

Backtracking - 2

In This Lecture

1. Permutations of an Array ✓
2. Generate Parentheses ✓

Permutations of an Array

Input: $\text{nums} = [1, 2, 3]$

Output: $[[1, 2, 3], [1, 3, 2], [2, 1, 3], [2, 3, 1], [3, 1, 2], [3, 2, 1]]$

Input: $\text{nums} = [0, 1]$

Output: $[[0, 1], [1, 0]]$



$\begin{matrix} A & B & C \\ \downarrow & & \\ B & A & C \\ C & A & B \end{matrix}$

3!

$0 \rightarrow 0 \rightarrow 6$
 $0 \rightarrow 1 \rightarrow 6$
 $0 \rightarrow 2 \rightarrow 6$
 $0 \rightarrow 3 \rightarrow 6$

$(2, 4)$
 4!

Permutations of an Array

↳ [] : subproblem

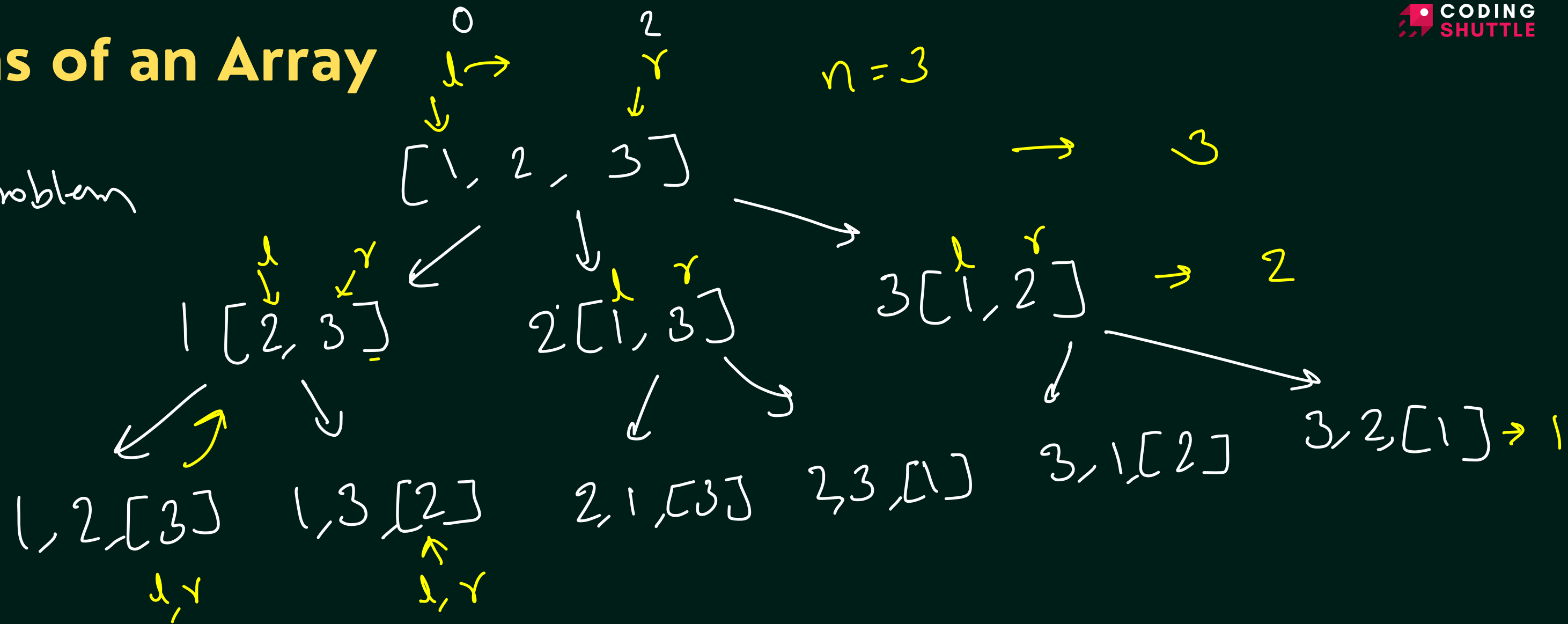
[3] → [3]

