Java - Introduction to Programming
Lecture 1

Installation & First Program

1. Install Java

a. Install JDK (https://www.oracle.com/in/java/technologies/javase-downloads.html)
b. Install IntelliJ (https://www.jetbrains.com/idea/download/#section=mac)
OR
b. Install Visual Studio Code (VS Code) - Prefer THIS (https://code.visualstudio.com/download)

2. Sample Code

Functions

A function is a block of code which takes some input, performs some operations and returns some output.
The functions stored inside classes are called methods.
The function we have used is called main.

Class

A class is a group of objects which have common properties. A class can have some properties and functions (called methods).
The class we have used is Main.

3. Our 1st Program

```
public class Main {

   public static void main(String[] args) {
  // Our 1st Program
       System.out.println("Hello World");
   }
}
```

Java - Introduction to Programming
Lecture 2

Variables & Data Types

1. Variables

A variable is a container (storage area) used to hold data.
Each variable should be given a unique name (identifier).

```
package com.apnacollege;

public class Main {

    public static void main(String[] args) {
        // Variables
        String name = "Aman";
        int age = 30;

        String neighbour = "Akku";
        String friend = neighbour;
    }
}
```

2. Data Types

Data types are declarations for variables. This determines the type and size of data associated with variables which is essential to know since different data types occupy different sizes of memory.

There are 2 types of Data Types :

- Primitive Data types : to store simple values
- Non-Primitive Data types : to store complex values

Primitive Data Types

These are the data types of fixed size.

Data Type	Meaning	Size (in Bytes)	Range
byte	2's complement integer	1	-128 to 127
short	2's complement integer	2	-32K to 32K
int	Integer numbers	4	-2B to 2B
long	2's complement integer (larger values)	8	-9,223,372,036,854,775,808 to 9,223,372,036,854,775,807
float	Floating-point	4	Upto 7 decimal digits
double	Double Floating-point	8	Upto 16 decimal digits
char	Character	2	a, b, c .. A, B, C .. @, #, $ ..
bool	Boolean	1	True, false

Non-Primitive Data Types
These are of variable size & are usually declared with a 'new' keyword.

Eg : String, Arrays

```
String name = new String("Aman");
int[] marks = new int[3];
marks[0] = 97;
marks[1] = 98;
marks[2] = 95;
```

3. Constants

A constant is a variable in Java which has a fixed value i.e. it cannot be assigned a different value once assigned.

```java
package com.apnacollege;

public class Main {

    public static void main(String[] args) {
   // Constants
        final float PI = 3.14F;
    }
}
```

Homework Problems

1. Try to declare meaningful variables of each type. Eg - a variable named age should be a numeric type (int or float) not byte.
2. Make a program that takes the radius of a circle as input, calculates its radius and area and prints it as output to the user.
3. Make a program that prints the table of a number that is input by the user.

   (HINT - You will have to write 10 lines for this but as we proceed in the course you will be studying about 'LOOPS' that will simplify your work A LOT!)

KEEP LEARNING & KEEP PRACTICING :)

Java - Introduction to Programming

Lecture 3

1. Conditional Statements 'if-else'

The if block is used to specify the code to be executed if the condition specified in if is true, the else block is executed otherwise.

```
int age = 30;
if(age > 18) {
   System.out.println("This is an adult");
} else {
   System.out.println("This is not an adult");
}
```

2. Conditional Statements 'switch'

Switch case statements are a substitute for long if statements that compare a variable to multiple values. After a match is found, it executes the corresponding code of that value case.

The following example is to print days of the week:

```
int n = 1;
switch(n) {
   case 1 :
       System.out.println("Monday");
       break;
   case 2 :
       System.out.println("Tuesday");
       break;
   case 3 :
       System.out.println("Wednesday");
       break;
   case 4 :
       System.out.println("Thursday");
       break;
   case 5:
       System.out.println("Friday");
       break;
   case 6 :
       System.out.println("Saturday");
       break;
   default :
       System.out.println("Sunday");
}
```

Homework Problems

1. Make a Calculator. Take 2 numbers (a & b) from the user and an operation as follows :

   1 : + (Addition) a + b

   - 2 : - (Subtraction) a - b
   - 3 : * (Multiplication) a * b
   - 4 : / (Division) a / b
   - 5 : % (Modulo or remainder) a % b

   Calculate the result according to the operation given and display it to the user.

2. Ask the user to enter the number of the month & print the name of the month. For eg - For '1' print 'January', '2' print 'February' & so on.

KEEP LEARNING & KEEP PRACTICING :)

Java - Introduction to Programming
Lecture 4

Loops

A loop is used for executing a block of statements repeatedly until a particular condition is satisfied. A loop consists of an initialization statement, a test condition and an increment statement.

For Loop

The syntax of the for loop is :

```
for (initialization; condition; update) {
 // body of-loop
}
```

```java
for (int i=1; i<=20; i++) {
   System.out.println(i);
}
```

While Loop

The syntax for while loop is :

```
while(condition) {
 // body of the loop
}
```

```java
int i = 0;
while(i<=20) {
   System.out.println(i);
   i++;
}
```

Do-While Loop

The syntax for the do-while loop is :

```
do {
 // body of loop;
}
while (condition);
```

```java
int i = 0;
do {
   System.out.println(i);
```

```
    i++;
} while(i<=20);
```

Homework Problems

1. Print all even numbers till n.
2. Run

```
for(; ;) {

            System.out.println("Apna College");

        }
```

loop on your system and analyze what happens. Try to think of the reason for the output produced.

3. Make a menu driven program. The user can enter 2 numbers, either 1 or 0.

   If the user enters 1 then keep taking input from the user for a student's marks(out of 100).

   If they enter 0 then stop.

   If he/ she scores :

   Marks >=90 -> print "This is Good"

   89 >= Marks >= 60 -> print "This is also Good"

   59 >= Marks >= 0 -> print "This is Good as well"

   Because marks don't matter but our effort does.

   (Hint : use do-while loop but think & understand why)

BONUS

Qs. Print if a number is prime or not (Input n from the user).

[In this problem you will learn how to check if a number is prime or not]

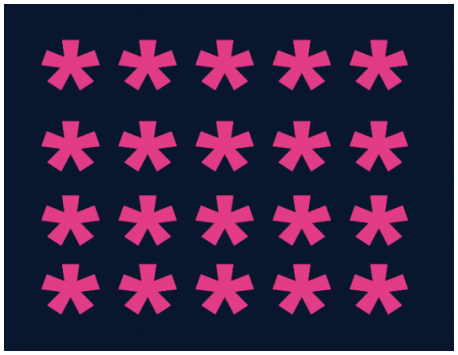
Homework Solution (Lecture 3)

```java
import java.util.*;

public class Conditions {
   public static void main(String args[]) {
       Scanner sc = new Scanner(System.in);
       int a = sc.nextInt();
       int b = sc.nextInt();
       int operator = sc.nextInt();

       /**
        * 1 -> +
        * 2 -> -
        * 3 -> *
        * 4 -> /
        * 5 -> %
        */

       switch(operator) {
           case 1 : System.out.println(a+b);
           break;
           case 2 : System.out.println(a-b);
           break;
           case 3 : System.out.println(a*b);
           break;
           case 4 : if(b == 0) {
                       System.out.println("Invalid Division");
                   } else {
                       System.out.println(a/b);
                   }
           break;
           case 5 : if(b == 0) {
                       System.out.println("Invalid Division");
                   } else {
                       System.out.println(a%b);
                   }
           break;
           default : System.out.println("Invalid Operator");
       }
   }
```

```
}
```

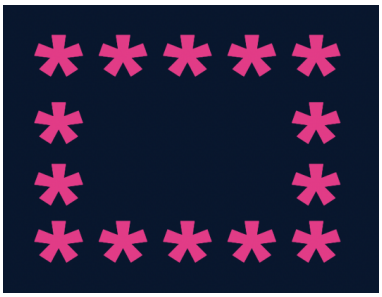
Java - Introduction to Programming
Lecture 5

Patterns - Part 1

1. 

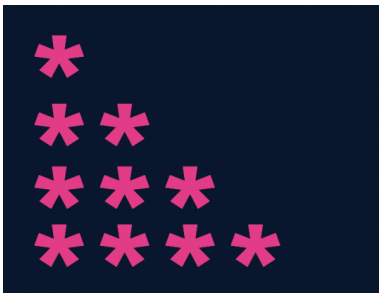
```java
import java.util.*;

public class Patterns {
   public static void main(String args[]) {
       int n = 5;
       int m = 4;
       for(int i=0; i<n; i++) {
           for(int j=0; j<m; j++) {
               System.out.print("*");
           }
           System.out.println();
       }
   }
}
```

2.



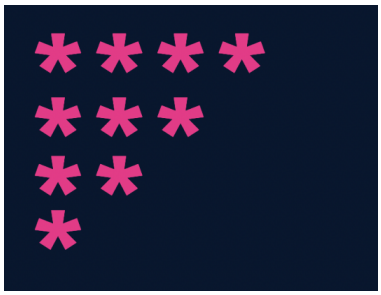
```java
import java.util.*;

public class Patterns {
   public static void main(String args[]) {
       int n = 5;
       int m = 4;
       for(int i=0; i<n; i++) {
           for(int j=0; j<m; j++) {
               if(i == 0 || i == n-1 || j == 0 || j == m-1) {
                   System.out.print("*");
               } else {
                   System.out.print(" ");
               }
           }
           System.out.println();
       }
   }
}
```

3.



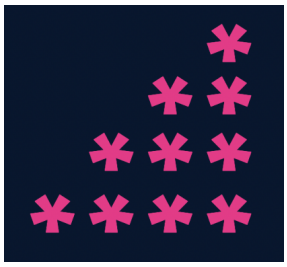
```java
import java.util.*;

public class Patterns {
   public static void main(String args[]) {
       int n = 4;

       for(int i=1; i<=n; i++) {
           for(int j=1; j<=i; j++) {
                   System.out.print("*");
           }
           System.out.println();
       }
   }
}
```

4.



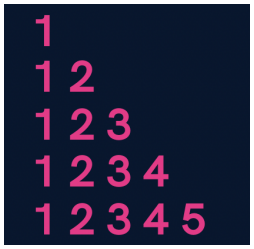
```java
import java.util.*;

public class Patterns {
   public static void main(String args[]) {
       int n = 4;

       for(int i=n; i>=1; i--) {
           for(int j=1; j<=i; j++) {
                   System.out.print("*");
           }
           System.out.println();
       }
   }
}
```

5.



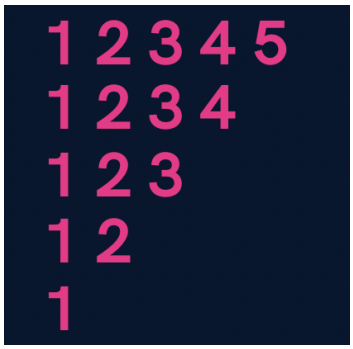
```java
import java.util.*;

public class Patterns {
   public static void main(String args[]) {
       int n = 4;

       for(int i=n; i>=1; i--) {
           for(int j=1; j<i; j++) {
               System.out.print(" ");
           }

           for(int j=0; j<=n-i; j++) {
               System.out.print("*");
           }
           System.out.println();
       }
   }
}
```

6.



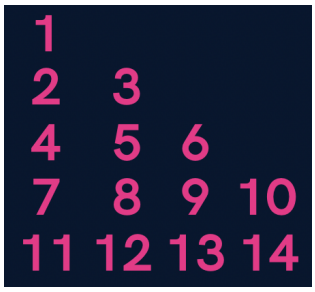

```java
import java.util.*;

public class Patterns {
   public static void main(String args[]) {
       int n = 5;

       for(int i=1; i<=n; i++) {
           for(int j=1; j<=i; j++) {
               System.out.print(j);
           }
           System.out.println();
       }
   }
}
```

7.




```java
import java.util.*;

public class Patterns {
   public static void main(String args[]) {
       int n = 5;

       for(int i=n; i>=1; i--) {
           for(int j=1; j<=i; j++) {
               System.out.print(j);
           }
           System.out.println();
       }
   }
}
```

8.



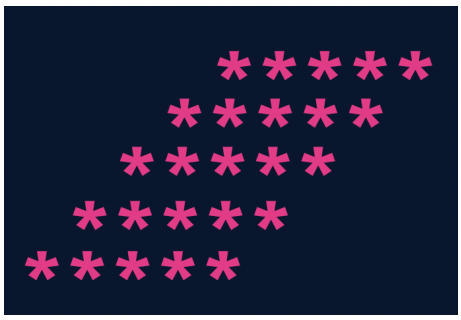

```java
import java.util.*;

public class Patterns {
   public static void main(String args[]) {
       int n = 5;
       int number = 1;

       for(int i=1; i<=n; i++) {
           for(int j=1; j<=i; j++) {
               System.out.print(number+" ");
               number++;
           }
           System.out.println();
       }
   }
}
```

9.

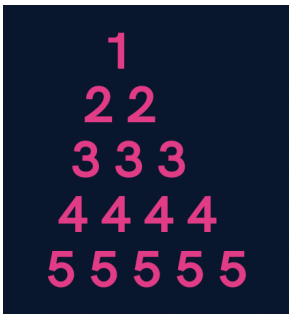

```java
import java.util.*;

public class Patterns {
   public static void main(String args[]) {
       int n = 5;

       for(int i=1; i<=n; i++) {
           for(int j=1; j<=i; j++) {
               if((i+j) % 2 == 0) {
                   System.out.print(1+" ");
               } else {
                   System.out.print(0+" ");
               }
           }
           System.out.println();
       }
   }
}
```

Homework Problems (Solutions in next Lecture's Video)

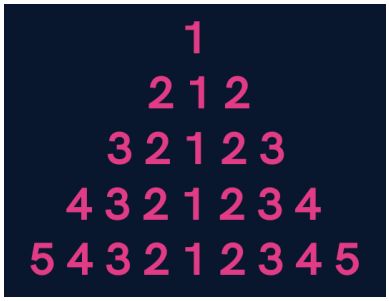
1. Print a solid rhombus.



2. Print a number pyramid.



3. Print a palindromic number pyramid.



Homework Solution (Lecture 4)

1. Print all even numbers till n.

```java
public class Solutions {

    public static void main(String args[]) {

        int n = 25;



        for(int i=1; i<=n; i++) {

            if(i % 2 == 0) {

                System.out.println(i);

            }

        }

    }
}

```

3. Make a menu driven program. The user can enter 2 numbers, either 1 or 0. If the user enters 1 then keep taking input from the user for a student's marks(out of 100).

   If they enter 0 then stop.

   If he/ she scores :

   Marks >=90 -> print "This is Good"

   89 >= Marks >= 60 -> print "This is also Good"

   59 >= Marks >= 0 -> print "This is Good as well"

   Because marks don't matter but our effort does.

