TP Sessions-Bit Manipulation and Number Based Problems

Given x number of 1's followed by y number of 0's, your task is to find the decimal representation of the x and y.

```
    int decimal = Math.pow(2, x) - 1
     decimal =decima1 * Math.pow(2, y)
```

Better approach

```
-------------------------------------
         int res=0
         int decimal = (1 << x) - 1
         decimal <<= y
```

if number is too large use big integer class

```
        import java.math.BigInteger;
        BigInteger x = scanner.nextBigInteger();
        BigInteger y = scanner.nextBigInteger();

         BigInteger res = BigInteger.ZERO;

        BigInteger res =
BigInteger.ONE.shiftLeft(x.intValue()).subtract(BigInteger.ONE).shiftLeft(y.intValue());
```

Given Xth and Yth Bit position. Create a number where X and Yth bit are Set:

```
int result= (1<<x) | (1<<y)
```

In a given integer - N, check whether the ith bit is set or not.

suppose i=2 and N=10, 1010 in binary: 2nd bit is 0(starting from 0,1,2)

```
if(n>>i & 1==1) then
    print true
else
    print false
```

Calculate number of bits required to represent an integer value:

```
                while n>0 do
                 count++
                 n>>=1
                 print count
```

instead: int bits = (int)(Math.log$_{10}$(num) / Math.log$_{10}$(2)) + 1;

For example Take num=4

this is equal to $\log_{10}(4)/\log_{10}(2)$--> $\log_2(4)=2+1=3$

Reverse the Bits of an integer number and print the value in decimal.

```
  while N>0 Do
      res=0
     res = (res << 1) | (n & 1);
      n >>= 1;
    }
   print res
```

N&1 to extract LSB bit of original number.

Res<<1 to shift the result bit to the left side so that we can reverse the original number.

OR operation to combine the shifted res with the extracted bit.

n>>=1 to move to the next bit in the number

Sum of 2 numbers using bitwise operators

```
  int x=5, y=3
 while y != 0 Do
        carry = x & y
        x = x ^ y
        y = carry << 1
print(x)
```

- x & y calculates the carry bits.
- x ^ y calculates the sum bits without carry.
- carry << 1 shifts the carry bit left
- Repeat until there's no carry left.

Largest Power of 3 less than or equal to given number N:

```
 initalize res to 1
 initalize power to 1

 until power < N Do
    res=power
    power =power * 3

 print(res)
```

If the number is too large use BigInteger Class

```
   String input = scanner.nextLine();
   BigInteger N = new BigInteger(input);
        // or read directly as: BigInteger x = scanner.nextBigInteger();

        BigInteger res = BigInteger.ONE;
        BigInteger power = BigInteger.ONE;

            while (power.compareTo(N) < 0) {
            res = power;
            power = power.multiply(BigInteger.valueOf(3));
        }

        print(res)
```

Print Number of trailing zeroes in the factorial of a given number N

GENERAL APPROACH

```
      mainfunction()
      {
         read long int value
         long fact=factorial(n)
         long count=counttrailingzeroes(fact)
         print(count)
      }

      factorial(long n)
      {
            intitalize long res=1
            for i=1 to n   (i=1;i<=n;i++)
            res=res*i
            return res
      }

    counttrailingzeroes(long n)
      {
        int count = 0;
       while n > 0 Do
         if n mod 10 == 0 then
            count++
         else
            break the loop
        n= n/10;
       END WHILE
        return count
     }
```

BETTER APPROACH

every multiple of 5 contributes to number of trailing zeroes in N!

use formula: n/5+n/25+n/125 and so on!!

initalize count=0

```
while n >0 Do
count = count + (n/5)
n = n/5
END WHILE

print(count)
```

Check if a given number is Prime Number or Not

```
   int flag=1
   if n<=1
      print not Prime
      return

   for i=2 to Math.sqrt(n) DO
      if n mod i==0 then
      set flag to 0
       break the loop

   if flag==1 then
      print "prime"
   else
     print "not Prime"
```

