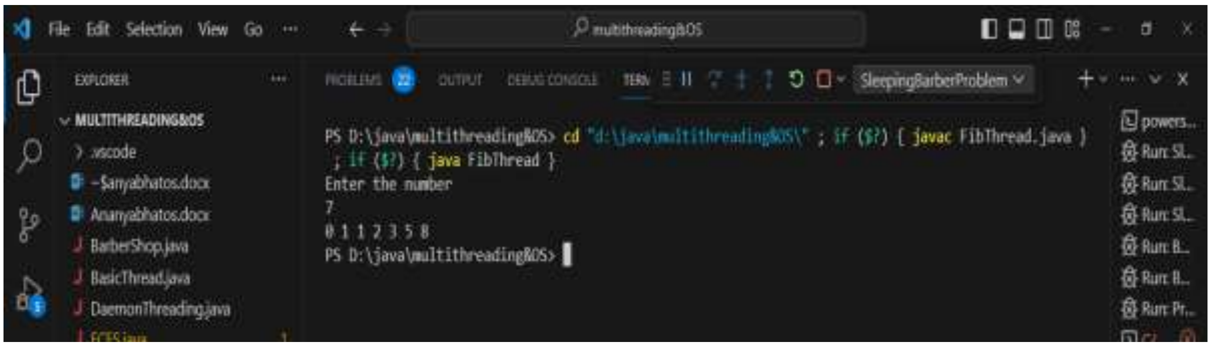
Question 2

Write a multithreaded program that generates the Fibonacci series.

Program:

```
import java.util.Scanner;
class Fibonacci extends Thread{
    int n;
    int series[];
    public Fibonacci(int n){
        this.n = n;
        series = new int[n];
    }
public void run(){
    series[0] = 0;
    series[1] = 1;
    for(int i =2;i<n;i++){
        series[i] = series[i-1] + series[i-2];
    }
}
void printSeries(){
    for(int i =0;i<n;i++)
        System.out.print(series[i] + " ");
    }
}
public class FibThread {
    public static void main(String[] args) {
        Scanner sc = new Scanner(System.in);
        System.out.println("Enter the number");
        int n = sc.nextInt();
        Fibonacci fib = new Fibonacci(n);
        fib.start();
        try {
            Thread.sleep(1000);
        } catch (InterruptedException e) {
        // TODO Auto-generated catch block
            e.printStackTrace();
        }
        fib.printSeries();
    }
}
```

Output:



```
PS D:\java\multithreading&OS> cd "d:\java\multithreading&OS\" ; if ($?) { javac FibThread.java }
 ; if ($?) { java FibThread }
Enter the number
7
0 1 1 2 3 5 8
PS D:\java\multithreading&OS>
```

Question 3

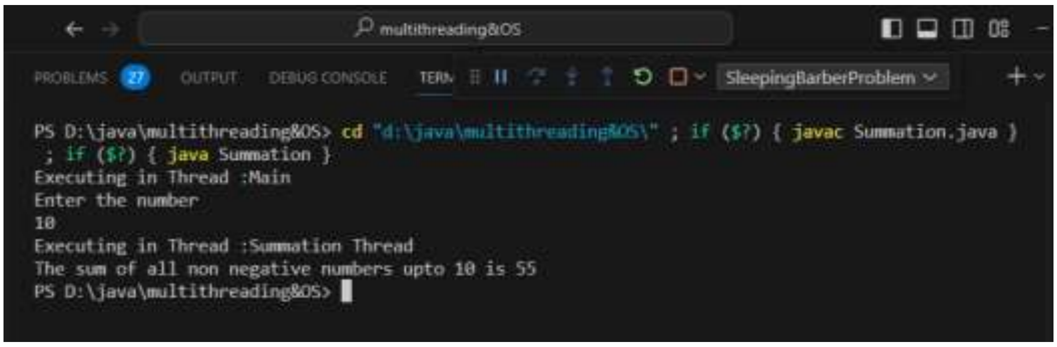
Write a program that demonstrates the basic Threads API for constructing a multithreaded program that calculates the summation of a nonnegative integer in a separate thread.

Program:

```
import java.util.Scanner;
class Sum extends Thread{
    int n,sum;
    public Sum(int n){
        this.n = n;
        sum =0;
    }
    public void run(){
        for(int i=0;i<=n;i++)
            sum += i;    }
    public void printSum(){
        Thread.currentThread().setName("Summation Thread");
        System.out.println("Executing in Thread :" +
Thread.currentThread().getName());
```

```
        System.out.println("The sum of all non negative 
numbers upto "+ n + " is " + sum);
    }
}
public class Summation {
    public static void main(String[] args) {
    // TODO Auto-generated method stub
        Thread.currentThread().setName("Main");
        System.out.println("Executing in Thread :" + 
Thread.currentThread().getName());
        Scanner sc = new Scanner(System.in);
        System.out.println("Enter the number");
        int n = sc.nextInt();
        Sum obj = new Sum(n);
        obj.start();
        try {
            Thread.sleep(1000);
        } catch (InterruptedException e) {
            e.printStackTrace();
        }
        obj.printSum();
    }
}
```