(Hint : use do-while loop but think & understand why)

```java
import java.util.*;

public class Solutions {
   public static void main(String args[]) {
       Scanner sc = new Scanner(System.in);
       int input;

       do {
           int marks = sc.nextInt();
           if(marks >= 90 && marks <= 100) {
               System.out.println("This is Good");
           } else if(marks >= 60 && marks <= 89) {
               System.out.println("This is also Good");
           } else if(marks >= 0 && marks <= 59) {
               System.out.println("This is Good as well");
           } else {
               System.out.println("Invalid");
           }

           System.out.println("Want to continue ? (yes(1) or no(0))");
           input = sc.nextInt();

       } while(input == 1);
   }
}
```

Qs. Print if a number n is prime or not (Input n from the user).

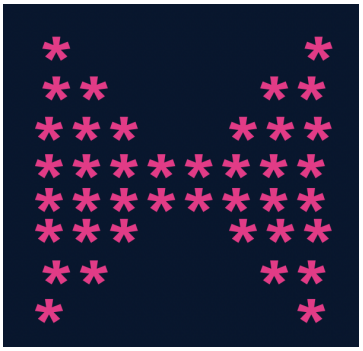
[In this problem you will learn how to check if a number is prime or not]

```java
import java.util.*;

public class Solutions {
   public static void main(String args[]) {
       Scanner sc = new Scanner(System.in);
       int n = sc.nextInt();

       boolean isPrime = true;
       for(int i=2; i<=n/2; i++) {
```

```
            if(n % i == 0) {
                isPrime = false;
                break;
            }
        }

        if(isPrime) {
            if(n == 1) {
                System.out.println("This is neither prime not composite");
            } else {
                System.out.println("This is a prime number");
            }
        } else {
            System.out.println("This is not a prime number");
        }
    }
}
```

Java - Introduction to Programming
Lecture 6

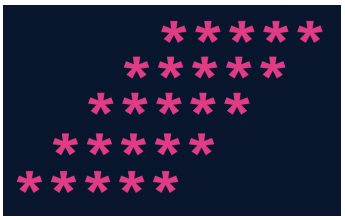
Patterns - Part 2

1. 

```
import java.util.*;

public class Solutions {
   public static void main(String args[]) {
       int n = 4;

       //upper part
       for(int i=1; i<=n; i++) {
           for(int j=1; j<=i; j++) {
               System.out.print("*");
           }

           int spaces = 2 * (n-i);
           for(int j=1; j<=spaces; j++) {
               System.out.print(" ");
           }

           for(int j=1; j<=i; j++) {
               System.out.print("*");
           }
           System.out.println();
       }
```

```
        //lower part
        for(int i=n; i>=1; i--) {
            for(int j=1; j<=i; j++) {
                System.out.print("*");
            }

            int spaces = 2 * (n-i);
            for(int j=1; j<=spaces; j++) {
                System.out.print(" ");
            }

            for(int j=1; j<=i; j++) {
                System.out.print("*");
            }
            System.out.println();
        }
    }
}
```

2.



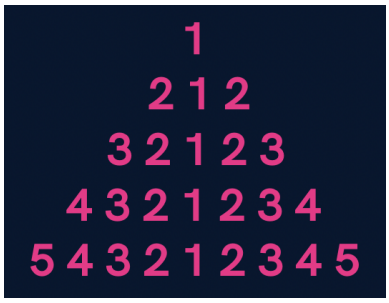
```
import java.util.*;

public class Solutions {
    public static void main(String args[]) {
        int n = 5;
```

```
        for(int i=1; i<=n; i++) {
            //spaces
            for(int j=1; j<=n-i; j++) {
                System.out.print(" ");
            }

            //stars
            for(int j=1; j<=n; j++) {
                System.out.print("*");
            }
            System.out.println();
        }
    }
}
```

3.

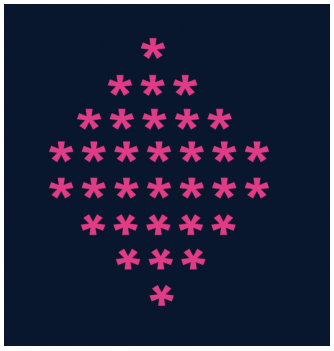

```java
import java.util.*;

public class Solutions {
   public static void main(String args[]) {
       int n = 5;

       for(int i=1; i<=n; i++) {
           //spaces
           for(int j=1; j<=n-i; j++) {
               System.out.print(" ");
           }

           //numbers
           for(int j=1; j<=i; j++) {
               System.out.print(i+" ");
           }
           System.out.println();
       }
   }
}
```

4.




```java
import java.util.*;

public class Solutions {
   public static void main(String args[]) {
       int n = 5;
       for(int i=1; i<=n; i++) {
           //spaces
           for(int j=1; j<=n-i; j++) {
               System.out.print(" ");
           }

           //first part
           for(int j=i; j>=1; j--) {
               System.out.print(j);
           }

           //second part
           for(int j=2; j<=i; j++) {
               System.out.print(j);
           }
           System.out.println();
       }
   }
}
```

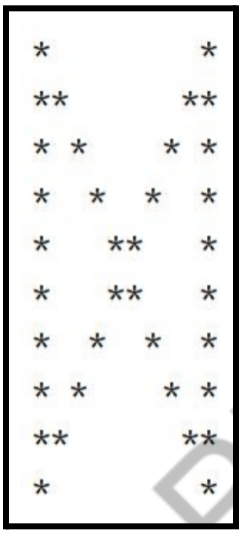
5.



```java
import java.util.*;

public class Solutions {
   public static void main(String args[]) {
       int n = 5;

       //upper part
       for(int i=1; i<=n; i++) {
           //spaces
           for(int j=1; j<=n-i; j++) {
               System.out.print(" ");
           }
           for(int j=1; j<=2*i-1; j++) {
               System.out.print("*");
           }
           System.out.println();
       }

       //lower part
       for(int i=n; i>=1; i--) {
           //spaces
           for(int j=1; j<=n-i; j++) {
               System.out.print(" ");
           }
           for(int j=1; j<=2*i-1; j++) {
               System.out.print("*");
           }
           System.out.println();
       }
   }
}
```

Homework Problems

1. **Print a hollow Butterfly.**



2. **Print a hollow Rhombus.**

```
  *****
 *     *
*     *
*     *
*****
```

3. **Print Pascal's Triangle.**

```
    1
   1 1
  1 2 1
 1 3 3 1
1 4 6 4 1
```

4. **Print half Pyramid.**

```
    1
```

1 2

1 2 3

1 2 3 4

1 2 3 4 5

5. **Print Inverted Half Pyramid.**

11111

222

33

4

Java - Introduction to Programming
Lecture 7

Methods/Functions

A function is a block of code that performs a specific task.
Why are functions used?

a. If some functionality is performed at multiple places in software, then rather than writing the same code, again and again, we create a function and call it everywhere. This helps reduce code redundancy.
b. Functions make maintenance of code easy as we have to change at one place if we make future changes to the functionality.
c. Functions make the code more readable and easy to understand.

The **syntax** for function declaration is :

```
return-type function_name (parameter 1, parameter2,  ..... parameter n){
//function_body
}
return-type
```

The **return type** of a function is the data type of the variable that that function returns.

For eg - If we write a function that adds 2 integers and returns their sum then the return type of this function will be 'int' as we will return a sum that is an integer value.
When a function does not return any value, in that case the return type of the function is 'void'.

function_name
It is the unique name of that function.
It is always recommended to declare a function before it is used.

Parameters
A function can take some parameters as inputs. These parameters are specified along with their data types.
For eg- if we are writing a function to add 2 integers, the parameters would be passed like –
int add (int num1, int num2)

main function

The main function is a special function as the computer starts running the code from the beginning of the main function. Main function serves as the entry point for the program.

Example :

```
package com.apnacollege;

public class Main {
   //A METHOD to calculate sum of 2 numbers - a & b
   public static void sum(int a, int b) {
       int sum = a + b;
       System.out.println(sum);
   }

   public static void main(String[] args) {
      int a = 10;
      int b = 20;
       sum(a, b); // Function Call

   }
}
```

Qs. Write a function to multiply 2 numbers.

```
import java.util.*;



public class Functions {



   //Multiply 2 numbers

   public static int multiply(int a, int b) {

       return a*b;

   }

   public static void main(String args[]) {

       Scanner sc = new Scanner(System.in);
```

```
        int a = sc.nextInt();

        int b = sc.nextInt();



        int result = multiply(a, b);

        System.out.println(result);

    }

}
```

Qs. Write a function to calculate the factorial of a number.

```
import java.util.*;

public class Functions {
    // public static int calculateSum(int a, int b) {
    //     int sum = a + b;
    //     return sum;
    // }

    // public static int calculateProduct(int a, int b) {
    //    return a * b;
    // }

    public static void printFactorial(int n) {
        //loop
        if(n < 0) {
            System.out.println("Invalid Number");
            return;
        }
        int factorial = 1;

        for(int i=n; i>=1; i--) {
            factorial = factorial * i;
        }

        System.out.println(factorial);
        return;
    }
```

```
    public static void main(String args[]) {
        Scanner sc = new Scanner(System.in);
        int n = sc.nextInt();

        printFactorial(n);
    }
}
```

Qs. Write a function to calculate the product of 2 numbers.

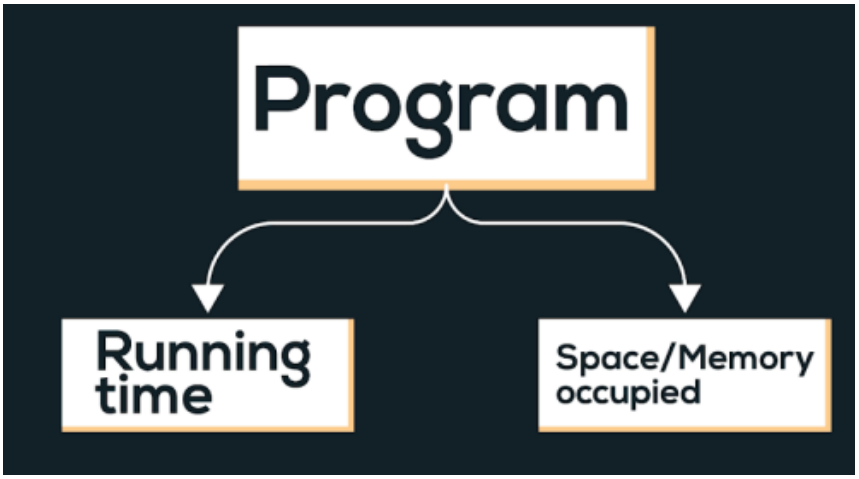
```
import java.util.*;



public class Functions {

    // public static int calculateSum(int a, int b) {

    //     int sum = a + b;

    //     return sum;

    // }



    public static int calculateProduct(int a, int b) {

       return a * b;

    }



        public static void main(String args[]) {

        Scanner sc = new Scanner(System.in);

        int a = sc.nextInt();

        int b = sc.nextInt();

        System.out.println(calculateProduct(a, b));

    }

}
```

Homework Problems

1. Make a function to check if a number is prime or not.
2. Make a function to check if a given number n is even or not.
3. Make a function to print the table of a given number n.
4. Read about Recursion.

Java - Introduction to Programming
Lecture 8

Time & Space Complexity



Time complexity of an algorithm quantifies the amount of time taken by an algorithm to run as a function of the length of the input.

Types of notations

1. O-notation: It is used to denote asymptotic upper bound. For a given function g(n), we denote it by O(g(n)). Pronounced as "big-oh of g of n". It is also known as worst case time complexity as it denotes the upper bound in which the algorithm terminates.
2. Ω-notation: It is used to denote asymptotic lower bound. For a given function g(n), we denote it by Ω(g(n)). Pronounced as "big-omega of g of n". It is also known as best case time complexity as it denotes the lower bound in which the algorithm terminates.
3. Θ-notation: It is used to denote the average time of a program.

Examples :

```
int a = 0;
for (int i = 1; i <= n; i++)
{
  a = a + 1;
}
```

Linear Time Complexity. O(n)

Comparison of functions on the basis of time complexity

It follows the following order in case of time complexity:

$O(n^n) > O(n!) > O(n^3) > O(n^2) > O(n.log(n)) > O(n.log(log(n))) > O(n) > O(sqrt(n)) > O(log(n)) > O(1)$

Note: Reverse is the order for better performance of a code with corresponding time complexity, i.e. a program with less time complexity is more efficient.

Space Complexity

Space complexity of an algorithm quantifies the amount of time taken by a program to run as a function of length of the input. It is directly proportional to the largest memory your program acquires at any instance during run time.
For example: *int* consumes 4 bytes of memory.

Java - Introduction to Programming
Lecture 10

Arrays In Java

Arrays in Java are like a list of elements of the same type i.e. a list of integers, a list of booleans etc.

a. Creating an Array (method 1) - with new keyword

```
int[] marks = new int[3];
marks[0] = 97;
marks[1] = 98;
marks[2] = 95;
```

b. Creating an Array (method 2)

```
int[] marks = {98, 97, 95};
```

c. Taking an array as an input and printing its elements.

```
import java.util.*;

public class Arrays {
   public static void main(String args[]) {
       Scanner sc = new Scanner(System.in);
       int size = sc.nextInt();
       int numbers[] = new int[size];

       for(int i=0; i<size; i++) {
           numbers[i] = sc.nextInt();
       }

       //print the numbers in array
       for(int i=0; i<arr.length; i++) {
           System.out.print(numbers[i]+" ");
       }
   }
}
```

Homework Problems

1. Take an array of names as input from the user and print them on the screen.

```java
import java.util.*;



public class Arrays {

   public static void main(String args[]) {

      Scanner sc = new Scanner(System.in);

      int size = sc.nextInt();

      String names[] = new String[size];



      //input

      for(int i=0; i<size; i++) {

          names[i] = sc.next();

      }



      //output

       for(int i=0; i<names.length; i++) {

           System.out.println("name " + (i+1) +" is : " + names[i]);

       }



   }

}
```

2. Find the maximum & minimum number in an array of integers.

[HINT : Read about Integer.MIN_VALUE & Integer.MAX_VALUE in Java]

```java
import java.util.*;


public class Arrays {

   public static void main(String args[]) {

      Scanner sc = new Scanner(System.in);

      int size = sc.nextInt();

      int numbers[] = new int[size];


      //input

      for(int i=0; i<size; i++) {

          numbers[i] = sc.nextInt();

      }


      int max = Integer.MIN_VALUE;

      int min = Integer.MAX_VALUE;


       for(int i=0; i<numbers.length; i++) {

           if(numbers[i] < min) {

               min = numbers[i];

           }

           if(numbers[i] > max) {

               max = numbers[i];

           }

       }
```

```
        System.out.println("Largest number is : " + max);

        System.out.println("Smallest number is : " + min);



    }

}
```

3. Take an array of numbers as input and check if it is an array sorted in ascending order.

   Eg : { 1, 2, 4, 7 } is sorted in ascending order.