Instead of using Math.sqrt the better efficient way could be:

```
for i=2 to i*i<=n
   if n mod i==0
     set flag=0
     break the loop
```

Print Prime numbers from 1 to given range N

```
mainfunction()
{
      read n
      for i=1 to n+1 Do
       if(checkprime(i)):
           System.out.print(i+" ")
}
```

```
boolean checkprime(int n)
{
    if n is less than or equal to 1
        return False
    for i=2 to Math.sqrt(n) Do
        if n%i==0
            return false
    return true
}
```

Print Prime Numbers upto given Count

```
read N
set count=0
set i=1
while count<n Do:
    res=checkprime(i)
    if res==true
        System.out.print(i+"  ")
        increment count++
    increment i++
```

```
boolean checkprime(int n)
{
    if n is less than or equal to 1
        return False
    for i=2 to Math.sqrt(n) Do
        if n%i==0 then
            return false
    return true
}
```

SIEVE OF ERATOSTHENES: THE MOST OPTIMIZED PRIME NUMBER LOGIC

```
        boolean[] prime = new boolean[n + 1]
        for int i=0 to n Do
          set prime values to true


        OuterLoop for int i=2 to i*i<=n Do
           check if prime[i] is true if so then gotoinner loop
                  for int j=p*p to n (Note: increment innerloop by j=j+p)
                     set prime[j] to false


           for int i=2 to n Do
            if prime[i] is true then
              print(prime[i]+" ")
```

Print prime numbers upto given range N for T test cases each on new line

```
Take input number of test cases T
iterate from i=1 to T Do
    read integer number n
   call printupton(n) function


function printupton(n):
    iterate from i to n Do
        if(checkforrime(i)==true):
            print(i+" ")
    println()
End Function


function boolean checkforprime(int n)
    if n<=1 then
        return false
    iterate from i=2 to sqrt(n) D0
        if n%i==0 then
            return false
    return true
End function
```

for example:

```
T=3
10
2 3 5 7
20
2 3 5 7 11 13 17 19
100
2 3 5 7 11 13 17 19 23 29 31 37 41 43 47 53 59 61 67 71 73 79 83 89 97
```

compute a power b where b value can be as large as 10^9.
don’t use inbuilt function pow.

Basic Approach

```
Read a value (base)
Read b value (power)
long result = 1;
        while (b != 0) {
            result = result * a;
            b--;
        }
```

For large values of power (10^9) this approach will take too long to compute.
i,e 10^9 multiplications, which is computationally expensive and will take a significant amount of time to complete,
Time Complexity is O(b), which is not efficient for large b.

Optimized Approach

Efficient Reduction: Instead of iterating b times, we reduce b exponentially by halving it, achieving O(logb) time complexity.
Handles Large Powers: The method works even for very large powers like 10^9 where direct multiplication would take too long.
Modulo Operation: Keeps intermediate results within limits, preventing overflow.

formula: a^b if b is odd for example 2^3: formula is: a^b=a*a^(b-1)
        if b is even: a^b=(a*a)^b/2 for example: 2^4= (2*2)^4/2 =4^2=16

```
        int t = sc.nextInt();  // Number of test cases
         int MOD = 1000000007;

         while (t-- > 0) {
            Read a value
             Read b value
           declare long result=1
          assign a to long base i.e long base =a

             while (b > 0) {
                 if (b % 2 == 1) {
                     result = (result * base) % MOD;
                 }
                 base = (base * base) % MOD;
                 b /= 2;
             }
             print(result)
         }
```

