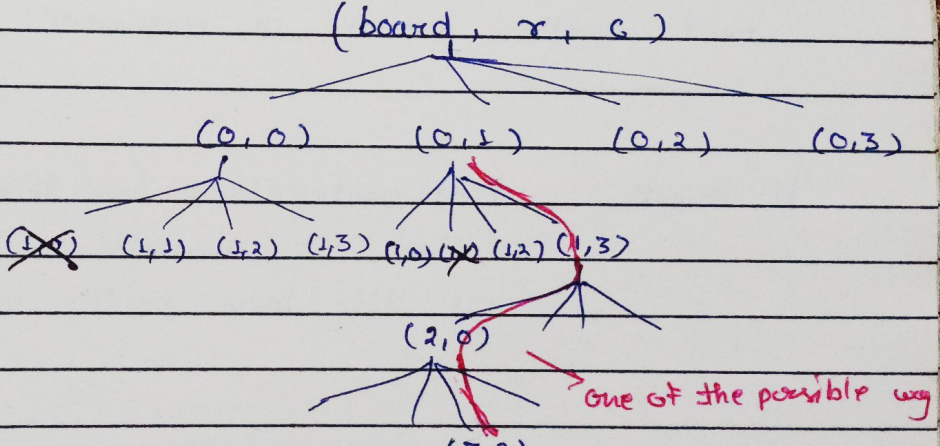


Find the total number of ways to place the queens.

→ Place queens so that no two are eleminating one another.



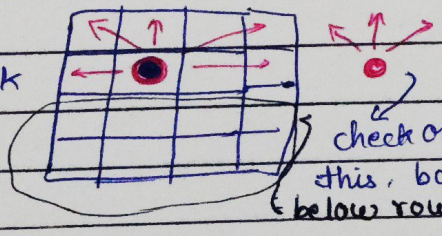


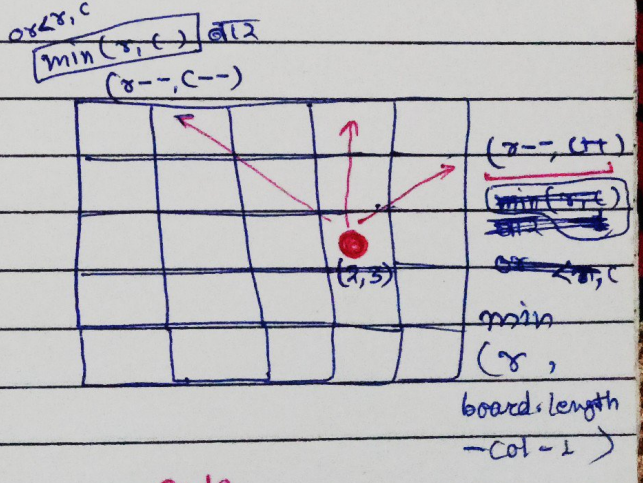


How to check whether the perticular condition is safe or not

is safe();

To check





Code
= NQueens.java in javafolder

Knights ⇒  ⇒ houses

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Time complexity:

Recurrence Relation:

$T(N) = N * T(N-1) + O(N^2)$

Akkra Bazzi formula

$O(N^3 + N!) = O(N!)$

Time complexity lecture

tip ⇒ you can elemenate for loops with conditions, but then you need another variable in argument

N - knights, First understand how thing work, knight works then if available on lee, give it a try if not able then prefer vidic.

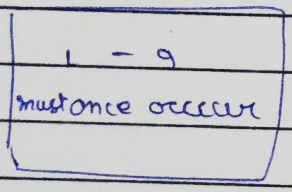
Leetcode 79 World search

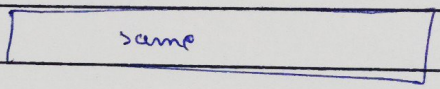
Leetcode 37. Sudoku Solver

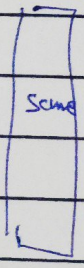
9×9 का board होता है, 😊, ये भी नो पता था question कैसे solve होता। 😊

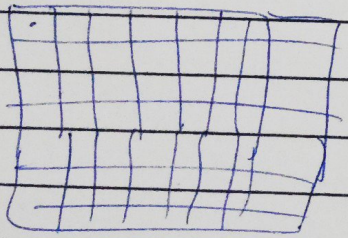
⇒ Sudoku puzzel is 9×9 board, where you have to put the numbers from 1 to 9 with some rulles.