1! = 1

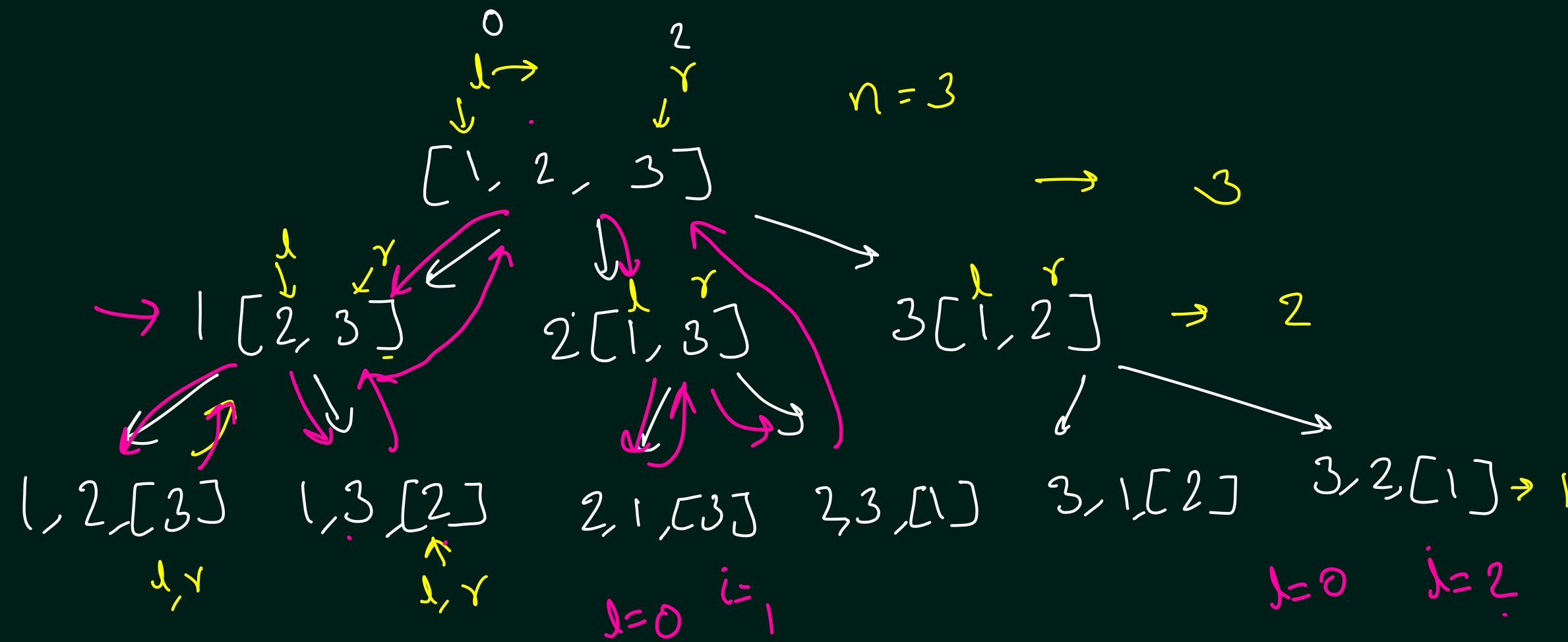
1, 2, 3
1, 3, 2

Base case: $l == r$

1, 2, 3
1, 3, 2



Permutations of an Array



1, 2, 3
→ 1, 3, 2

1, 3, 2
3[1, 2]
[3, 1, 2] [3, 2, 1]