can be solved using BigInteger class (but wont work if constraints are mentioned)

```
 BigInteger mod = new BigInteger("1000000007");
        int t=scanner.nextInt();
        while(t-->0)
        {
        BigInteger result = BigInteger.ONE;
        BigInteger a = scanner.nextBigInteger();
        BigInteger b = scanner.nextBigInteger();
        while (!b.equals(BigInteger.ZERO))
        {
            result = (result.multiply(a)).mod(mod);

            b = b.subtract(BigInteger.ONE);
```

```
}

System.out.println(result);
}
```

```
Beautiful NUmber
---------------
input=1223433444
output=1223433444 is a beautiful number


 Function boolean check_beautiful(int num)

        String str = String.valueOf(num)
        int[] count = new int[10]
        iterate from i=0 to i<str.length() Do
            int digit = str.charAt(i) - '0'
            count[digit]++
        end For
        iterate from i=0 to i<str.length() Do
            int digit = str.charAt(i) - '0'
            if (count[digit] != digit)
               return False
         End For

        return true
End Function
```

```
Find Duplicate Number using Array Count Approach
-------------------------------------------------
input=5
2 1 4 3 2
output=2


Function int findDuplicate(int[] nums)
           int len = nums.length;
           int[] cnt = new int[Integer.Max_Value]
            For iterate from i=0 to i<len Do
                cnt[nums[i]]++
                if cnt[nums[i]] > 1
                    return nums[i]
            End For
      return -1
End Function
```

```
Duplicate Number Using ArrayList
-----------------------------------

Function  int findDuplicate(int[] nums)
    ArrayList<Integer> arr = new ArrayList<>()
    for (int num : nums)
        if (arr.contains(num))
            return num
        else
        arr.add(num)
    }
    return -1
End Function
```

```
Duplicate Number Using HashSet
---------------------------------

Function  int findDuplicate(int[] nums)
    HashSet<Integer> arr = new HashSet<>()
    for (int num : nums)
        if (!arr.add(num))
            return num
    return -1
End Function1
```

hashset takes O(1) for lookup
 whereas arraylist uses O(n)

```
Print Unique Elements in Array Basic Approach
-------------------------------------------
input=5
1 2 1 1 3
output=
2 3

   findAndPrintUniqueElements(int[] array, int N)
        int[] frequency = new int[N]

          for (int i = 0; i < N; i++)
            for (int j = 0; j < N; j++)
                if (array[i] == array[j])
                    frequency[i]++


            for (int i = 0; i < N; i++)
            if (frequency[i] == 1)
                print(array[i])
```

```
Print Unique Elements in Array Optimized Approach
-------------------------------------------
 HashSet<Integer> unique = new HashSet<>()
 HashSet<Integer> duplicate = new HashSet<>()
        for (int num : array)
            if (!unique.add(num))
                duplicate.add(num)

unique.removeAll(duplicate)
 for (int i : unique)
      print(i)
```

```
Count Pairs with given Sum K Basic Approach
--------------------------------------------
input=
7
4 3 2 6 5 1 3
6
output=
Number of pairs with sum 6: 3
```

```
int countPairs(int[] nums, int K)
    int count = 0
    int n = nums.length

    for (int i = 0; i < n; i++)
        for (int j = i + 1; j < n; j++)
            if (nums[i] + nums[j] == K)
                count++
            }
        }
    }
      print(count)
```

Count Pairs with Sum K using Compliment approach

```
int countPairs(int[] nums, int K)
  int count = 0
        int[] res = new int[10000] //assume max value upto 10000
        for (int num : nums)
            int complement = target - num
            count += res[complement]
            res[num]++

       print count
```

Kth Smallest Element in an Array Basic Approach

```
3 4 66
34 5 7
8 77 22
Enter the value of k:
3
[3, 4, 66, 34, 5, 7, 8, 77, 22]
The 3rd smallest element is: 5
```

```
            int rows = matrix.length
            int cols = matrix[0].length
            int[] flatArray = new int[rows * cols]
            int index = 0
            for (int i = 0; i < rows; i++)
                for (int j = 0; j < cols; j++)
                    flatArray[index++] = matrix[i][j]

            Arrays.sort(flatArray)
            print (flatArray[k - 1])
```