   {3, 4, 6, 2} is not sorted in ascending order.

```
import java.util.*;



public class Arrays {

    public static void main(String args[]) {

        Scanner sc = new Scanner(System.in);

        int size = sc.nextInt();

        int numbers[] = new int[size];



        //input

        for(int i=0; i<size; i++) {

            numbers[i] = sc.nextInt();

        }



        boolean isAscending = true;
```

```
        for(int i=0; i<numbers.length-1; i++) { // NOTICE numbers.length - 1 as
termination condition

            if(numbers[i] > numbers[i+1]) { // This is the condition for
descending order

                isAscending = false;

            }

        }



        if(isAscending) {

            System.out.println("The array is sorted in ascending order");

        } else {

            System.out.println("The array is not sorted in ascending order");

        }



    }

}
```

Java - Introduction to Programming
Lecture 11

2D Arrays In Java

It is similar to 2D matrices that we studied in 11th and 12th class.

a. Creating a 2D Array - with new keyword

```
int[][] marks = new int[3][3];
```

b. Taking a matrix as an input and printing its elements.

```
import java.util.*;

public class TwoDArrays {
   public static void main(String args[]) {
       Scanner sc = new Scanner(System.in);
       int rows = sc.nextInt();
       int cols = sc.nextInt();

       int[][] numbers = new int[rows][cols];

       //input
       //rows
       for(int i=0; i<rows; i++) {
           //columns
           for(int j=0; j<cols; j++) {
               numbers[i][j] = sc.nextInt();
           }
       }


       for(int i=0; i<rows; i++) {
           for(int j=0; j<cols; j++) {
                   System.out.print(numbers[i][j]+" ");
               }
               System.out.println();
           }
   }
```

```
}
```

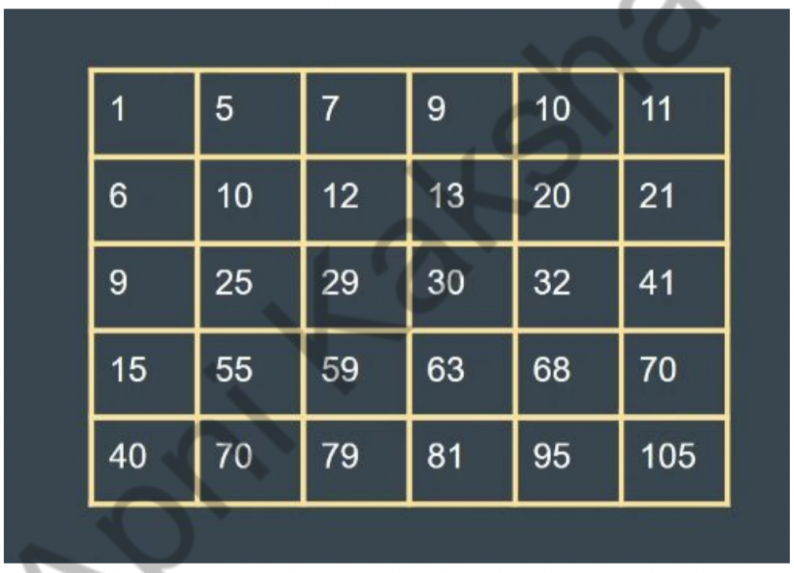
c. Searching for an element x in a matrix.

```
import java.util.*;

public class TwoDArrays {
   public static void main(String args[]) {
       Scanner sc = new Scanner(System.in);
       int rows = sc.nextInt();
       int cols = sc.nextInt();

       int[][] numbers = new int[rows][cols];

       //input
       //rows
       for(int i=0; i<rows; i++) {
           //columns
           for(int j=0; j<cols; j++) {
               numbers[i][j] = sc.nextInt();
           }
       }

       int x = sc.nextInt();

       for(int i=0; i<rows; i++) {
           for(int j=0; j<cols; j++) {
               //compare with x
               if(numbers[i][j] == x) {
                   System.out.println("x found at location (" + i + ", " + j +
")");
               }
           }
       }



   }
}
```

Homework Problems

1. Print the spiral order matrix as output for a given matrix of numbers. [Difficult for Beginners]

For example: for the given matrix,



1	5	7	9	10	11
6	10	12	13	20	21
9	25	29	30	32	41
15	55	59	63	68	70
40	70	79	81	95	105

Spiral order is given by:
1 5 7 9 10 11 21 41 70 105 95 81 79 70 40 15 9 6 10 12 13 20 32 68 63 59 55 25 29 30 29.

APPROACH :

Algorithm: (We are given a 2D matrix of n X m).

1. We will need 4 variables:

a. row_start - initialized with 0.

b. row_end - initialized with n-1.

c. column_start - initialized with 0.

d. column_end - initialized with m-1.

2. First of all, we will traverse in the row row_start from column_start

to column_end and we will increase the row_start with 1 as we have traversed the starting row.

3. Then we will traverse in the column column_end from row_start to row_end and decrease the column_end by 1.

4. Then we will traverse in the row row_end from column_end to column_start and decrease the row_end by 1.

5. Then we will traverse in the column column_start from row_end to row_start and increase the column_start by 1.

6. We will do the above steps from 2 to 5 until row_start <= row_end and column_start <= column_end.

```
import java.util.*;


public class Arrays {

   public static void main(String args[]) {

      Scanner sc = new Scanner(System.in);

      int n = sc.nextInt();

      int m = sc.nextInt();



      int matrix[][] = new int[n][m];

      for(int i=0; i<n; i++) {

           for(int j=0; j<m; j++) {

               matrix[i][j] = sc.nextInt();

           }

      }



      System.out.println("The Spiral Order Matrix is : ");

      int rowStart = 0;
```

```
int rowEnd = n-1;

int colStart = 0;

int colEnd = m-1;



//To print spiral order matrix

while(rowStart <= rowEnd && colStart <= colEnd) {

    //1

    for(int col=colStart; col<=colEnd; col++) {

        System.out.print(matrix[rowStart][col] + " ");

    }

    rowStart++;



    //2

    for(int row=rowStart; row<=rowEnd; row++) {

        System.out.print(matrix[row][colEnd] +" ");

    }

    colEnd--;



    //3

    for(int col=colEnd; col>=colStart; col--) {

        System.out.print(matrix[rowEnd][col] + " ");

    }

    rowEnd--;



    //4

    for(int row=rowEnd; row>=rowStart; row--) {
```

```
            System.out.print(matrix[row][colStart] + " ");

        }

        colStart++;



        System.out.println();

    }

  }

}
```

2. For a given matrix of N x M, print its transpose.

```
import java.util.*;



public class Arrays {

   public static void main(String args[]) {

      Scanner sc = new Scanner(System.in);

      int n = sc.nextInt();

      int m = sc.nextInt();



      int matrix[][] = new int[n][m];

      for(int i=0; i<n; i++) {

           for(int j=0; j<m; j++) {

               matrix[i][j] = sc.nextInt();

           }

      }
```

```
        System.out.println("The transpose is : ");
        //To print transpose
        for(int j=0; j<m ;j++) {
            for(int i=0; i<n; i++) {
                System.out.print(matrix[i][j]+" ");
            }
            System.out.println();
        }
    }
}
```

Java - Introduction to Programming
Lecture 12

Strings

Declaration

```
String name = "Tony";
```

Taking Input

```
Scanner sc = new Scanner(System.in);
        String name = sc.next();
```

Concatenation (Joining 2 strings)

```
String firstName = "Tony";
        String secondName = "Stark";

        String fullName = firstName + " " + secondName;
        System.out.println(fullName);
```

Print length of a String

```
String firstName = "Tony";
        String secondName = "Stark";

        String fullName = firstName + " " + secondName;
        System.out.println(fullName.length());
```

Access characters of a string

```
String firstName = "Tony";
        String secondName = "Stark";

        String fullName = firstName + " " + secondName;

        for(int i=0; i<fullName.length(); i++) {
            System.out.println(fullName.charAt(i));
        }
```

Compare 2 strings

```java
import java.util.*;

public class Strings {
   public static void main(String args[]) {
       String name1 = "Tony";
       String name2 = "Tony";

       if(name1.equals(name2)) {
           System.out.println("They are the same string");
       } else {
           System.out.println("They are different strings");
       }

       //DO NOT USE == to check for string equality
       //Gives correct answer here
       if(name1 == name2) {
           System.out.println("They are the same string");
       } else {
           System.out.println("They are different strings");
       }

       //Gives incorrect answer here
       if(new String("Tony") == new String("Tony")) {
           System.out.println("They are the same string");
       } else {
           System.out.println("They are different strings");
       }

   }
}
```

Substring

The substring of a string is a subpart of it.

```java
public class Strings {
   public static void main(String args[]) {
       String name = "TonyStark";

       System.out.println(name.substring(0, 4));
```

```
    }
}
```

ParseInt Method of Integer class

```
public class Strings {
    public static void main(String args[]) {
        String str = "123";
        int number = Integer.parseInt(str);
        System.out.println(number);


    }
}
```

ToString Method of String class

```
public class Strings {
    public static void main(String args[]) {
       int number = 123;
       String str = Integer.toString(number);
       System.out.println(str.length());


    }
}
```

ALWAYS REMEMBER : Java Strings are Immutable.

Homework Problems

1. Take an array of Strings input from the user & find the cumulative (combined) length of all those strings.

```java
import java.util.*;



public class Strings {

   public static void main(String args[]) {

     Scanner sc = new Scanner (System.in);

     int size = sc.nextInt();

     String array[] = new String[size];

     int totLength = 0;



     for(int i=0; i<size; i++) {

       array[i] = sc.next();

       totLength += array[i].length();

     }



     System.out.println(totLength);

   }

}
```

2. Input a string from the user. Create a new string called ‘result’ in which you will replace the letter ‘e’ in the original string with letter ‘i’.

   Example :

   original = “eabcdef’ ; result = “iabcdif”

   Original = “xyz” ; result = “xyz”

```java
import java.util.*;


public class Strings {

   public static void main(String args[]) {

     Scanner sc = new Scanner (System.in);

     String str = sc.next();

     String result = "";


     for(int i=0; i<str.length(); i++) {

       if(str.charAt(i) == 'e') {

         result += 'i';

       } else {

         result += str.charAt(i);

       }

     }


     System.out.println(result);

   }

}
```

3. Input an email from the user. You have to create a username from the email by deleting the part that comes after '@'. Display that username to the user.

   Example :

   email = "apnaCollegeJava@gmail.com" ; username = "apnaCollegeJava"

   email = "helloWorld123@gmail.com"; username = "helloWorld123"

```java
import java.util.*;


public class Strings {

   public static void main(String args[]) {

     Scanner sc = new Scanner (System.in);

     String email = sc.next();

     String userName = "";


     for(int i=0; i<email.length(); i++) {

       if(email.charAt(i) == '@') {

        break;

       } else {

         userName += email.charAt(i);

       }

     }


     System.out.println(userName);

   }

}
```

Java - Introduction to Programming
Lecture 13

String Builder

Declaration

```
StringBuilder sb = new StringBuilder("Apna College");
     System.out.println(sb);
```

Get A Character from Index

```
StringBuilder sb = new StringBuilder("Tony");
     //Set Char
     System.out.println(sb.charAt(0));
```

Set a Character at Index

```
StringBuilder sb = new StringBuilder("Tony");
     //Get Char
     sb.setCharAt(0, 'P');
     System.out.println(sb);
```

Insert a Character at Some Index

```
import java.util.*;

public class Strings {
   public static void main(String args[]) {
     StringBuilder sb = new StringBuilder("tony");
     //Insert char
     sb.insert(0, 'S');
     System.out.println(sb);
   }
}
```

Delete char at some Index

```
import java.util.*;

public class Strings {
   public static void main(String args[]) {
     StringBuilder sb = new StringBuilder("tony");
     //Insert char
     sb.insert(0, 'S');
     System.out.println(sb);

      //delete char
     sb.delete(0, 1);
     System.out.println(sb);
   }
}
```

Append a char

Append means to add something at the end.

```
import java.util.*;

public class Strings {
   public static void main(String args[]) {
     StringBuilder sb = new StringBuilder("Tony");
     sb.append(" Stark");
     System.out.println(sb);
   }
}
```

Print Length of String

```
import java.util.*;

public class Strings {
   public static void main(String args[]) {
     StringBuilder sb = new StringBuilder("Tony");
     sb.append(" Stark");
     System.out.println(sb);

     System.out.println(sb.length());
   }
}
```

Reverse a String (using StringBuilder class)

```java
import java.util.*;

public class Strings {
   public static void main(String args[]) {
     StringBuilder sb = new StringBuilder("HelloWorld");

     for(int i=0; i<sb.length()/2; i++) {
       int front = i;
       int back = sb.length() - i - 1;

       char frontChar = sb.charAt(front);
       char backChar = sb.charAt(back);

       sb.setCharAt(front, backChar);
       sb.setCharAt(back, frontChar);
     }

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

Homework Problems

Try Solving all the String questions with StringBuilder.

Java - Introduction to Programming
Lecture 14

Bit Manipulation

Get Bit

```java
import java.util.*;

public class Bits {
   public static void main(String args[]) {
      int n = 5; //0101
      int pos = 3;
      int bitMask = 1<<pos;

      if((bitMask & n) == 0) {
          System.out.println("bit was zero");
      } else {
          System.out.println("bit was one");
      }
   }
}
```

Set Bit

```java
import java.util.*;

public class Bits {
   public static void main(String args[]) {
      int n = 5; //0101
      int pos = 1;
      int bitMask = 1<<pos;

      int newNumber = bitMask | n;
      System.out.println(newNumber);
   }
}
```

Clear Bit

```java
import java.util.*;
public class Bits {
  public static void main(String args[]) {
     int n = 5; //0101
     int pos = 2;
     int bitMask = 1<<pos;
     int newBitMask = ~(bitMask);
     int newNumber = newBitMask & n;
     System.out.println(newNumber);
  }
}
```

Update Bit

```java
import java.util.*;

public class Bits {
   public static void main(String args[]) {
       Scanner sc = new Scanner(System.in);
       int oper = sc.nextInt();
       // oper=1 -> set; oper=0 -> clear
      int n = 5;
      int pos = 1;

      int bitMask = 1<<pos;
      if(oper == 1) {
          //set
          int newNumber = bitMask | n;
          System.out.println(newNumber);
      } else {
       //clear
       int newBitMask = ~(bitMask);
       int newNumber = newBitMask & n;
       System.out.println(newNumber);
      }