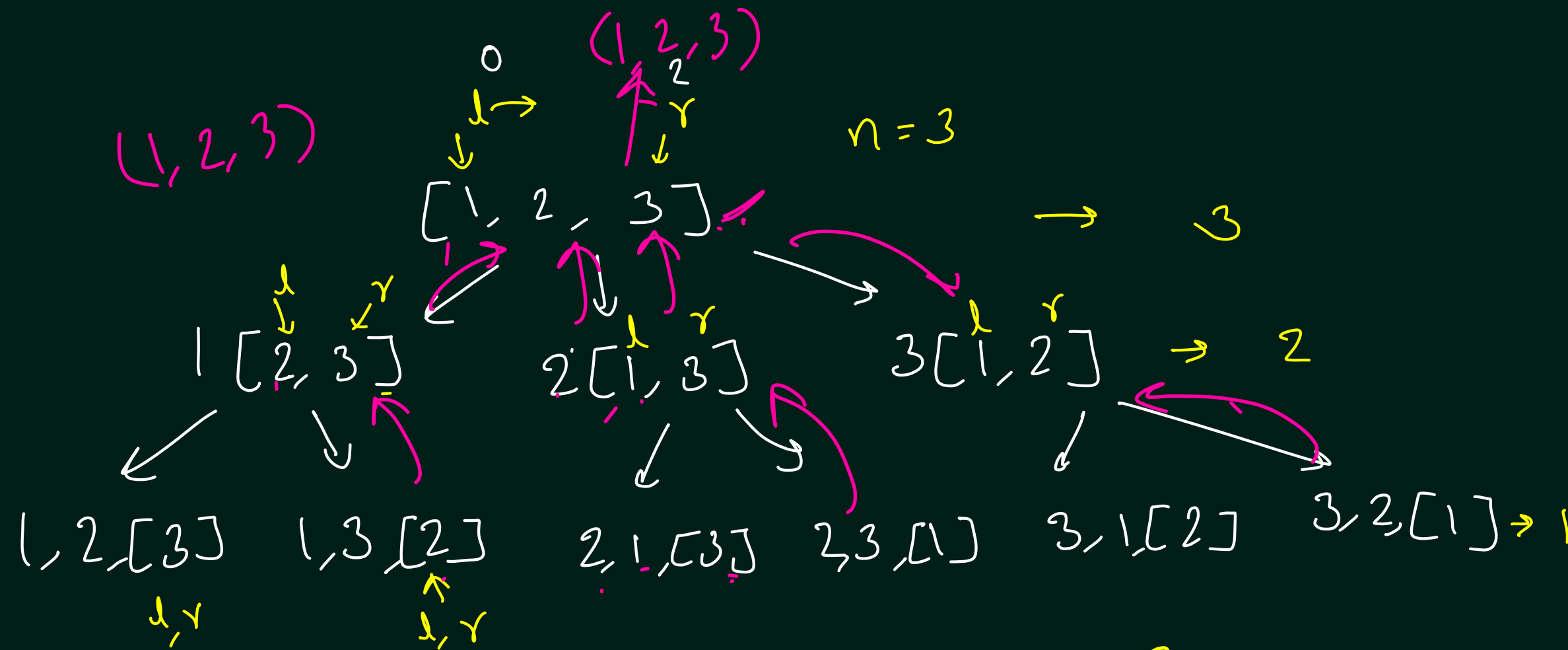
3, 2, 1
1[2, 3]
1, 2, 3, [1, 3, 2]

```
public static void main(String[] args) {
    int a[] = {1, 2, 3};
    permute(a, 0, a.length-1);
}
```

2 usages

```
static void permute(int a[], int l, int r) {
    if(l == r) {
        printArray(a);
        return;
    }
    for(int i = l; i <= r; i++) {
        swap(a, i, l);
        permute(a, l+1, r);
        //swap(a, i, l); //Backtracking
    }
}
```

Permutations of an Array



- 1, 2, 3
- 1, 3, 2
- 2, 1, 3
- 2, 3, 1
- 3, 1, 2
- 3, 2, 1

$O(n! \times n)$ $n = 3 \rightarrow 3!$

$O(n)$

```
public static void main(String[] args) {
    int a[] = {1, 2, 3};
    permute(a, 0, a.length-1);
}

2 usages
static void permute(int a[], int l, int r) {
    if(l == r) {
        printArray(a);
        return;
    }
    for(int i = l; i <= r; i++) {
        swap(a, i, l);
        permute(a, l+1, r);
        //swap(a, i, l); //Backtracking
    }
}
```