Kth Smallest Element in an Array using Priority Queue

```
 PriorityQueue<Integer> minHeap = new PriorityQueue<>()
        for (int i = 0; i < rows; i++)
            for (int j = 0; j < cols; j++)
                minHeap.offer(matrix[i][j]);
```

```
      iny k=sc.nextInt()

        int kthSmallest = -1
        for (int i = 0; i < k; i++)
            kthSmallest = minHeap.poll()

        print kthSmallest
```

```
Transpose Matrix
---------------------

        {1, 2}
        {4, 5}  3*2 matrix
        {7, 8}
        after transpose becomes 2*3 matrix
        {1,4,7}
        {2,5,8}


           int[][] transpose1(int[][] matrix)
                int rows = matrix.length;
                int cols = matrix[0].length;
                int[][] transpose = new int[cols][rows];

                for (int i = 0; i < rows; i++) {
                    for (int j = 0; j < cols; j++) {
                        transpose[j][i] = matrix[i][j];



            public static void printMatrix(int[][] matrix)
                for (int[] row : matrix)
                    for (int value : row)
                        System.out.print(value + " ")
                    println()
```

```
Zero Matrix
---------------
input=
Enter the size of the square matrix: 4
Enter matrix elements (0s and 1s):
0 1 0 1
0 1 0 1
1 1 1 1
1 1 1 1
output=
Modified Matrix:
0 0 0 0
0 0 0 0
0 1 0 1
0 1 0 1
```

```
 setZeroMatrix(int[][] matrix, int n)
        boolean[] row = new boolean[n]
```

```
boolean[] col = new boolean[n]

for (int i = 0; i < n; i++)
    for (int j = 0; j < n; j++)
        if (matrix[i][j] == 0)
            row[i] = true
            col[j] = true


for (int i = 0; i < n; i++)
    if (row[i])
        for (int j = 0; j < n; j++)
            matrix[i][j] = 0


for (int j = 0; j < n; j++)
    if (col[j])
        for (int i = 0; i < n; i++)
            matrix[i][j] = 0
```

MATRIX MULTIPLICATION

For matrix multiplication, the number of columns in the first matrix must be equal to the number of rows in the second matrix. The resulting matrix, longstreakhas the number of rows of the first and the number of columns of the second matrix.

```
int[][] multiply(int[][] a, int[][] b)
       if (a[0].length != b.length)
         print "Cant Multiply bcz Matrix A columns must match Matrix B"
          EXIT

       int rowsA = a.length
       int colsA = a[0].length
       int rowsB = b.length
       int colsB = b[0].length
       int[][] result = new int[rowsA][colsB]

       for (int i = 0; i < rowsA; i++)
           for (int j = 0; j < colsB; j++)
               result[i][j] = 0
               for (int k = 0; k < colsA; k++)
                   result[i][j] += a[i][k] * b[k][j]
```

Big Factorial

```
Constraints:
---------------
Input length: within integer range
Output length: 1<=length(n)<1000

Test Case examples:
--------------------
input=45
output=
Factorial of 45 is:
119622220865480194561963161495657715064383733760000000000

input=124
output=
Factorial of 124 is:
1506141741511140879795014161993280686076322918971939407100785852066825250652908790935063463
1159673850691712435674404619250412953547310447825510676604683764441946110045200570541670400
00000000000000000000000000

input= -5853
output=
Factorial is not defined for negative numbers.

input= !@#$%^&*)fgfg(*&+_)
output=
Special Characters and Alphabets are not allowed.

*/     try{
            String input = scanner.nextLine().trim();
            int number = Integer.parseInt(input);

             if (number < 0)
                throw new GrietException("Factorial is not defined for negative numbers.")

            if (!input.matches("\\d+"))
               print "Special Characters and Alphabets are not allowed."
                return;

            BigInteger factorial = calculateFactorial(number)
            print "factorial"


        } catch (GrietException e) {
            print(e.getMessage())
        } catch (NumberFormatException e) {
            print("Special Characters and Alphabets are not allowed.")
        }
    }

    private static BigInteger calculateFactorial(int n) {
        BigInteger result = BigInteger.ONE
        for (int i = 2; i <= n; i++) Do
            result = result.multiply(BigInteger.valueOf(i))
        end for
        return result
```