   }
}
```

Homework Problems

1. Write a program to find if a number is a power of 2 or not.
2. Write a program to toggle a bit a position = “pos” in a number “n”.
3. Write a program to count the number of 1’s in a binary representation of the number.
4. Write 2 functions => decimalToBinary() & binaryToDecimal() to convert a number from one number system to another. [BONUS]

ArrayList in Java

Operations :

1. Declare an ArrayList of different Types
2. Add Element
3. Get Element
4. Add Element at a specific Index
5. Set Element at a specific Index
6. Delete Element from an Index
7. Size of the List
8. Loop/Iterate on the List
9. Sort the List

```java
import java.util.ArrayList;
import java.util.Collections;

class ArrayLists {
   public static void main(String args[]) {
       ArrayList<Integer> list = new ArrayList<Integer>();
       ArrayList<String> list2 = new ArrayList<String>();
       ArrayList<Boolean> list3 = new ArrayList<Boolean>();

       //add elements
       list.add(1);
       list.add(3);
       list.add(4);
       list.add(5);
       System.out.println(list);

       //to get an element
       int element = list.get(0); // 0 is the index
       System.out.println(element);

       //add element in between
       list.add(1,2); // 1 is the index and 2 is the element to be added
       System.out.println(list);

       //set element
```

```
        list.set(0,0);
        System.out.println(list);

        //delete elements
        list.remove(0); // 0 is the index
        System.out.println(list);

        //size of list
        int size = list.size();
        System.out.println(size);

        //Loops on lists
        for(int i=0; i<list.size(); i++) {
            System.out.print(list.get(i) + " ");
        }
        System.out.println();

        //Sorting the list
        list.add(0);
        Collections.sort(list);
        System.out.println(list);
    }
}
```

Homework Problems

Try solving all problems of arrays with arraylists.

BEST Linked List Questions
Java

1. **Find the nth node from the end & remove it.**

Time complexity – O(n)

Space complexity – O(1)

```java
public ListNode removeNthFromEnd(ListNode head, int n) {
    if(head.next == null) {
        return null;
    }


    int size = 0;
    ListNode temp = head;
    while(temp != null) {
        temp = temp.next;
        size++;
    }

    //removing SIZEth node from last i.e. head
    if(n == size) {
        return head.next;
    }

    //find previous node
    int ptf = size - n; // position to find
    ListNode prev = head; // previous node
    int cp = 1; // current position

    while(cp != ptf) {
        prev = prev.next;
        cp++;
    }

    prev.next = prev.next.next;
    return head;
```

```
}
```

2. **Check if a Linked List is a palindrome**

Time complexity - O(n)

Space complexity - O(1)

```
public ListNode getMiddle(ListNode head) {
    ListNode fast = head;
    ListNode slow = head;
    while (fast.next != null && fast.next.next != null) {
        fast = fast.next.next;
        slow = slow.next;
    }
    return slow;
}

public ListNode reverse(ListNode head) {
    ListNode prev = null;
    ListNode curr = head;

    while (curr != null) {
        ListNode next = curr.next;
        curr.next = prev;
        prev = curr;
```

```
        curr = next;
    }
    return prev;
}



public boolean isPalindrome(ListNode head) {
    if(head == null || head.next == null) {
        return true;
    }

    ListNode firstHalfEnd = getMiddle(head);
    ListNode secondHalfStart = reverse(firstHalfEnd.next);
    ListNode firstHalfStart = head;

    while(secondHalfStart != null) {
        if(secondHalfStart.val != firstHalfStart.val) {
            return false;
        }
        secondHalfStart = secondHalfStart.next;
        firstHalfStart = firstHalfStart.next;
    }

    return true;
}
```

3. **Detecting Loop in a Linked List.**

Time complexity - O(n)

Space complexity - O(1)

```java
public boolean hasCycle(ListNode head) {

   ListNode slow = head;

   ListNode fast = head;



   while(fast != null && fast.next != null) {

       slow = slow.next;

       fast = fast.next.next;



       if(fast == slow) {

           return true;

       }

   }



   return false;

}
```

Homework Problems

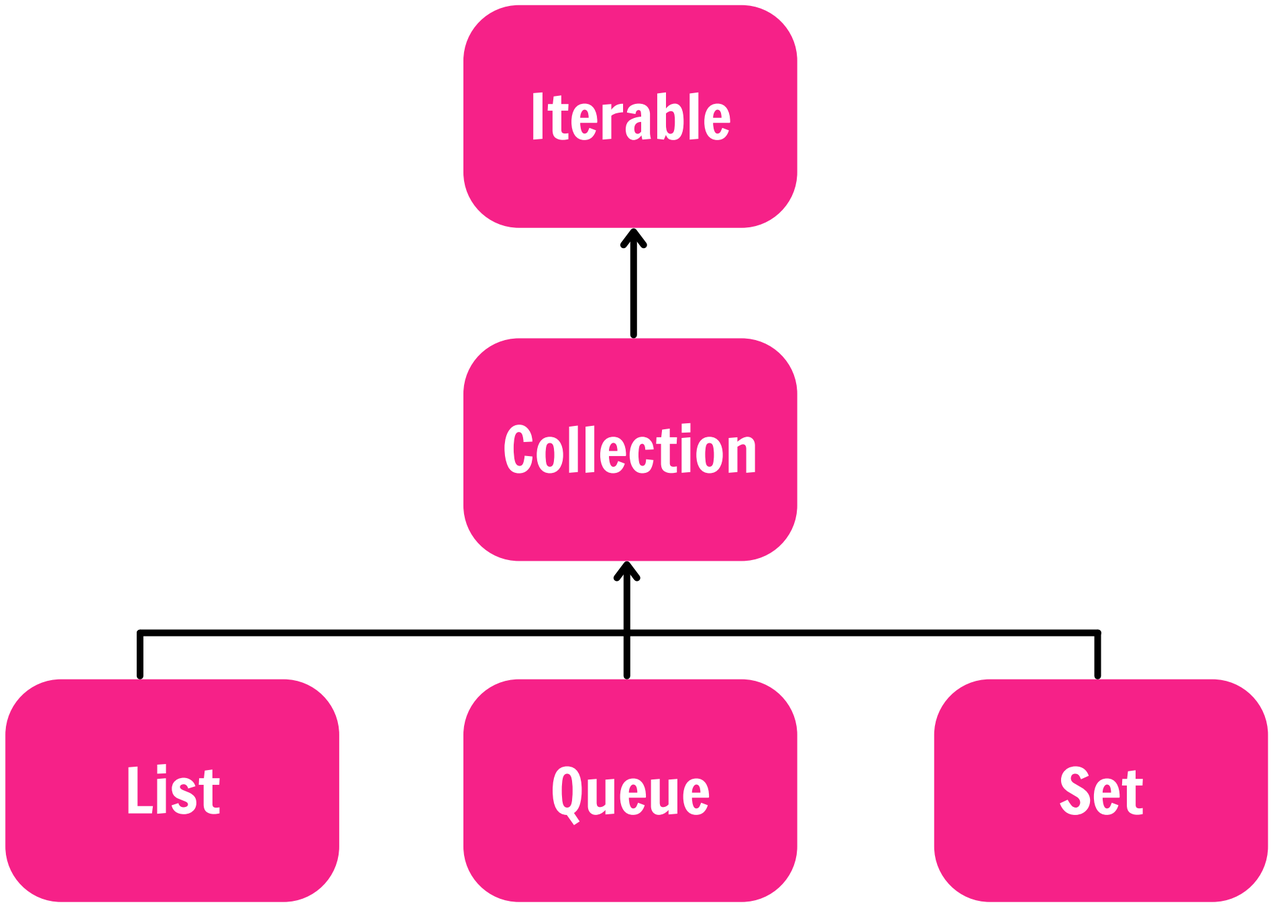
1. Removing Loops in a Linked List.

   (Please try on your own first. The answer will be updated soon!)

JAVA

Collection Framework

Collection of Classes & Interfaces

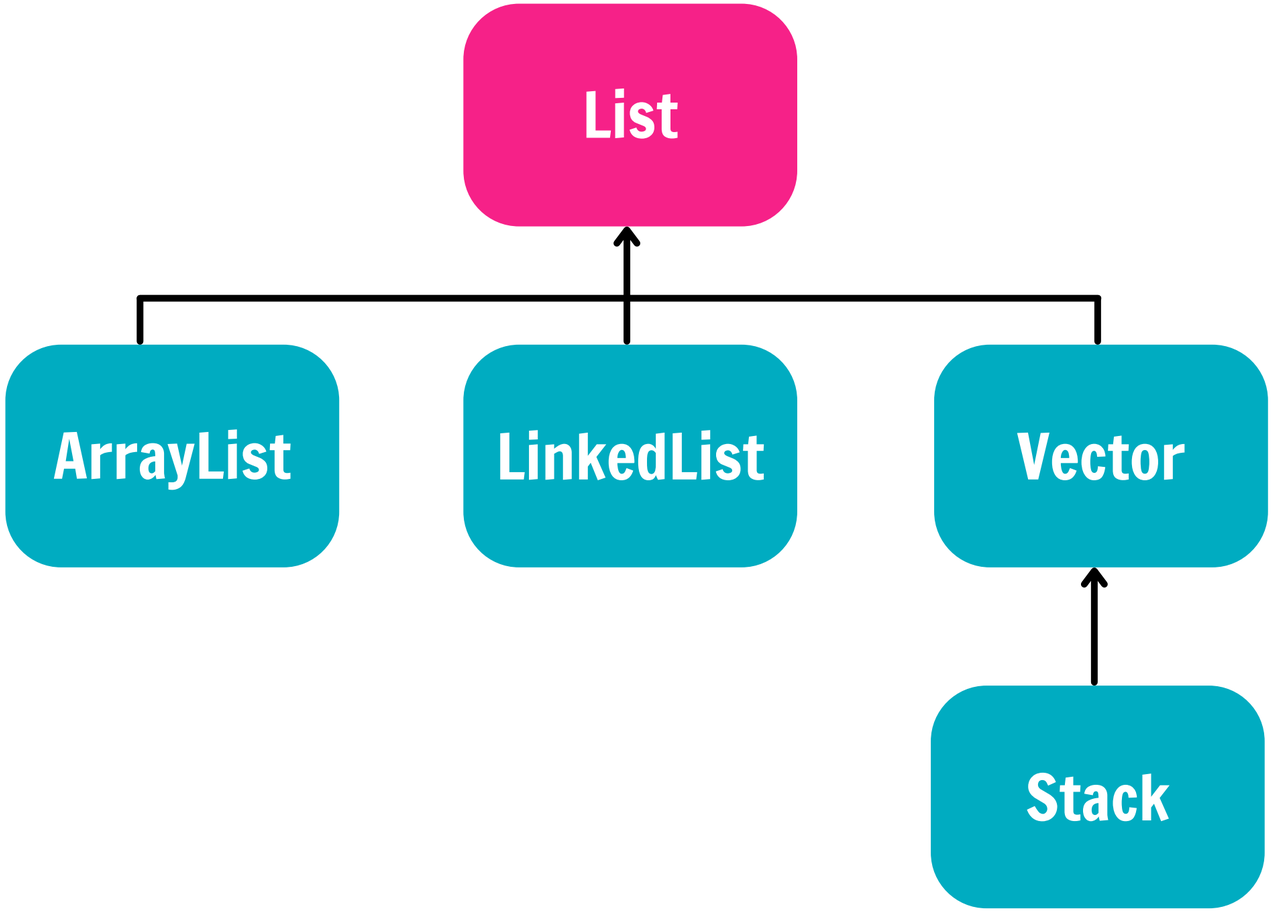


JAVA

Methods on Collections

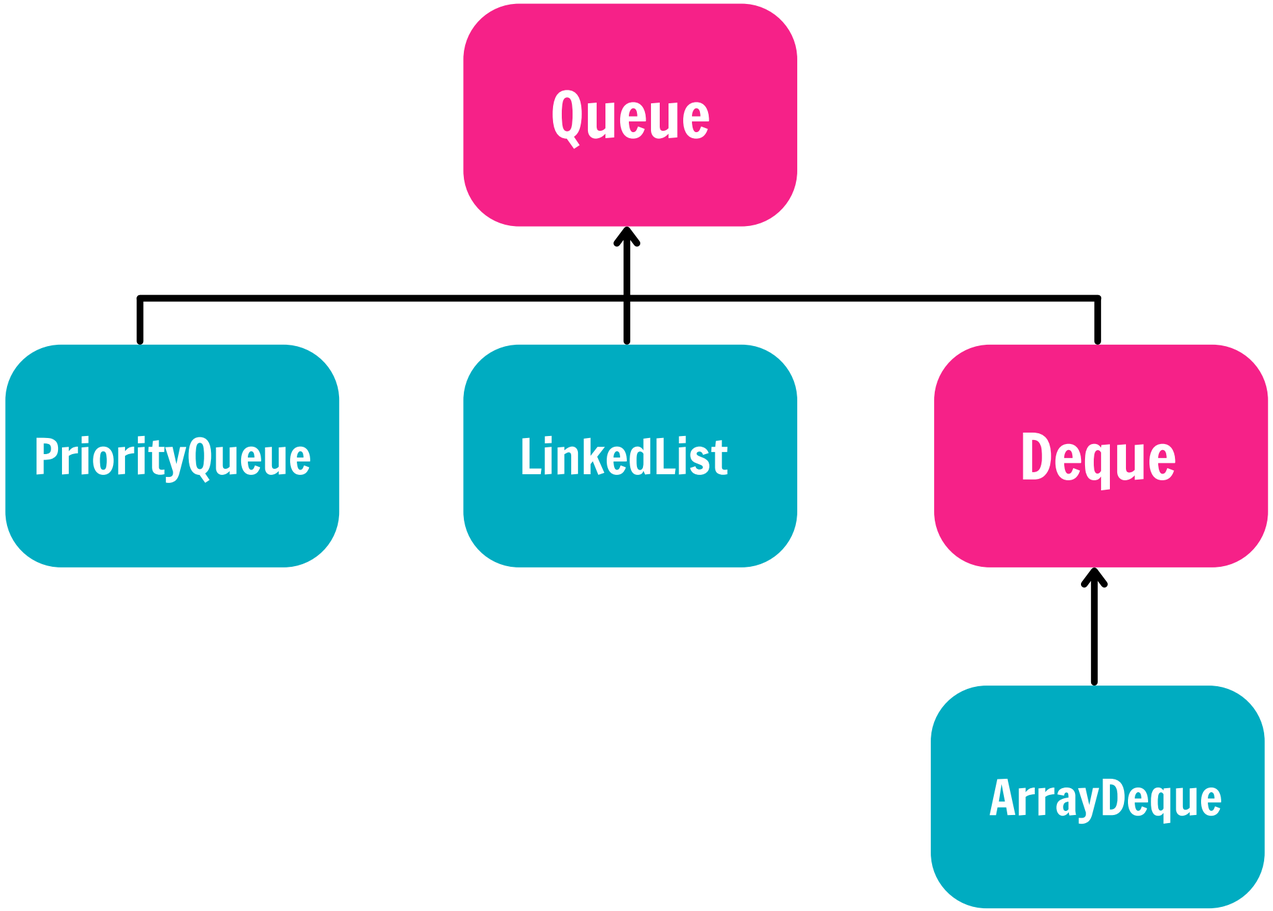
- add
- size
- remove
- iterate
- addAll
- removeAll
- clear

List Interface

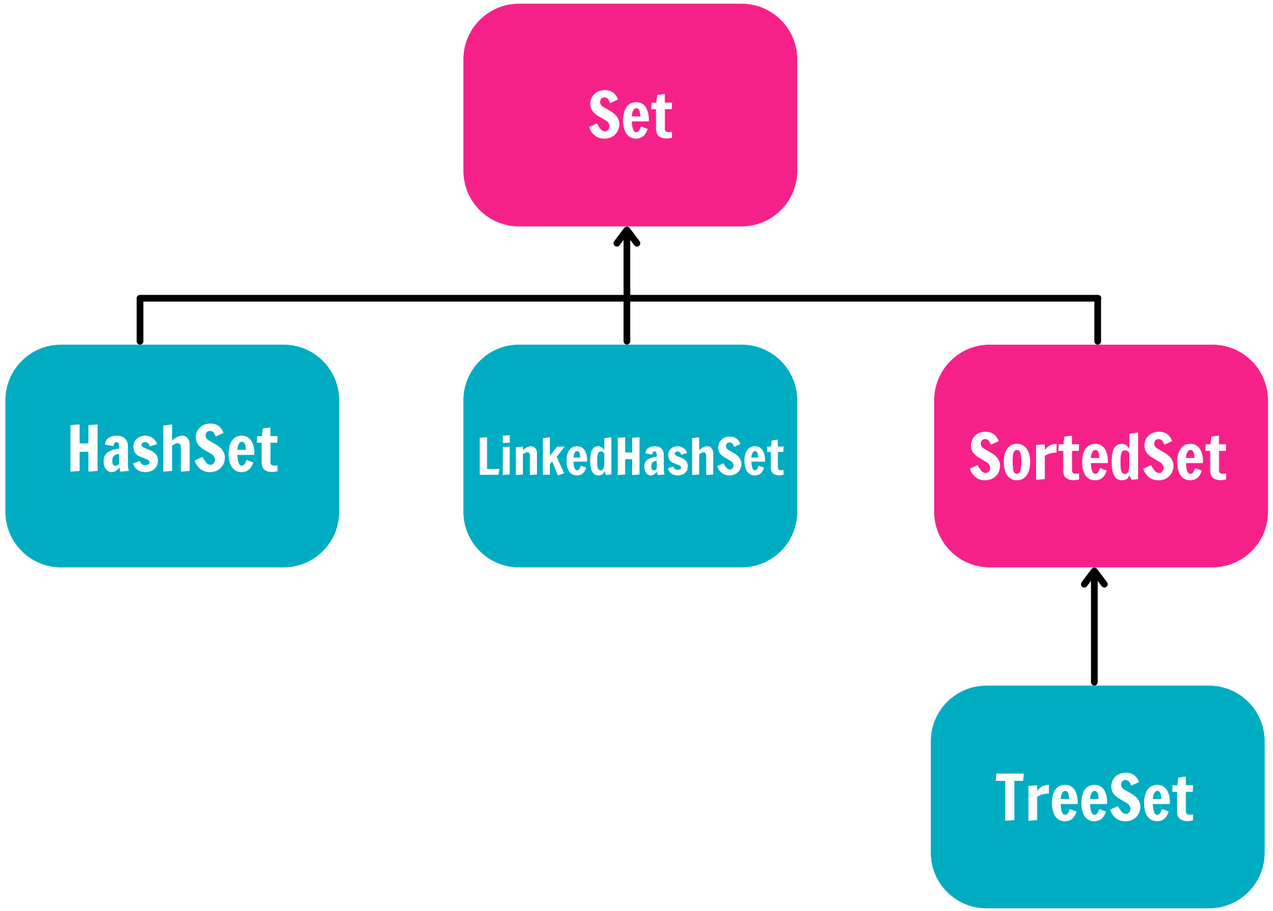


JAVA

Queue Interface（FIFO）

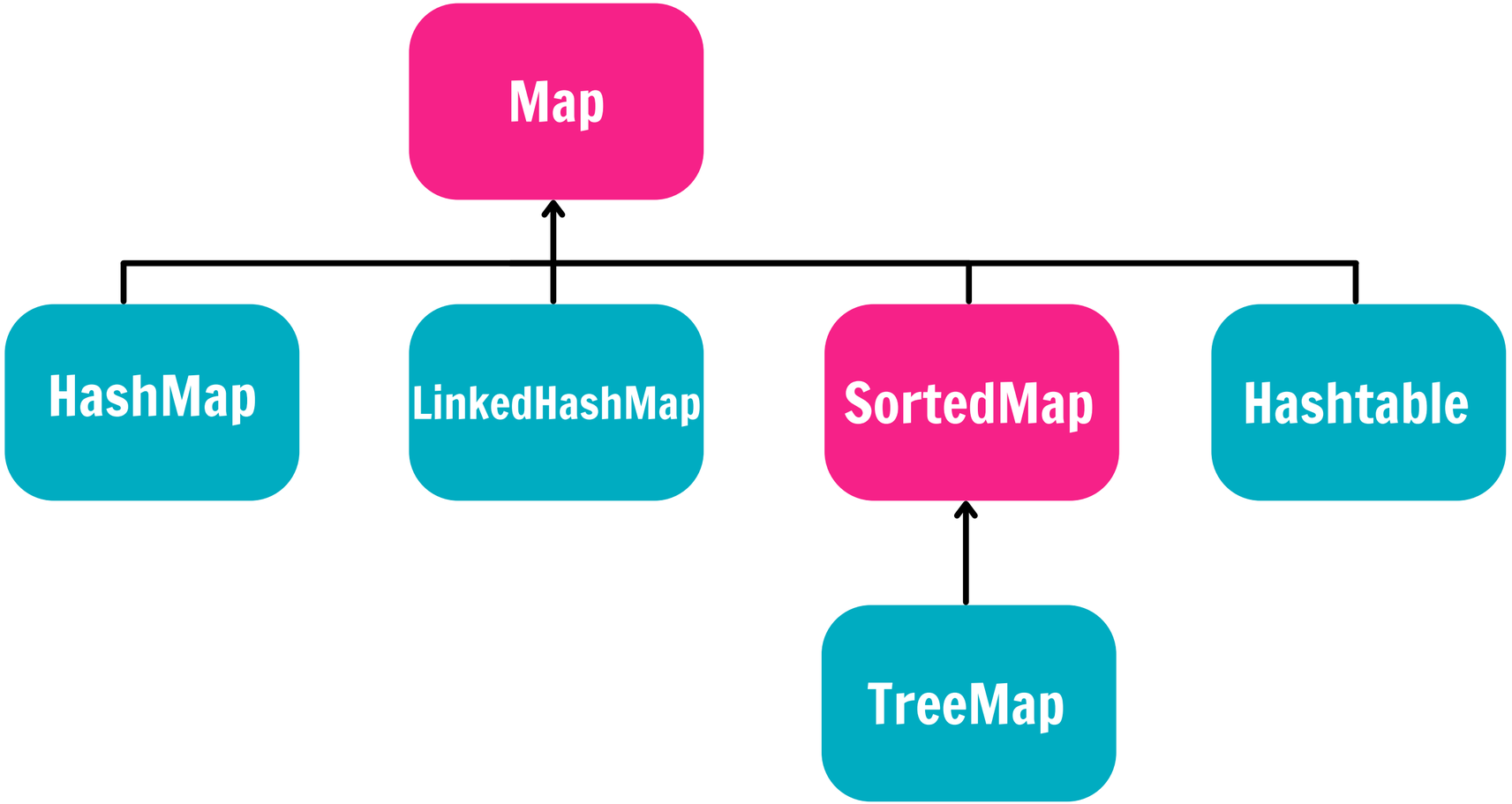


Set Interface



JAVA

Map Interface



HashMap in Java