Generate Parentheses

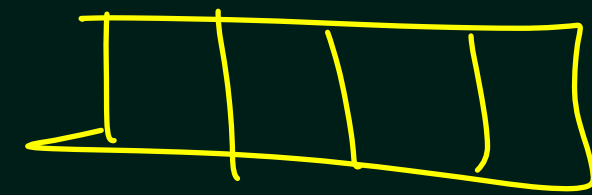
✓ For n = 2

Print: $\overbrace{()(), ()()}$

n = 2 → open
→ close
→ valid

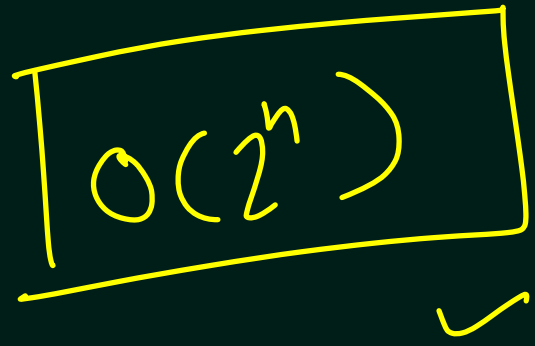
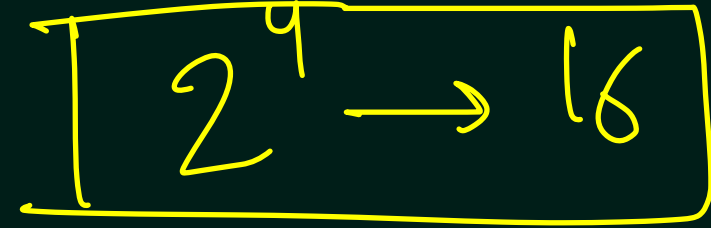
$)()()$ $()()()$