Welcome Back Armstrong

```
   An Armstrong number:is a number that is the sum of its own digits each raised to the power of the
number of digits.

Input/Output Constraint:
--------------------------
1<=N<10^17

Output format: return true if its armstrong number, return false if its not an armstrong number.
                Don't print any output message in ur code.

Test Case Examples:
-----------------------
input= 153
output=
153 is an Armstrong number.

Explaination: 1^3 +5^3 +3^3 =153 Hence its an Armstrong number.

input= 9474
output=
9474 is an Armstrong number.

Explaination: 9^4 + 4^4 + 7^4 + 4^4 = 9474 hence its an Armstrong number.

input= 24678050
output= 24678050 is an Armstrong number.

input=35641594208964132
output=35641594208964132 is an Armstrong number.

input=4929273885928088826
output=4929273885928088826 is not an Armstrong number.

*/
// Start writing your code from here

    public static boolean Met(String numStr)
        int length = numStr.length()
        long sum = 0

        for (int i = 0; i < length; i++) Do
            int digit = Character.getNumericValue(numStr.charAt(i));
            sum += Math.pow(digit, length);
      END for

        return sum == Long.parseLong(numStr);
```

In Python u can take a limit variable assigbed to 10**17, at any point if sum exceeds limit value u can return false or else return true.

Next Smallest Palindrome

```
1<=number<=10^17

Test Case Example:
-------------------
input=8496395839536
output=
Next Smallest Palindrome: 8496395936948


input=1268
output=
Next Smallest Palindrome: 1331


input=9775577457
output=
Next Smallest Palindrome: 9775665779

      long num = scanner.nextLong()
      long res = PalindromeChecker(num)

        print res as next Smallest Palindrome
      }

private static long PalindromeChecker(long num)
        while (true) Do
            num++
            if (isPalindrome(num))
                return num
        end While
Close function

private static boolean isPalindrome(long num)
        long originalNum = num
        long rev = 0

        while (num > 0) Do
            long digit = num % 10
            rev = rev * 10 + digit
            num /= 10
        end while

        return originalNum == rev
End Function
```

```
Universal Palindrome
------------------------
```

```
input=1221
output=palindrome

input=ar77ra
output=palindrome

input=*&*
ouptut=palindrome
```

```java
    public static boolean isPalindrome(String str) {
        String rev = new StringBuilder(str).reverse().toString();
        return str.equals(rev);
    }
```

Big Digit Sum

```
Big Digit Sum
--------------------

Constraints:
-------------
input= 1 <= length(N) <= 10^3
output= result should be within integer range.

Note:
 Print appropriate error messages if user enters any other characters apart from digits in the input.
 As given in the test cases below. Remove if there are any extra whitespaces in input.

test case examples:
-----------------------
input=1234
output=
10

input=5678765432456787654345676543456765434567654 3
output=
228

input=9999999999999999999999999999999999999999999999999999999999999999999999999999999999
output= 738

input=     Griet1661
output=
Only digits are allowed

input=$&*(((*&!#$_+)))
Special characters are not allowed


     String input = scanner.nextLine().trim()
        sumOfDigits(input)

    public static void sumOfDigits(String N)
        boolean hasAlphabet = false
        boolean hasSpecialChar = false

        for (char ch : N.toCharArray())
            if (Character.isLetter(ch))
                hasAlphabet = true
                break;
            else if (!Character.isDigit(ch))
                hasSpecialChar = true
                break

        if (hasAlphabet)
          print "Only digits are allowed"
            return;
        else if (hasSpecialChar)
            print "Special characters are not allowed"
            return

        int digitSum = 0
        for (char digit : N.toCharArray())
            digitSum += Character.getNumericValue(digit)

        print digitSum
```