```java
import java.util.*;

public class Hashing {
   public static void main(String args[]) {
       //Creation
       HashMap<String, Integer> map = new HashMap<>();

       //Insertion
       map.put("India", 120);
       map.put("US", 30);
       map.put("China", 150);

       System.out.println(map);

       map.put("China", 180);
       System.out.println(map);


       //Searching
       if(map.containsKey("Indonesia")) {
           System.out.println("key is present in the map");
       } else {
           System.out.println("key is not present in the map");
       }

       System.out.println(map.get("China")); //key exists
       System.out.println(map.get("Indonesia")); //key doesn't exist

       //Iteration (1)
       for( Map.Entry<String, Integer> e : map.entrySet()) {
           System.out.println(e.getKey());
           System.out.println(e.getValue());
       }

       //Iteration (2)
       Set<String> keys = map.keySet();
       for(String key : keys) {
           System.out.println(key+ " " + map.get(key));
       }
```

```
        //Removing
        map.remove("China");
        System.out.println(map);


    }
}
```

HashSet in Java

```java
import java.util.HashSet;
import java.util.Iterator;

public class Hashing {
   public static void main(String args[]) {
       HashSet<Integer> set = new HashSet<>();

       //Add
       set.add(1);
       set.add(2);
       set.add(3);
       set.add(1);

       //Size
       System.out.println("size of set is : " + set.size());

       //Search
       if(set.contains(1)) {
           System.out.println("present");
       }

       if(!set.contains(6)) {
           System.out.println("absent");
       }

       //Delete
       set.remove(1);
       if(!set.contains(1)) {
           System.out.println("absent");
       }

       //Print all elements
       System.out.println(set);

       //Iteration - HashSet does not have an order
       set.add(0);
       Iterator it = set.iterator();
        while (it.hasNext()) {
           System.out.print(it.next() + ", ");
       }
```

```
        System.out.println();

        //isEmpty
        if(!set.isEmpty()) {
            System.out.println("set is not empty");
        }
    }
}
```

Java - DSA

Trees

1. Build Tree from given Preorder Sequence

```java
//Build a Tree from its Preorder traversal

public class BinaryTreesYT {
    static class Node {
        int data;
        Node left;
        Node right;

        Node(int data) {
            this.data = data;
            this.left = null;
            this.right = null;
        }
    }

    static class BinaryTree {
        static int idx = -1;
        public static Node buildTree(int nodes[]) {
            idx++;
            if(nodes[idx] == -1) {
                return null;
            }
            Node newNode = new Node(nodes[idx]);
            newNode.left = buildTree(nodes);
            newNode.right = buildTree(nodes);
            return newNode;
        }
    }

    public static void main(String args[]) {
        int nodes[] = {1, 2, 4, -1, -1, 5, -1, -1, 3, -1, 6, -1, -1};
        BinaryTree tree = new BinaryTree();

        Node root = tree.buildTree(nodes);
        System.out.println(root.data);
    }
```

```
}
```

2. Tree Traversals

a. Preorder

```
public static void preorder(Node root) {
        if(root == null) {
            System.out.print(-1+" ");
            return;
        }
        System.out.print(root.data+" ");
        preorder(root.left);
        preorder(root.right);
    }
```

b. Inorder

```
public static void inorder(Node root) {
        if(root == null) {
            System.out.print(-1+" ");
            return;
        }
        inorder(root.left);
        System.out.print(root.data+" ");
        inorder(root.right);
    }
```

c. Postorder

```
public static void postorder(Node root) {
        if(root == null) {
            System.out.print(-1+" ");
            return;
        }
        postorder(root.left);
        postorder(root.right);
        System.out.print(root.data+" ");
    }
```

d. Level Order

```
public static void levelOrder(Node root) {
        if(root == null) {
            return;
        }
        Queue<Node> q = new LinkedList<>();
        q.add(root);
        q.add(null);
        while(!q.isEmpty()) {
            Node curr = q.remove();
            if(curr == null) {
                System.out.println();
                //queue empty
                if(q.isEmpty()) {
                    break;
                } else {
                    q.add(null);
                }
            } else {
                System.out.print(curr.data+" ");
                if(curr.left != null) {
                    q.add(curr.left);
                }
                if(curr.right != null) {
                    q.add(curr.right);
                }
            }
        }
    }
```

3. Height of Tree

```
public static int height(Node root) {
        if(root == null) {
            return 0;
        }

        int leftHeight = height(root.left);
        int rightHeight = height(root.right);
        return Math.max(leftHeight, rightHeight) + 1;
```

```
    }
```

4. Count of Nodes of Tree

```
public static int countOfNodes(Node root) {
        if(root == null) {
            return 0;
        }

        int leftNodes = countOfNodes(root.left);
        int rightNodes = countOfNodes(root.right);
        return leftNodes + rightNodes + 1;
    }
```

5. Sum of Nodes of Tree

```
public static int sumOfNodes(Node root) {
        if(root == null) {
            return 0;
        }

        int leftSum = sumOfNodes(root.left);
        int rightSum = sumOfNodes(root.right);
        return leftSum + rightSum + root.data;
    }
```

6. Diameter of Tree - Approach1 O(N^2)

```
public static int diameter(Node root) {
        if(root == null) {
            return 0;
        }

        int diam1 = height(root.left) + height(root.right) + 1;
        int diam2 = diameter(root.left);
        int diam3 = diameter(root.right);

        return Math.max(diam1, Math.max(diam2, diam3));
    }
```

7. Diameter of Tree - Approach2 O(N)

```
public static TreeInfo diameter(Node root) {
       if(root == null) {
           return new TreeInfo(0, 0);
       }

       TreeInfo leftTI = diameter(root.left);
       TreeInfo rightTI = diameter(root.right);

       int myHeight = Math.max(leftTI.height, rightTI.height) + 1;

       int diam1 = leftTI.height + rightTI.height + 1;
       int diam2 = leftTI.diam;
       int diam3 = rightTI.diam;

       int myDiam = Math.max(diam1, Math.max(diam2, diam3));

       return new TreeInfo(myHeight, myDiam);
   }
```

8. Subtree of another tree

```
 public boolean isIdentical(TreeNode root,TreeNode subRoot){
       if(subRoot == null && root == null){
           return true;
       }
       if(root == null || subRoot == null){
           return false;
       }
       if(root.val == subRoot.val){
           return isIdentical(root.left, subRoot.left) &&
isIdentical(root.right, subRoot.right);
       }
       return false;
   }

   public boolean isSubtree(TreeNode root, TreeNode subRoot) {
       if(subRoot == null){
           return true;
       }
       if(root == null){
           return false;
```

```
        }
        if(isIdentical(root, subRoot)){
            return true;
        }
        return isSubtree(root.left, subRoot) || isSubtree(root.right, subRoot);
    }
```

JAVA Class 1 (Codes)

Q1. Print numbers from 5 to 1.