1. each of digits 1-9 must occur exactly once in each row.
2. each of digit 1-9 must occur exactly once in each column
3. ——"—— once in each of 9, 3×3 sub-boxes of the grid









we will firstly see what are empty indexes,

and we will try to check from 1-9 which ever will be suitable we will putt

letter on it we realize, (How we will realize if my last grid end of colum will remain empty and I am unable to ~~solve~~ put the ~~prob~~ number which I have)

it means previously I have putt something wrong. and I need to change it, for this I will do backtrack and whatever choises I have made I will check them and I try to put that number there

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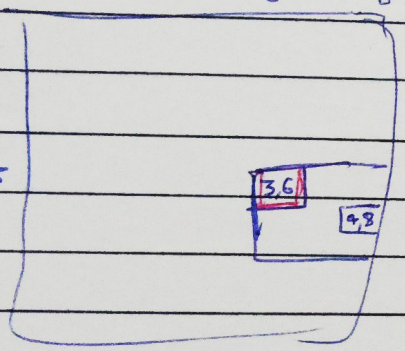
Note - when a choice can effect future answers use Backtracking

you are given a incomplete sudoku

isSafe function ⇒ rows, colums

how will you find the 3x3 box, mean the indexes where we are currently at, where does they belong.



(3, 6) where it's box is starting

So srow ⇒ row - row % 3 → (3 bcz 3 → 3)

3 - 3 % 3 ⇒ 3

scol → col - col % 3

6 - 6 % 3 ⇒ 6

Hence there box start from (3, 6)

(7, 8) where it's box is starting

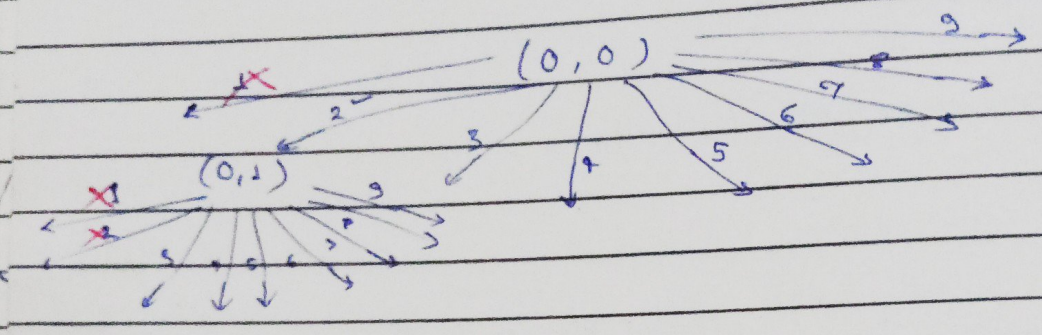
srow = row - row % 3 → 7 - 7 % 3 → 3

scol = col - col % 3 → 8 - 8 % 3 → 6 → (3,6)

We need it bcz we are passing only board not the small box indexes. in our arguments.

```
static boolean isSafe ( int[][] board, int row, int col, int num)
{   // three thing we will check                                    }
static boolean solve ( int[][] board) {
```

Shraddha Khapra, Better explanation then kunal kushwah for Sudoku




```
public boolean helper ( char[][] board , int row , int col )
{
    if ( row == board.length ) { return true; }
int nrow = 0;
int ncol = 0;
if ( col != board.length - 1 )
{ nrow = row; ncol = col+1; }
else
    { nrow = row+1; ncol = 0; }

if ( board[row][col] != '.' ) { if ( helper ( board , nrow , ncol ) ) return true; }
else {
    for ( int i=1; i<=9; i++)
    {   if ( isSafe ( board , row , col , i ) )
        {   board[row][col] = (char)(i+'0');
            if ( helper ( board , nrow , ncol ) )
                return true;
            else board[row][col] = '.';
        }
    }
}
```

isSafe function → write by yourself

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