Sum Between the largest and second largest in the arraylist

```
input=2 1 6 7 8 9 5 4 10
quit
output=
Sum between the largest and second-largest numbers: 9
```

```
STEPs:
--------
  INITIALIZE ArrayList named as numbers

  WHILE (sc.hasNextInt())
      READ number and ADD to numbers

  IF (numbers.size() < 2)
      PRINT "At least two distinct numbers are required."
      RETURN

  INITIALIZE Bigindex = 0
  INITIALIZE secondBig index= -1

Iterate from i=1 to i less than numbers.size() Do
      IF (numbers[i] > numbers[Bigindex])
          secondBigindex = Bigindex
          Bigindex = i
      ELSE IF (secondBigindex == -1 OR numbers[i] > numbers[secondBigindex])
          secondBigindex = i

  INITIALIZE sum = 0
  k = MIN(Big, secondBig)

  Iterate from j=k+1 TO k < (Big + secondBig - k)
      sum = sum + numbers[j]

  PRINT "Sum between the largest and second-largest numbers: " + sum
```

Harmony in Array

```
input=5
3 2 5 3 2
output=
Harmony Index: 2
```

```
  int harmonyindex(ArrayList<Integer> arr, int n)
        int totalSum = 0
        int leftSum = 0

        for (int i = 0; i < n; i++)
            totalSum += arr.get(i)

        for (int i = 0; i < n; i++)
            totalSum -= arr.get(i)

            if (leftSum == totalSum)
                return i

            leftSum += arr.get(i)
        }

        return -1
    }
```

Unique Pairs and Count in 2D array of Strings

```
input=5
virat kohli
rohit sharma
ishan kishan
virat kohli
KL rahul
output=
1
2
3
3
4
```

```
        int n = scanner.nextInt()
        scanner.nextLine()

        String[][] input = new String[n][2]

        for (int i = 0; i < n; i++)
            String line = scanner.nextLine()
            input[i] = line.split(" ")

        uniquePairs(input)


 void uniquePairs(String[][] pairs)
        HashSet<String> set = new HashSet<>()
        int count = 0

        for (String[] i : pairs)
            String merged = i[0] + " " + i[1]

            if (set.contains(merged))
                print(count)
             else
                set.add(merged)
                count++;
                print(count)
```

Winning Candidate

```
input=5
3 1 3 3 2
output=
Winning Candidate: 3


STEPs:
---------
 winningCandidate(ArrayList<Integer> list)
        int count = 0
        int candidate = -1
        for (int num : list)
            if (count == 0)
                candidate = num

            if(num==candidate)
             count++
            else count--

        int finalCount = 0
        for (int num : list)
            if (num == candidate)
                finalCount++

        if (finalCount > list.size() / 2)
            return candidate


        return -1
```

Longest Consecutive Subsequence

```
input=2 1 0 3 quit
output=
Length of the longest consecutive subsequence: 4

input=44 45 2 6 47 90 48 12 56 49 100 50
quit
output=
Length of the longest consecutive subsequence: 4

Explaination: 47,48,49,50 is the longest consecutive sequence hence output is 4.
```

```
STEPs:
--------
Function Subsequence(HashSet<Integer> arr)
        int longstreak = 0

        for (int num : numberSet) {
            if (!numberSet.contains(num - 1))
                int curnum = num
                int curstreak = 1


                while (numberSet.contains(curnum + 1))
                    curnum++
                    curstreak++


                longstreak = Math.max( longstreak, streak)


        print(longstreak)
```

Searching, sorting

```
Array, Key, Segment, Search
-----------------------------
input=
9
3 6 2 2 5 7 4 5 2
3 //key
3 //segment
output=No Key not found in every segment

Explaination: segment size is 3 so. segments are {3,6,2}, {2,5,7} and {4,5,2}
key value is 3 which is present in every segment.
input=
9
6 7 2 5 2 9 4 3 2
2 //key
3 //segment
output=Yes the key found in every segment
```