```
public static void printNumbers(int n) {
        if(n == 0) {
            return;
        }
        System.out.println(n);
        printNumbers(n-1);
    }
```

Q2. Print numbers from 1 to 5.

```
public static void printNumbers(int n) {
        if(n == 6) {
            return;
        }
        System.out.println(n);
        printNumbers(n+1);
    }
```

Q3. Print the sum of first n natural numbers.

```
class Recursion1 {
    public static void printSum(int n, int sum) {
        if(n == 0) {
            System.out.println(sum);
            return;
        }

        sum += n;
        printSum(n-1, sum);
    }
    public static void main(String args[]) {
        printSum(5, 0);
    }
}
```

Q4. Print factorial of a number n.

```
class Recursion1 {
   public static void printFactorial(int n, int fact) {
       if(n == 0) {
           System.out.println(fact);
           return;
       }

       fact *= n;
       printFactorial(n-1, fact);
   }
   public static void main(String args[]) {
       printFactorial(5, 1);
   }
}
```

Q5. Print the fibonacci sequence till nth term.

```
class Recursion1 {
   public static void printFactorial(int a, int b, int n) {
       if(n == 0) {
           return;
       }

       System.out.println(a);
       printFactorial(b, a+b, n-1);
   }
   public static void main(String args[]) {
       printFactorial(0, 1, 5);
   }
}
```

Q6. Print x^n (with stack height = n)

```
class Recursion1 {
   public static int printPower(int x, int n) {
       if(n == 0) {
           return 1;
       }

       if(x == 0) {
           return 0;
       }
```

```
        int x_ = printPower(x, n-1);
        int xn = x * x_;
        return xn;
    }
    public static void main(String args[]) {
        int x = 2, n = 5;
        int output = printPower(x, n);
        System.out.println(output);
    }
}
```

Q7. Print x^n (with stack height = logn)

```
class Recursion1 {
    public static int printPower(int x, int n) {
        if(n == 0) {
            return 1;
        }

        if(n % 2 == 0) {
            return printPower(x, n/2) * printPower(x, n/2);
        }

        else {
            return x * printPower(x, n/2) * printPower(x, n/2);
        }
    }

    public static void main(String args[]) {
        int x = 2, n = 5;
        int output = printPower(x, n);
        System.out.println(output);
    }
}
```

Java - Introduction to Programming
Exercise 1 SOLUTIONS

1. Enter 3 numbers from the user & make a function to print their average.
   //Try to convert it into a function on your own.

```
import java.util.*;

public class Solutions {
   public static void main(String args[]) {
      Scanner sc = new Scanner(System.in);
      int a = sc.nextInt();
      int b = sc.nextInt();
      int c = sc.nextInt();

      int average = (a + b + c) / 3;
      System.out.println(average);
   }
}
```

2. Write a function to print the sum of all odd numbers from 1 to n.

```
import java.util.*;

public class Solutions {
   public static void printSum(int n) {
       int sum = 0;

      for(int i=1; i<=n; i++) {
        if(i % 2 != 0) {
            sum = sum + i;
        }
      }

      System.out.println(sum);
   }
   public static void main(String args[]) {
      Scanner sc = new Scanner(System.in);
```

```
        int n = sc.nextInt();
        printSum(n);
    }
}
```

3. Write a function which takes in 2 numbers and returns the greater of those two.

```
import java.util.*;

public class Solutions {
    public static int getGreater(int a, int b) {
        if(a > b) {
            return a;
        } else {
            return b;
        }
    }
    public static void main(String args[]) {
        Scanner sc = new Scanner(System.in);
        int a = sc.nextInt();
        int b = sc.nextInt();
        System.out.println(getGreater(a, b));
    }
}
```

4. Write a function that takes in the radius as input and returns the circumference of a circle.

```
import java.util.*;

public class Solutions {
    public static Double getCircumference(Double radius) {
        return 2 * 3.14 * radius;
    }
    public static void main(String args[]) {
        Scanner sc = new Scanner(System.in);
        Double r = sc.nextDouble();
        System.out.println(getCircumference(radius));
    }
}
```

5. Write a function that takes in age as input and returns if that person is eligible to vote or not. A person of age > 18 is eligible to vote.

```java
import java.util.*;

public class Solutions {
   public static boolean isElligible(int age) {
       if(age > 18) {
           return true;
       }
       return false;
   }
   public static void main(String args[]) {
      Scanner sc = new Scanner(System.in);
      int age = sc.nextInt();
      System.out.println(isElligible(age));
   }
}
```

6. Write an infinite loop using do while condition.

```java
import java.util.*;

public class Solutions {
   public static void main(String args[]) {
      do {

      } while(true);
   }
}
```

7. Write a program to enter the numbers till the user wants and at the end it should display the count of positive, negative and zeros entered.

```java
import java.util.*;

public class Solutions {
   public static void main(String args[]) {
       int positive = 0, negative = 0, zeros = 0;
       System.out.println("Press 1 to continue & 0 to stop");
       Scanner sc = new Scanner(System.in);
       int input = sc.nextInt();
```

```
        while(input == 1) {
            System.out.println("Enter your number : ");
            int number = sc.nextInt();
            if(number > 0) {
                positive++;
            } else if(number < 0) {
                negative++;
            } else {
                zeros++;
            }

            System.out.println("Press 1 to continue & 0 to stop");
            input = sc.nextInt();
        }

        System.out.println("Positives : "+ positive);
        System.out.println("Negatives : "+ negative);
        System.out.println("Zeros : "+ zeros);
    }
}
```

8. Two numbers are entered by the user, x and n. Write a function to find the value of one number raised to the power of another i.e. x^n.
   //Try to convert it into a function on your own.

```
import java.util.*;

public class Solutions {
   public static void main(String args[]) {
        System.out.println("Enter x");
        Scanner sc = new Scanner(System.in);
        int x = sc.nextInt();
        System.out.println("Enter n");
        int n = sc.nextInt();

        int result = 1;
        //Please see that n is not too large or else result will exceed the size
of int
        for(int i=0; i<n; i++) {
```

```
            result = result * x;
        }

        System.out.println("x to the power n is : "+ result);
    }
}
```

9. Write a function that calculates the Greatest Common Divisor of 2 numbers. (BONUS)

```
import java.util.*;

public class Solutions {
   public static void main(String args[]) {
       Scanner sc = new Scanner(System.in);
       int n1 = sc.nextInt();
       int n2 = sc.nextInt();

       while(n1 != n2) {
           if(n1>n2) {
               n1 = n1 - n2;
           } else {
               n2 = n2 - n1;
           }
       }
       System.out.println("GCD is : "+ n2);
   }
}
```

//Try to convert it into a function on your own.

10. Write a program to print Fibonacci series of n terms where n is input by user :
0 1 1 2 3 5 8 13 21 .....
In the Fibonacci series, a number is the sum of the previous 2 numbers that came before it.
(BONUS)

```
import java.util.*;

public class Solutions {
   public static void main(String args[]) {
       Scanner sc = new Scanner(System.in);
```

```
            int n = sc.nextInt();

            int a = 0, b = 1;

            System.out.print(a+" ");

            if(n > 1) {
                //find nth term
                for(int i=2; i<=n; i++) {
                    System.out.print(b+" ");
                    //the concept below is called swapping
                    int temp = b;
                    b = a + b;
                    a = temp;
                }

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

Java - Introduction to Programming

Exercise 1

Questions

1. Enter 3 numbers from the user & make a function to print their average.
2. Write a function to print the sum of all odd numbers from 1 to n.
3. Write a function which takes in 2 numbers and returns the greater of those two.
4. Write a function that takes in the radius as input and returns the circumference of a circle.
5. Write a function that takes in age as input and returns if that person is eligible to vote or not. A person of age > 18 is eligible to vote.
6. Write an infinite loop using do while condition.
7. Write a program to enter the numbers till the user wants and at the end it should display the count of positive, negative and zeros entered.
8. Two numbers are entered by the user, x and n. Write a function to find the value of one number raised to the power of another i.e. x^n.
9. Write a function that calculates the Greatest Common Divisor of 2 numbers. (BONUS)
10. Write a program to print Fibonacci series of n terms where n is input by user :
    0 1 1 2 3 5 8 13 21 .....
    In the Fibonacci series, a number is the sum of the previous 2 numbers that came before it.
    (BONUS)

Introduction to Linked List
Java

Linked List

LinkedList class Implementation (Collection Framework)

```java
import java.util.*;

class LL {
   public static void main(String args[]) {
       LinkedList<String> list = new LinkedList<String>();
       list.add("is");
       list.add("a");
       list.addLast("list");
       list.addFirst("this");
       list.add(3, "linked");
       System.out.println(list);

       System.out.println(list.get(0));
       System.out.println(list.size());
       list.remove(3);
       list.removeFirst();
       list.removeLast();

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

Scratch Implementation (Important for BEGINNERS)

```
class LL {



   Node head;

   private int size;



   LL () {

       size = 0;

   }



   public class Node {

       String data;

       Node next;



       Node(String data) {

           this.data = data;

           this.next = null;

           size++;

       }

   }



   public void addFirst(String data) {

       Node newNode = new Node(data);

       newNode.next = head;

       head = newNode;

   }
```

```java
public void addLast(String data) {
    Node newNode = new Node(data);

    if(head == null) {
        head = newNode;
        return;
    }

    Node lastNode = head;
    while(lastNode.next != null) {
        lastNode = lastNode.next;
    }

    lastNode.next = newNode;
}

public void printList() {
    Node currNode = head;

    while(currNode != null) {
        System.out.print(currNode.data+" -> ");
        currNode = currNode.next;
    }

    System.out.println("null");
```

```
}

public void removeFirst() {
    if(head == null) {
        System.out.println("Empty List, nothing to delete");
        return;
    }

    head = this.head.next;
    size--;
}

public void removeLast() {
    if(head == null) {
        System.out.println("Empty List, nothing to delete");
        return;
    }

    size--;
    if(head.next == null) {
        head = null;
        return;
    }

    Node currNode = head;
    Node lastNode = head.next;
```

```
        while(lastNode.next != null) {
            currNode = currNode.next;
            lastNode = lastNode.next;
        }

        currNode.next = null;
    }

    public int getSize() {
        return size;
    }

    public static void main(String args[]) {
        LL list = new LL();
        list.addLast("is");
        list.addLast("a");
        list.addLast("list");
        list.printList();

        list.addFirst("this");
        list.printList();
        System.out.println(list.getSize());

        list.removeFirst();
```

```
        list.printList();



        list.removeLast();

        list.printList();

    }

}
```

How to insert in the middle of a Linked List (at a specified index ‘i’) ?

Scratch

```
public void addInMiddle(int index, String data) {

        if(index > size || index < 0) {

            System.out.println("Invalid Index value");

            return;

        }

        size++;



        Node newNode = new Node(data);

        if(head == null || index == 0) {

            newNode.next = head;

            head = newNode;

            return;

        }

         Node currNode = head;

        for(int i=1; i<size; i++) {

            if(i == index) {
```

```
                Node nextNode = currNode.next;

                currNode.next = newNode;

                newNode.next = nextNode;

                break;

            }

            currNode = currNode.next;

        }

    }
```

LinkedList class

```
import java.util.*;



class LL {

    public static void main(String args[]) {

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



        list.addFirst("shradha");

        list.addFirst("name");

        list.addFirst("my");

        System.out.println(list);



        list.add(2, "is");

        System.out.println(list);

    }

}
```

Homework Problems

1. Make a Linked List & add the following elements to it : (1, 5, 7, 3 , 8, 2, 3). Search for the number 7 & display its index.
2. Take elements(numbers in the range of 1-50) of a Linked List as input from the user. Delete all nodes which have values greater than 25.

Code

```java
public static void divide(int arr[], int si, int ei) {
    if(si >= ei) {
        return;
    }

    int mid = si + (ei-si)/2;
    divide(arr, si, mid);
    divide(arr, mid+1, ei);
    conquer(arr, si, mid, ei);
}
```

```java
public static void conquer(int arr[], int si, int mid, int ei) {
    int merged[] = new int[ei-si+1];
    int idx1 = si;
    int idx2 = mid+1;
    int x = 0;
    while(idx1 <= mid && idx2 <= ei) {
        if(arr[idx1] <= arr[idx2]) {
            merged[x++] = arr[idx1++];
        } else {
            merged[x++] = arr[idx2++];
        }
    }

    while(idx1 <= mid) {
        merged[x++] = arr[idx1++];
    }

    while(idx2 <= ei) {
        merged[x++] = arr[idx2++];
    }

    for(int i=0, j=si; i<merged.length; i++, j++) {
        arr[j] = merged[i];
    }
}
```

Time Complexity : O(nlogn)

OBJECT ORIENTED PROGRAMMING SYSTEMS
JAVA

Object-Oriented Programming is a methodology or paradigm to design a program using classes and objects. It simplifies the software development and maintenance by providing some concepts defined below :

Class is a user-defined data type which defines its properties and its functions. Class is the only logical representation of the data. For example, Human being is a class. The body parts of a human being are its properties, and the actions performed by the body parts are known as functions. The class does not occupy any memory space till the time an object is instantiated.

Object is a run-time entity. It is an instance of the class. An object can represent a person, place or any other item. An object can operate on both data members and member functions.

Example 1:

```
class Student {
   String name;
   int age;

   public void getInfo() {
       System.out.println("The name of this Student is " + this.name);
       System.out.println("The age of this Student is " + this.age);
   }
}

public class OOPS {
   public static void main(String args[]) {
       Student s1 = new Student();
       s1.name = "Aman";
       s1.age = 24;
       s1.getInfo();

       Student s2 = new Student();
```

```
        s2.name = "Shradha";
        s2.age = 22;
        s2.getInfo();
    }
}
```

Example 2:

```
class Pen {
    String color;

    public void printColor() {
        System.out.println("The color of this Pen is " + this.color);
    }
}

public class OOPS {
    public static void main(String args[]) {
        Pen p1 = new Pen();
        p1.color = blue;

        Pen p2 = new Pen();
        p2.color = black;

        Pen p3 = new Pen();
        p3.color = red;

        p1.printColor();
        p2.printColor();
        p3.printColor();
    }
}
```

Note : When an object is created **using** a new keyword, then space is allocated for the variable in a heap, and the starting address is stored in the stack memory.

'this' keyword : 'this' keyword in Java that refers to the current instance of the class. In OOPS it is used to:

1. pass the current object as a parameter to another method
2. refer to the current class instance variable

Constructor : Constructor is a special method which is invoked automatically at the time of object creation. It is used to initialize the data members of new objects generally.

- Constructors have the same name as class or structure.
- Constructors don't have a return type. (Not even void)
- Constructors are only called once, at object creation.

There can be **three types** of constructors in Java.

1. Non-Parameterized constructor : A constructor which has no argument is known as non-parameterized constructor(or no-argument constructor). It is invoked at the time of creating an object. If we don't create one then it is created by default by Java.