$((((($
 $((())$



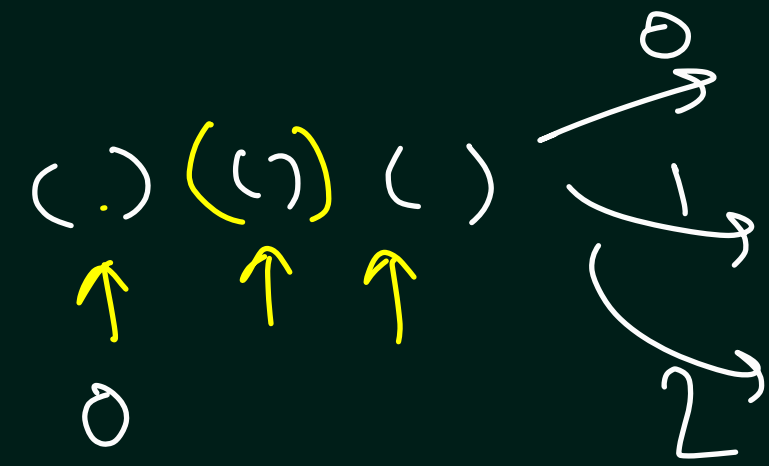
For n = 3

Print: $((()))$, $((()())$, $((()())$, $((()())$, $((()())$



$()()()$

$O(n \times 2^n)$



$((())$

$()()()$

Generate Parentheses

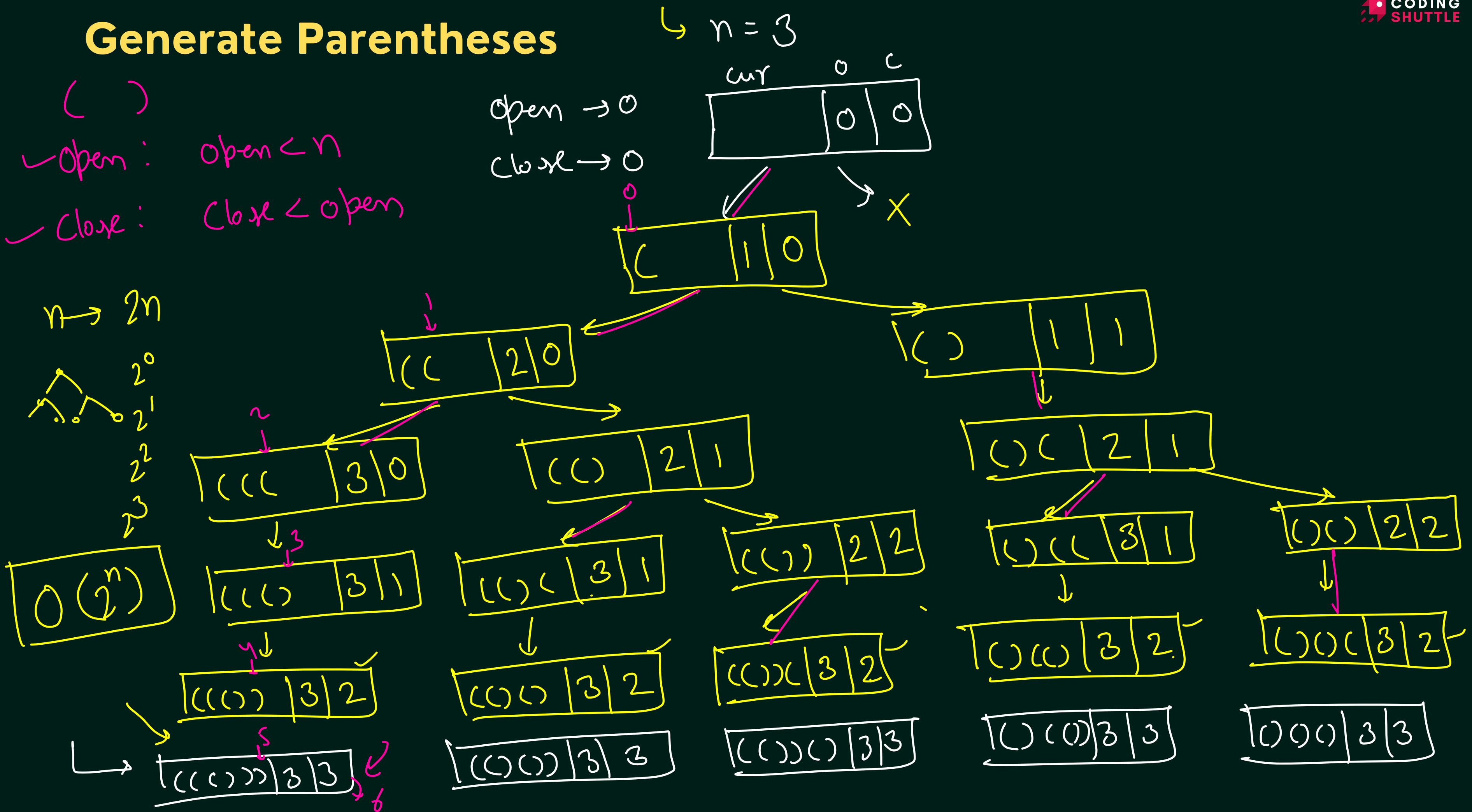
$n = 3$

open $\rightarrow 0$
close $\rightarrow 0$

cur	o	c
	0	0

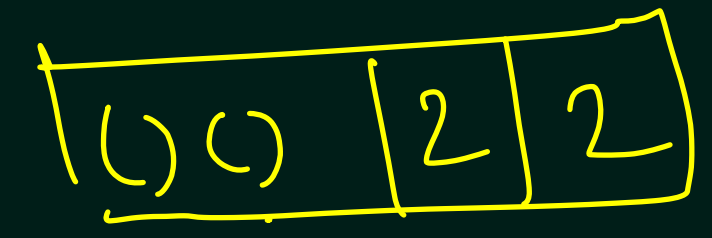
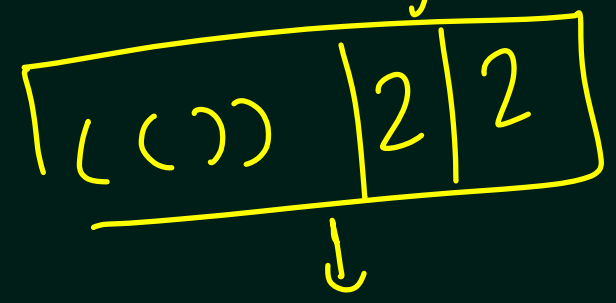
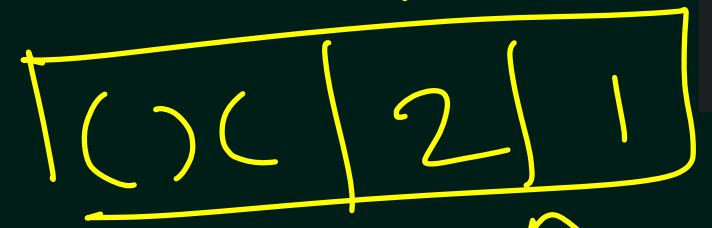
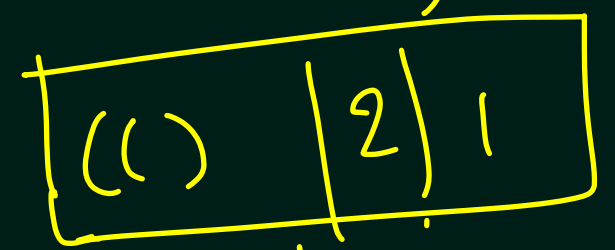
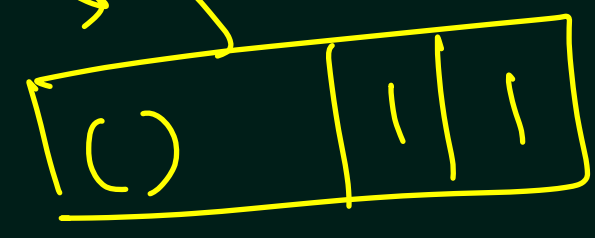
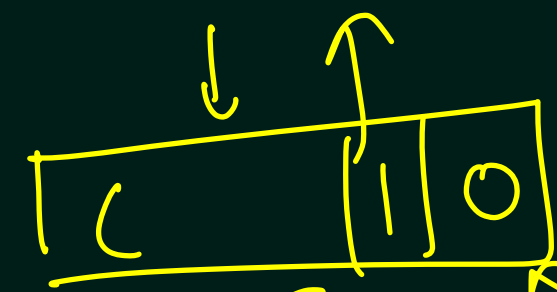
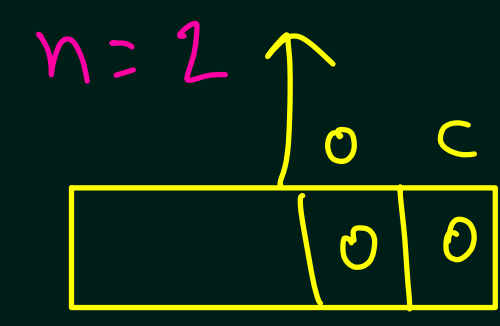
()
Open: $open < n$
Close: $close < open$

$n \rightarrow 2n$



0
1
2
3
4

() () ()



```
3 usages
static void generateParentheses(int n, String cur, int i, int open, int close) {
    if(i == 2*n) {
        System.out.println(cur);
        return;
    }
    if(open < n) {
        cur = cur + '(';
        generateParentheses(n, cur, i+1, open+1, close);
        cur = cur.substring(0, cur.length()-1); // backtracking
    }
    if(close < open) {
        cur = cur + ')';
        generateParentheses(n, cur, i+1, open, close+1);
    }
}
```

(())
() ()