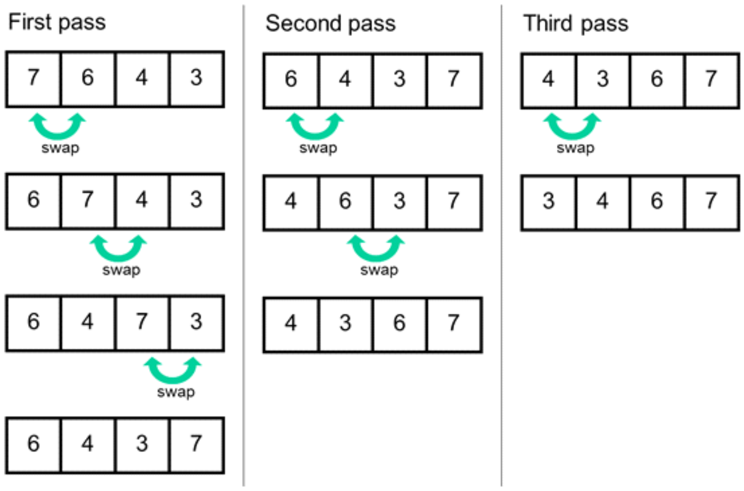
```
Function int KeyPresentInSegments(int arr[], int n, int x, int k)
        for (int i = 0; i < n; i += k)
            int found = 0
            for (int j = i; j < i + k && j < n; j++)
                if (arr[j] == x)
                    found = 1
                    break

            if (found == 0)
                return 0

  return 1                //i.e key present in every segment
```

```
Smaller < X < Greater
---------------------
input=10
2 1 3 4 5 7 12 45 78 10
output=
Index of the element: 2

input=5
10 2 2 3 1 0
output=No such element found.
```

```
Function int findElement(int[] arr, int n)
        for (int i = 1; i < n - 1; i++)
            if (check(arr, n, i) == 1)
                return i

    return -1

Function int check(int[] arr, int n, int ind)
        int i = ind - 1
        int j = ind + 1

        while (i >= 0)
            if (arr[i] > arr[ind])
```

```
                return 0
            i--

        while (j < n)
            if (arr[j] < arr[ind])
                return 0
            j++

   return 1
```

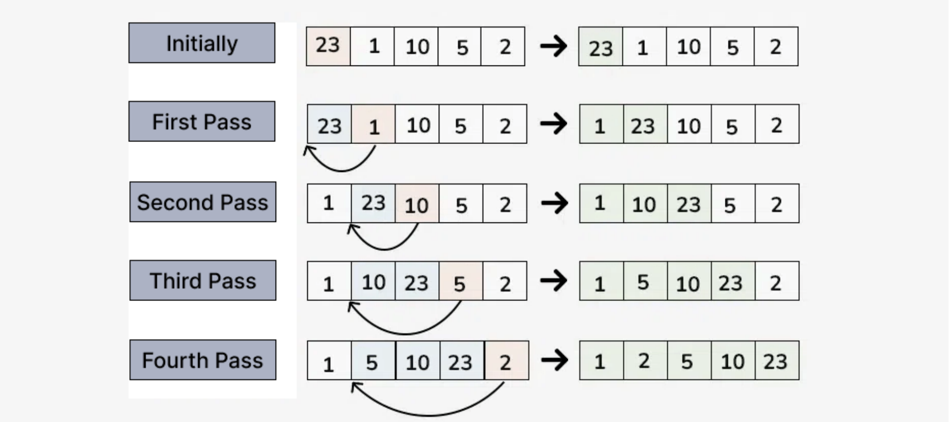
Effcient Bubble Sort



```
input=7
34 21 67 45 123 43 89
output=
Pass 1: 21 34 45 67 43 89 123
Pass 2: 21 34 45 43 67 89 123
Pass 3: 21 34 43 45 67 89 123
Sorted array is:
21 34 43 45 67 89 123
```

```
for i from 0 to n-1
    flag = false

    for j from 0 to n-i-1
        if arr[j] > arr[j+1]
            swap arr[j] and arr[j+1]
            flag = true

       if flag is false
        break from the outerloop
    else
      for j from 0 to n:
     print pass output arr[j]

 back to main loop
```