```
class Student {
   String name;
   int age;

   Student() {
       System.out.println("Constructor called");
   }
}
```

2. Parameterized constructor : Constructor which has parameters is called a parameterized constructor. It is used to provide different values to distinct objects.

```
class Student {
   String name;
   int age;


   Student(String name, int age) {
       this.name = name;
       this.age = age;
   }
}
```

3. Copy Constructor : A Copy constructor is an **overloaded** constructor used to declare and initialize an object from another

object. There is only a user defined copy constructor in Java(C++ has a default one too).

```
class Student {
   String name;
   int age;

   Student(Student s2) {
       this.name = s2.name;
       this.age = s2.age;
   }
}
```

Note : Unlike languages like C++, Java has no Destructor. Instead, Java has an efficient garbage collector that deallocates memory automatically.

Polymorphism

Polymorphism is the ability to present the same interface for differing underlying forms (data types). With polymorphism, each of these classes will have different underlying data. Precisely, Poly means 'many' and morphism means 'forms'.

Types of Polymorphism IMP

1. Compile Time Polymorphism (Static)
2. Runtime Polymorphism (Dynamic)

Let's understand them one by one :

Compile Time Polymorphism : The polymorphism which is implemented at the compile time is known as compile-time polymorphism. Example - Method Overloading

Method Overloading : Method overloading is a technique which allows you to have more than one function with the same function name but with different functionality. Method overloading can be possible on the following basis:

1. The type of the parameters passed to the function.
2. The number of parameters passed to the function.

```
class Student {
   String name;
   int age;

   public void displayInfo(String name) {
       System.out.println(name);
   }

   public void displayInfo(int age) {
       System.out.println(age);
   }

   public void displayInfo(String name, int age) {
```

```
        System.out.println(name);
        System.out.println(age);
    }
}
```

Runtime Polymorphism : Runtime polymorphism is also known as **dynamic polymorphism**. Function overriding is an example of runtime polymorphism. Function overriding means when the child class contains the method which is already present in the parent class. Hence, **the child class overrides the method of the parent class**. In case of function overriding, parent and child classes both contain the same function with a different definition. The call to the function is determined at runtime is known as runtime polymorphism.

```
class Shape {
    public void area() {
        System.out.println("Displays Area of Shape");
    }
}
class Triangle extends Shape {
    public void area(int h, int b) {
        System.out.println((1/2)*b*h);
    }
}
class Circle extends Shape {
    public void area(int r) {
        System.out.println((3.14)*r*r);
    }
}
```

Inheritance

Inheritance is a process in which one object acquires all the properties and

behaviors of its parent object automatically. In such a way, you can **reuse, extend or modify** the attributes and behaviors which are defined in other classes.

In Java, the class which inherits the members of another class is called derived class and the class whose members are inherited is called base class. The derived class is the specialized class for the base class.

Types of Inheritance :

1. Single inheritance : When one class inherits another class, it is known as single level inheritance

```
class Shape {
   public void area() {
        System.out.println("Displays Area of Shape");
   }
}
class Triangle extends Shape {
   public void area(int h, int b) {
        System.out.println((1/2)*b*h);
   }
}
```

2. Hierarchical inheritance : Hierarchical inheritance is defined as the process of deriving more than one class from a base class.

```
class Shape {
   public void area() {
        System.out.println("Displays Area of Shape");
   }
}
class Triangle extends Shape {
   public void area(int h, int b) {
        System.out.println((1/2)*b*h);
   }
}
class Circle extends Shape {
   public void area(int r) {
        System.out.println((3.14)*r*r);
   }
```

```
}
```

3. Multilevel inheritance : Multilevel inheritance is a process of deriving a class from another derived class.

```
class Shape {
   public void area() {
        System.out.println("Displays Area of Shape");
   }
}
class Triangle extends Shape {
   public void area(int h, int b) {
        System.out.println((1/2)*b*h);
   }
}
class EquilateralTriangle extends Triangle {
   int side;
}
```

4. Hybrid inheritance : Hybrid inheritance is a combination of simple, multiple inheritance and hierarchical inheritance.

Package in Java

Package is a group of similar types of classes, interfaces and sub-packages. Packages can be built-in or user defined.

Built-in packages - java, util, io etc.

```
import java.util.Scanner;
```

```
import java.io.IOException;
```

Access Modifiers in Java

- **Private**: The access level of a private modifier is only within the class. It cannot be accessed from outside the class.
- **Default**: The access level of a default modifier is only within the package. It cannot be accessed from outside the package. If you do not specify any access level, it will be the default.
- **Protected**: The access level of a protected modifier is within the package and outside the package through child class. If you do not make the child class, it cannot be accessed from outside the package.
- **Public**: The access level of a public modifier is everywhere. It can be accessed from within the class, outside the class, within the package and outside the package.

```
package newpackage;


class Account {
   public String name;
   protected String email;
   private String password;


   public void setPassword(String password) {
       this.password = password;
   }
```

```
}
public class Sample {
   public static void main(String args[]) {
       Account a1 = new Account();
       a1.name = "Apna College";
       a1.setPassword("abcd");
       a1.email = "hello@apnacollege.com";
   }
}
```

Encapsulation

Encapsulation is the process of combining data and functions into a single unit called class. In Encapsulation, the data is not accessed directly; it is accessed through the functions present inside the class. In simpler words, attributes of the class are kept private and public getter and setter methods are provided to manipulate these attributes. Thus, encapsulation makes the concept of data hiding possible.(**Data hiding**: a language feature to restrict access to members of an object, reducing the negative effect due to dependencies. e.g. "protected", "private" feature in Java).

Abstraction

We try to obtain an **abstract view**, model or structure of a real life problem, and reduce its unnecessary details. With definition of properties of problems, including the data which are affected and the operations which are identified, the model abstracted from problems can be a standard solution to this type of problems. It is an efficient way since there are nebulous real-life problems that have similar properties.

In simple terms, it is hiding the unnecessary details & showing only the essential parts/functionalities to the user.

Data binding **:** Data binding is a process of binding the application UI and business logic. Any change made in the business logic will reflect directly to the application UI.

Abstraction is achieved in 2 ways :

- Abstract class
- Interfaces (Pure Abstraction)

1. **Abstract Class**

- An abstract class must be declared with an abstract keyword.
- It can have abstract and non-abstract methods.
- It cannot be instantiated.
- It can have constructors and static methods also.
- It can have final methods which will force the subclass not to change the body of the method.

```
abstract class Animal {
   abstract void walk();
   void breathe() {
```

```
        System.out.println("This animal breathes air");
    }
    Animal() {
        System.out.println("You are about to create an Animal.");
    }
}

class Horse extends Animal {
    Horse() {
        System.out.println("Wow, you have created a Horse!");
    }
    void walk() {
        System.out.println("Horse walks on 4 legs");
    }
}

class Chicken extends Animal {
    Chicken() {
        System.out.println("Wow, you have created a Chicken!");
    }
    void walk() {
        System.out.println("Chicken walks on 2 legs");
    }
}

public class OOPS {
    public static void main(String args[]) {
       Horse horse = new Horse();
       horse.walk();
       horse.breathe();
    }
}
```

2. **Interfaces**

- All the fields in interfaces are public, static and final by default.
- All methods are public & abstract by default.
- A class that implements an interface must implement all the methods declared in the interface.
- Interfaces support the functionality of multiple inheritance.

```
interface Animal {

   void walk();

}



class Horse implements Animal {

   public void walk() {

       System.out.println("Horse walks on 4 legs");

   }

}



class Chicken implements Animal {

   public void walk() {

       System.out.println("Chicken walks on 2 legs");

   }

}
```

```
public class OOPS {

   public static void main(String args[]) {

      Horse horse = new Horse();

      horse.walk();

   }

}
```

Static Keyword

Static can be :

1. Variable (also known as a class variable)
2. Method (also known as a class method)
3. Block
4. Nested class

```
class Student {

   static String school;

   String name;

}

public class OOPS {
   public static void main(String args[]) {
```

```
        Student.school = "JMV";
        Student s1 = new Student();
        Student s2 = new Student();

        s1.name = "Meena";
        s2.name = "Beena";

        System.out.println(s1.school);
        System.out.println(s2.school);
    }
}
```

Code

```java
public static void quickSort(int arr[], int low, int high) {
    if (low < high) {
        int pi = partition(arr, low, high);

        quickSort(arr, low, pi - 1);
        quickSort(arr, pi + 1, high);
    }
}
```

```java
public static int partition(int[] arr, int low, int high) {
    int pivot = arr[high];
    int i = low-1;

    for(int j=low; j<high; j++) {
        if (arr[j] < pivot) {
            i++;
            //swap
            int temp = arr[i];
            arr[i] = arr[j];
            arr[j] = temp;
        }
    }
    //swap with pivot
    i++;
    int temp = arr[i];
    arr[i] = arr[high];
    arr[high] = temp;
    return i;
}
```

Time Complexity

Worst : O(n^2)

Average : O(nlogn)

Important

Worst case occurs when pivot is always the smallest or the largest element.

ADVANCED

Q1. Print all the permutations of a string.

```
public class Recursion3 {

   public static void printPermutation(String str, int idx, String perm) {
       if(str.length() == 0) {
           System.out.println(perm);
           return;
       }

       for(int i=0; i<str.length(); i++) {
           char currChar = str.charAt(i);
           String newStr = str.substring(0, i) + str.substring(i+1);
           printPermutation(newStr, idx+1, perm+currChar);
       }
   }
   public static void main(String args[]) {
       String str = "abc";
       printPermutation(str, 0, "");
   }
}
```

Time complexity - O(n*n!)

Q2. CountPathMaze

```
public class Recursion3 {

   public static int countPaths(int i, int j, int m, int n) {
       if(i == m-1 || j == n-1) {
           return 1;
       }

       return countPaths(i+1, j, m, n) + countPaths(i, j+1, m, n);
   }

   public static void main(String args[]) {
       int m = 4, n = 5;
       System.out.println(countPaths(0, 0, m, n));
   }
}
```

Time complexity - O(2^(m+n))

Q3. Tiling problem

```
public class Recursion3 {

   public static int placeTiles(int n, int m) {
       if(n < m) {
           return 1;
       } else if(n == m) {
           return 2;
       }

       return placeTiles(n-1, m) + placeTiles(n-m, m);
   }

   public static void main(String args[]) {
       int n = 4, m = 4;
       System.out.println(placeTiles(n, m));
   }
}
```

Q4. Friends pairing problem

```
public class Recursion3 {

   public static int pairFriends(int n) {
      if(n <= 1) {
          return 1;
      }

       return pairFriends(n-1) + (n-1) * pairFriends(n-2);
   }

   public static void main(String args[]) {
       int n = 3;
       System.out.println(pairFriends(n));
   }
}
```

Q5. Subsets of a set

```java
import java.util.ArrayList;

public class Recursion3 {

   public static void printSubsets(ArrayList<Integer> subset) {
       for(int i=0; i<subset.size(); i++) {
           System.out.print(subset.get(i)+" ");
       }
       System.out.println();
   }

   public static void findSubsets(int n, ArrayList<Integer> subset) {
       if(n == 0) {
           printSubsets(subset);
           return;
       }

       findSubsets(n-1, subset);
       subset.add(n);
       findSubsets(n-1, subset);
       subset.remove(subset.size() - 1);
   }

   public static void main(String args[]) {
       int n = 3;
       findSubsets(n, new ArrayList<Integer> ());
   }
}
```

ADVANCED

Q1. Print all the permutations of a string.

```
public class Recursion3 {

   public static void printPermutation(String str, int idx, String perm) {
       if(str.length() == 0) {
           System.out.println(perm);
           return;
       }

       for(int i=0; i<str.length(); i++) {
           char currChar = str.charAt(i);
           String newStr = str.substring(0, i) + str.substring(i+1);
           printPermutation(newStr, idx+1, perm+currChar);
       }
   }
   public static void main(String args[]) {
       String str = "abc";
       printPermutation(str, 0, "");
   }
}
```

Time complexity - O(n*n!)

Q2. CountPathMaze

```
public class Recursion3 {

   public static int countPaths(int i, int j, int m, int n) {
       if(i == m-1 || j == n-1) {
           return 1;
       }

       return countPaths(i+1, j, m, n) + countPaths(i, j+1, m, n);
   }

   public static void main(String args[]) {
       int m = 4, n = 5;
       System.out.println(countPaths(0, 0, m, n));
   }
}
```

Time complexity - O(2^(m+n))

Q3. Tiling problem

```
public class Recursion3 {

   public static int placeTiles(int n, int m) {
       if(n < m) {
           return 1;
       } else if(n == m) {
           return 2;
       }

       return placeTiles(n-1, m) + placeTiles(n-m, m);
   }

   public static void main(String args[]) {
       int n = 4, m = 4;
       System.out.println(placeTiles(n, m));
   }
}
```

Q4. Friends pairing problem

```
public class Recursion3 {

   public static int pairFriends(int n) {
      if(n <= 1) {
          return 1;
      }

       return pairFriends(n-1) + (n-1) * pairFriends(n-2);
   }

   public static void main(String args[]) {
       int n = 3;
       System.out.println(pairFriends(n));
   }
}
```

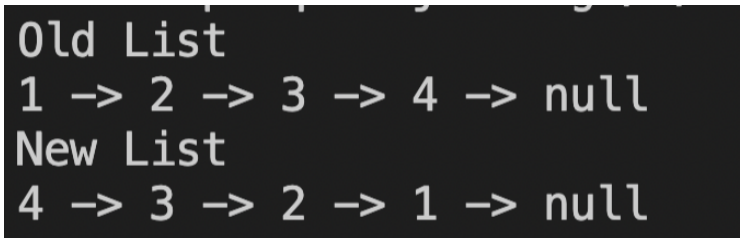
Q5. Subsets of a set

```java
import java.util.ArrayList;

public class Recursion3 {

   public static void printSubsets(ArrayList<Integer> subset) {
       for(int i=0; i<subset.size(); i++) {
           System.out.print(subset.get(i)+" ");
       }
       System.out.println();
   }

   public static void findSubsets(int n, ArrayList<Integer> subset) {
       if(n == 0) {
           printSubsets(subset);
           return;
       }

       findSubsets(n-1, subset);
       subset.add(n);
       findSubsets(n-1, subset);
       subset.remove(subset.size() - 1);
   }

   public static void main(String args[]) {
       int n = 3;
       findSubsets(n, new ArrayList<Integer> ());
   }
}
```

Reverse a Linked List

Java

Reverse a Linked List without using extra space.



Iterative Method

Time complexity - O(n)

Space complexity - O(1)

```java
public void reverseList() {
        if(head == null || head.next == null) {
            return;
        }

        Node prevNode = head;
        Node currNode = head.next;
        while(currNode != null) {
            Node nextNode = currNode.next;
            currNode.next = prevNode;
            prevNode = currNode;
            currNode = nextNode;
        }
        head.next = null;
        head = prevNode;
    }
```

Recursive Method

Time complexity - O(n)

Space complexity - O(1)

```
public Node reverseListRecursive(Node head) {

       //empty node || last node or only one node

       if(head == null || head.next == null) {

           return head;

       }


       Node newHead = reverseListRecursive(head.next);


       head.next.next = head;

       head.next = null;

       return newHead;

   }
```

Collections Method

Time complexity - O(n)

Space complexity - O(1)

```
LinkedList<Integer> list2 = new LinkedList<>();

       list2.add(1);

       list2.add(2);

       Collections.reverse(list2);
```

Homework Problems

1. https://leetcode.com/problems/swap-nodes-in-pairs/
2. https://leetcode.com/problems/remove-nth-node-from-end-of-list/
3. https://leetcode.com/problems/reverse-linked-list-ii/
4. https://leetcode.com/problems/remove-nth-node-from-end-of-list/

Sorting in JAVA

1. **Bubble Sort**

   Idea: if arr[i] > arr[i+1] swap them. To place the element in their respective position, we have to do the following operation N-1 times.

   Time Complexity: $O(N^2)$

   Code

```java
import java.util.*;

class Sorting {
   public static void printArray(int arr[]) {
       for(int i=0; i<arr.length; i++) {
           System.out.print(arr[i]+" ");
       }
       System.out.println();
   }

   public static void main(String args[]) {
       int arr[] = {7, 8, 1, 3, 2};

       //bubble sort
       for(int i=0; i<arr.length-1; i++) {
           for(int j=0; j<arr.length-i-1; j++) {
               if(arr[j] > arr[j+1]) {
                   //swap
                   int temp = arr[j];
                   arr[j] = arr[j+1];
                   arr[j+1] = temp;
               }
           }
       }

       printArray(arr);
   }
```

```
}
```

2. Selection Sort

Idea: The inner loop selects the minimum element in the unsorted array and places the elements in increasing order.

Time complexity: $O(N^2)$

Code

```
import java.util.*;

class Sorting {
   public static void printArray(int arr[]) {
       for(int i=0; i<arr.length; i++) {
           System.out.print(arr[i]+" ");
       }
       System.out.println();
   }

   public static void main(String args[]) {
       int arr[] = {7, 8, 1, 3, 2};

       //selection sort
       for(int i=0; i<arr.length-1; i++) {
           int smallest = i;
           for(int j=i+1; j<arr.length; j++) {
               if(arr[j] < arr[smallest]) {
                   smallest = j;
               }
           }
           //swap
           int temp = arr[smallest];
           arr[smallest] = arr[i];
           arr[i] = temp;
       }

       printArray(arr);
   }
```

```
}
```

3. Insertion Sort

Idea: Take an element from the unsorted array, place it in its corresponding position in the sorted part, and shift the elements accordingly.

Time Complexity: $O(N^2)$

Code

```
import java.util.*;

class Sorting {
   public static void printArray(int arr[]) {
       for(int i=0; i<arr.length; i++) {
           System.out.print(arr[i]+" ");
       }
       System.out.println();
   }

   public static void main(String args[]) {
       int arr[] = {7, 8, 1, 3, 2};

       //insertion sort
       for(int i=1; i<arr.length; i++) {
           int current = arr[i];
           int j = i - 1;
               while(j >= 0 && arr[j] > current) {
                   //Keep swapping
                   arr[j+1] = arr[j];
                   j--;
               }
           arr[j+1] = current;
       }
       printArray(arr);
   }
}
```

`

Sorting in JAVA

1. **Bubble Sort**

   Idea: if arr[i] > arr[i+1] swap them. To place the element in their respective position, we have to do the following operation N-1 times.

   Time Complexity: $O(N^2)$

   Code

```java
import java.util.*;

class Sorting {
   public static void printArray(int arr[]) {
       for(int i=0; i<arr.length; i++) {
           System.out.print(arr[i]+" ");
       }
       System.out.println();
   }

   public static void main(String args[]) {
       int arr[] = {7, 8, 1, 3, 2};

       //bubble sort
       for(int i=0; i<arr.length-1; i++) {
           for(int j=0; j<arr.length-i-1; j++) {
               if(arr[j] > arr[j+1]) {
                   //swap
                   int temp = arr[j];
                   arr[j] = arr[j+1];
                   arr[j+1] = temp;
               }
           }
       }

       printArray(arr);
   }
```

```
}
```

2. Selection Sort

Idea: The inner loop selects the minimum element in the unsorted array and places the elements in increasing order.

Time complexity: $O(N^2)$

Code

```
import java.util.*;

class Sorting {
   public static void printArray(int arr[]) {
       for(int i=0; i<arr.length; i++) {
           System.out.print(arr[i]+" ");
       }
       System.out.println();
   }

   public static void main(String args[]) {
       int arr[] = {7, 8, 1, 3, 2};

       //selection sort
       for(int i=0; i<arr.length-1; i++) {
           int smallest = i;
           for(int j=i+1; j<arr.length; j++) {
               if(arr[j] < arr[smallest]) {
                   smallest = j;
               }
           }
           //swap
           int temp = arr[smallest];
           arr[smallest] = arr[i];
           arr[i] = temp;
       }

       printArray(arr);
   }
```

```
}
```

3. Insertion Sort

Idea: Take an element from the unsorted array, place it in its corresponding position in the sorted part, and shift the elements accordingly.

Time Complexity: $O(N^2)$

Code

```
import java.util.*;

class Sorting {
   public static void printArray(int arr[]) {
       for(int i=0; i<arr.length; i++) {
           System.out.print(arr[i]+" ");
       }
       System.out.println();
   }

   public static void main(String args[]) {
       int arr[] = {7, 8, 1, 3, 2};

       //insertion sort
       for(int i=1; i<arr.length; i++) {
           int current = arr[i];
           int j = i - 1;
               while(j >= 0 && arr[j] > current) {
                   //Keep swapping
                   arr[j+1] = arr[j];
                   j--;
               }
           arr[j+1] = current;
       }
       printArray(arr);
   }
}
```

`

Queue

- Queue using Array

```java
//queue using array
public class QueueB {
   static class Queue {
       static int arr[];
       static int size;
       static int rear;

       Queue(int size) {
           this.size = size;
           arr = new int[size];
           rear = -1;
       }

       public static boolean isEmpty() {
           return rear == -1;
       }

       public static boolean isFull() {
           return rear == size-1;
       }

       public static void add(int data) {
           if(isFull()) {
               System.out.println("Overflow");
               return;
           }

           arr[++rear] = data;
       }

       //O(n)
       public static int remove() {
           if(isEmpty()) {
               System.out.println("empty queue");
               return -1;
           }
           int front = arr[0];
           for(int i=0; i<rear; i++) {
               arr[i] = arr[i+1];
```

```
            }
             rear-;
            return front;
        }

        public static int peek() {
            if(isEmpty()) {
                System.out.println("empty queue");
                return -1;
            }

            return arr[0];
        }
    }
    public static void main(String args[]) {
        Queue q = new Queue(5);
        q.add(1);
        q.add(2);
        q.add(3);
        System.out.println(q.remove());
        System.out.println(q.peek());
    }
}
```

Circular queue using array

```
//circular queue using array
public class QueueB {
    static class Queue {
        static int arr[];
        static int size;
        static int front = -1;
        static int rear = -1;

        Queue(int size) {
            this.size = size;
            arr = new int[size];
        }

        public static boolean isEmpty() {
            return rear == -1 && front == -1;
        }
```

```
    public static boolean isFull() {
        return (rear+1)%size == front;
    }

    public static void add(int data) {
        if(isFull()) {
            System.out.println("Overflow");
            return;
        }
        //if it's the 1st element
        if(front == -1) {
            front = 0;
        }

        rear = (rear + 1)%size;
        arr[rear] = data;
    }

    public static int remove() {
        if(isEmpty()) {
            System.out.println("empty queue");
            return -1;
        }
        int res = arr[front];

        //if only 1 element is present
        if(front == rear) {
            front = rear = -1;
        } else {
            front = (front+1)%size;
        }

        return res;
    }

    public static int peek() {
        if(isEmpty()) {
            System.out.println("empty queue");
            return -1;
        }
```

```
            return arr[front];
        }
    }
    public static void main(String args[]) {
        Queue q = new Queue(5);
        q.add(1);
        q.add(2);
        q.add(3);
        q.add(4);
        q.add(5);
        System.out.println(q.remove());
        q.add(6);
        System.out.println(q.remove());
        q.add(7);

        while(!q.isEmpty()) {
            System.out.println(q.remove());
        }
    }
}
```

- Queue using Linked List

```
//queue using Linked List
public class QueueB {
    static class Node {
        int data;
        Node next;
        Node(int data) {
            this.data = data;
            next = null;
        }
    }

    static class Queue {
        static Node head = null;
        static Node tail = null;

        public static boolean isEmpty() {
            return head == null && tail == null;
        }
```

```
    public static void add(int data) {
        Node newNode = new Node(data);
        if(isEmpty()) {
            tail = head = newNode;
        } else {
            tail.next = newNode;
            tail = newNode;
        }
    }

    public static int remove() {
        if(isEmpty()) {
            System.out.println("empty queue");
            return -1;
        }
        int front = head.data;
        //single node
        if(head == tail) {
            tail = null;
        }
        head = head.next;
        return front;
    }

    public static int peek() {
        if(isEmpty()) {
            System.out.println("empty queue");
            return -1;
        }

        return head.data;
    }
}
public static void main(String args[]) {
    Queue q = new Queue();
    q.add(1);
    q.add(2);
    q.add(3);
    q.add(4);
    q.add(5);
```

```
        while(!q.isEmpty()) {
            System.out.println(q.peek());
            q.remove();
        }
    }
}
```

- Java Collection Framework

```
//queue using Java Collection Framework
import java.util.*;

public class QueueB {
    public static void main(String args[]) {
        //Queue<Integer> q = new LinkedList();
        Queue<Integer> q = new ArrayDeque();
        q.add(1);
        q.add(2);
        q.add(3);
        q.add(4);
        q.add(5);

        while(!q.isEmpty()) {
            System.out.println(q.peek());
            q.remove();
        }
    }
}
```

- Queue using 2 stacks

```
//queue using 2 stacks
import java.util.*;

public class QueueB {
    static class Queue {
```

```
        static Stack<Integer> s1 = new Stack<>();
        static Stack<Integer> s2 = new Stack<>();

        public static boolean isEmpty() {
            return s1.isEmpty();
        }

        public static void add(int data) {
            while(!s1.isEmpty()) {
                s2.push(s1.pop());
            }
            s1.push(data);
            while(!s2.isEmpty()) {
                s1.push(s2.pop());
            }
        }

        public static int remove() {
            return s1.pop();
        }

        public static int peek() {
            return s1.peek();
        }
    }
    public static void main(String args[]) {
        Queue q = new Queue();
        q.add(1);
        q.add(2);
        q.add(3);

        while(!q.isEmpty()) {
            System.out.println(q.peek());
            q.remove();
        }
    }
}
```

Sudoku Solver (Backtracking 2)

Java

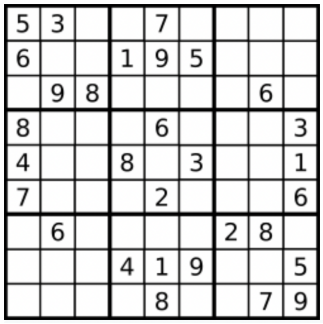
Write a program to solve a Sudoku puzzle by filling the empty cells.

A sudoku solution must satisfy all of the following rules:

1. Each of the digits 1-9 must occur exactly once in each row.
2. Each of the digits 1-9 must occur exactly once in each column.
3. Each of the digits 1-9 must occur exactly once in each of the 9 3x3 sub-boxes of the grid.

The '.' character indicates empty cells.

Sample Input



```
board =
[["5","3",".",".","7",".",".",".",".",".],["6",".",".","1","9","5",".",".",".",".],[".","9","8",".",".",".",".","6",".",".],["8",".",".",".","6",".",".",".",".","3"],["4",".",".","8",".","3",".",".",".","1"],["7",".",".",".","2",".",".",".",".","6"],[".","6",".",".",".",".",".","2","8","."],[".",".",".","4","1","9",".",".",".","5"],[".",".",".",".","8",".",".",".","7","9"]]
```

Sample Output

5	3	4	6	7	8	9	1	2
6	7	2	1	9	5	3	4	8
1	9	8	3	4	2	5	6	7
8	5	9	7	6	1	4	2	3
4	2	6	8	5	3	7	9	1
7	1	3	9	2	4	8	5	6
9	6	1	5	3	7	2	8	4
2	8	7	4	1	9	6	3	5
3	4	5	2	8	6	1	7	9

```
[["5","3","4","6","7","8","9","1","2"],["6","7","2","1","9","5","3","4","8"],["
1","9","8","3","4","2","5","6","7"],["8","5","9","7","6","1","4","2","3"],["4",
"2","6","8","5","3","7","9","1"],["7","1","3","9","2","4","8","5","6"],["9","6"
,"1","5","3","7","2","8","4"],["2","8","7","4","1","9","6","3","5"],["3","4","5
","2","8","6","1","7","9"]]
```

Code

a. StartingRow = 3*(row/3) & StartingCol = 3*(col/3)
b. StartingRow = row - row%3 & StartingCol = col - col%3

Code

```
class Solution {
   public boolean isSafe(char[][] board, int row, int col, int number) {
       //column
       for(int i=0; i<board.length; i++) {
           if(board[i][col] == (char)(number+'0')) {
               return false;
           }
       }

       //row
       for(int j=0; j<board.length; j++) {
           if(board[row][j] == (char)(number+'0')) {
               return false;
           }
       }

       //grid
       int sr = 3 * (row/3);
       int sc = 3 * (col/3);

       for(int i=sr; i<sr+3; i++) {
           for(int j=sc; j<sc+3; j++) {
               if(board[i][j] == (char)(number+'0')) {
                   return false;
               }
           }
       }
```

```
        return true;
    }

    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 + 1;
            ncol = 0;
        } else {
            nrow = row;
            ncol = col + 1;
        }

        if(board[row][col] != '.') {
            if(helper(board, nrow, ncol)) {
                return true;
            }
        } else {

            //fill the place
            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] = '.';
                }
            }
        }

        return false;
    }

    public void solveSudoku(char[][] board) {
        helper(board, 0, 0);
    }
}
```