Insertion Sort with Passes



Initially 23 1 10 5 2 → 23 1 10 5 2

First Pass 23 1 10 5 2 → 1 23 10 5 2

Second Pass 1 23 10 5 2 → 1 10 23 5 2

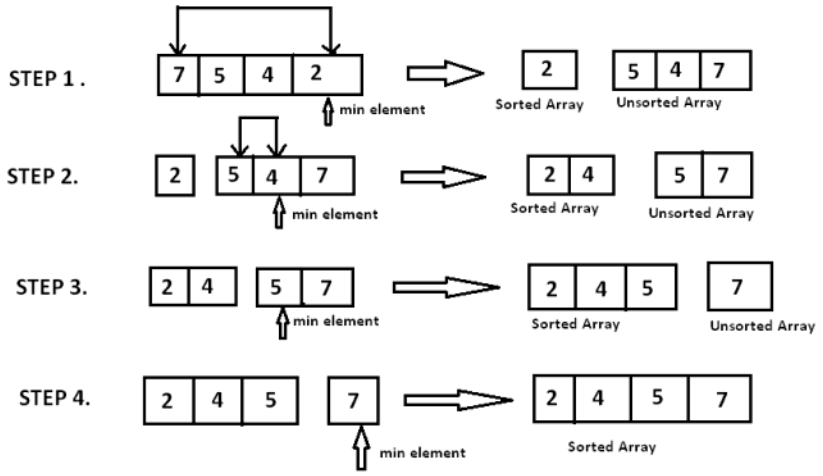
Third Pass 1 10 23 5 2 → 1 5 10 23 2

Fourth Pass 1 5 10 23 2 → 1 2 5 10 23

```
input = 5
12 78 45 2 18
output =
PASS - 1 :12 78 45  2   18
PASS - 2 :12 45 78  2   18
PASS - 3 :2  12 45  78  18
PASS - 4 :2  12 18  45  78

THE  SORTED LIST:
2   12  18  45  78
```

```
        for (int i = 1; i < n; i++)
            int key = arr[i]
            int j = i - 1
            while (j >= 0 && arr[j] > key) {
                arr[j + 1] = arr[j]
                j--
            }
            arr[j + 1] = key
            printArray(arr, n, i)
        }
    }

     printArray(int[] arr, int n, int pass)
        for (int k = 0; k < n; k++)
            System.out.print(arr[k] + " ")

        System.out.println()
```

Selection Sort



```
   for (int i = 0; i < n - 1; i++)
            int minIndex = i
            for (int j = i + 1; j < n; j++)
                if (array[j] < array[minIndex])
                    minIndex = j


            int temp = array[minIndex]
            array[minIndex] = array[i]
            array[i] = temp;

         print("Array after pass " + (i + 1) + ": ")
         for (int k = 0; k < n; k++)
          System.out.print(array[k] + " ");

   end for

        print final array
```

Quick Sort with last element as Pivot

```
input=4
5 4 3 1
output=
1 4 3 5
4 3 5
3 4
1 3 4 5
```

```
 public static void quicksort(int[] a, int left, int right)  //left=0, right=n-1
        if (left < right)
            int pivot = partition(a, left, right)
            quicksort(a, left, pivot - 1)
            quicksort(a, pivot + 1, right)



    public static int partition(int[] a, int left, int right)
        int pivot = a[right]
        int i = left - 1  //i track the position of the last element that is less than or equal to the pivot
        for (int j = left; j < right; j++)
            if (a[j] <= pivot)
                i++    //This means that all elements up to index i are guaranteed to be less than or equal to the pivot.
                swap(a, i, j)

        swap(a, i + 1, right)  //adjust the pivot
                   // When we swap the pivot with the element at index i + 1, we are effectively placing the pivot right
                  after the last element that is less than or equal to it.

        printArray(a, left, right) // Print the array after partitioning
        return i + 1
    }

     void swap(int[] a, int i, int j)
        int temp = a[i]
        a[i] = a[j]
        a[j] = temp


     void printArray(int[] a, int left, int right)
        for (int i = left; i <= right; i++)
            System.out.print(a[i] + " ")
        }
        System.out.println()
    }
}
```