Output:



```
PS D:\java\multithreading&OS> cd "d:\java\multithreading&OS\" ; if ($?) { javac Summation.java }
 ; if ($?) { java Summation }
Executing in Thread :Main
Enter the number
10
Executing in Thread :Summation Thread
The sum of all non negative numbers upto 10 is 55
PS D:\java\multithreading&OS> 
```

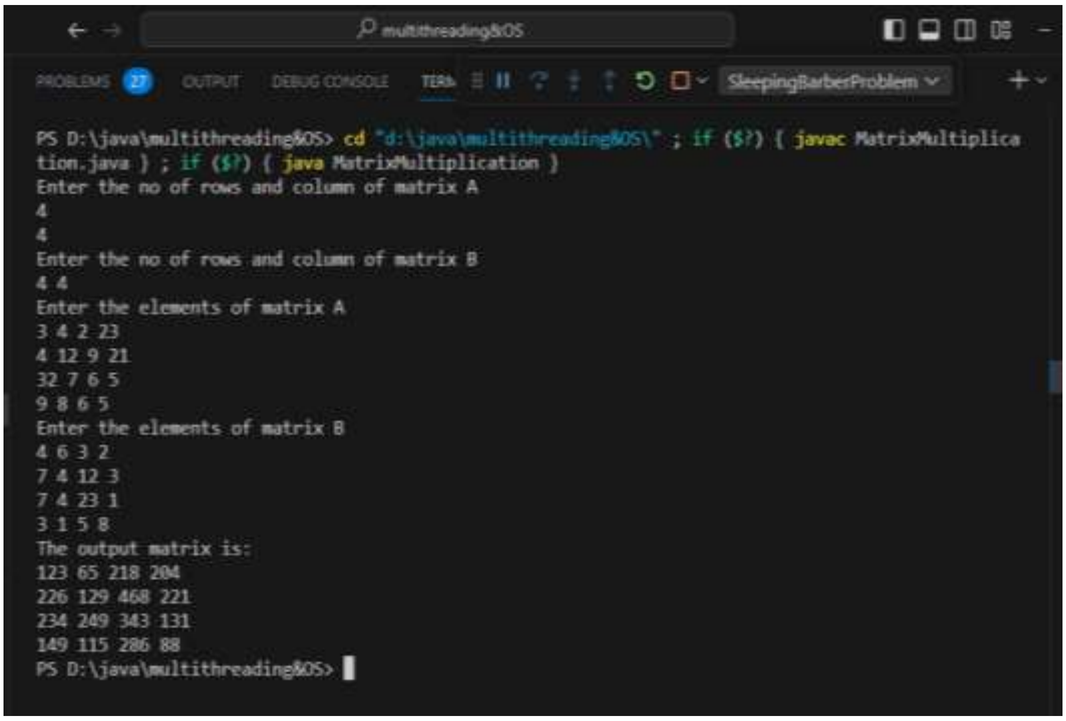
Question 4

Given two matrices A and B is a matrix with M rows and k columns and matrix B contains k rows and N columns, the matrix product of A and B is matrix C, where C contains M rows and N columns. Implement using multithreading concept.

Program:

```
import java.util.Scanner;
class Multiplication implements Runnable{
    int [][] matA ;
    int [][] matB;
    int [][] matC;
    int max_threads,i;
    Multiplication(int [][] matA,int [][] matB, int [][] matC,
int max ,int i){
        this.matA = matA;
        this.matB = matB;
        this.matC = matC;
        max_threads = max;
        this.i =i;
    }
    public void run(){
        int c = matA[0].length;
        for(int j =0;j<c;j++){
            for(int k =0;k<c;k++){
                matC[i][j] += matA[i][k]*matB[k][j];
            }
        }
    }
    public int[][] input(int [][] matrix){
        Scanner sc = new Scanner(System.in);
        int n = matrix.length;
        int m = matrix[0].length;
        for(int i=0;i<n;i++){
            for(int j =0;j<m;j++){
                matrix[i][j] = sc.nextInt();
            }
        }
        return matrix;
    }
    public void output(){
        int n = matC.length;
        int m = matC[0].length;
        for(int i=0;i<n;i++){
            for(int j =0;j<m;j++){
                System.out.print(matC[i][j] + " ");
            }
            System.out.println();
        }
    }
}
public class MatrixMultiplication {
    public static void main(String[] args) {
    // TODO Auto-generated method stub
        Scanner sc = new Scanner(System.in);
        int r1,c1,r2,c2;
        System.out.println("Enter the no of rows and column of
matrix A");
        r1 = sc.nextInt();
        c1 = sc.nextInt();
        int [][] matA = new int[r1][c1];
        System.out.println("Enter the no of rows and column of
matrix B");
        r2 = sc.nextInt();
        c2 = sc.nextInt();
        int [][] matB = new int[r2][c2];
        int [][] matC = new int[r1][c2];
        Multiplication obj = new Multiplication(matA, matB,
matC, r1, 0);
        System.out.println("Enter the elements of matrix A");
        matA = obj.input(matA);
        System.out.println("Enter the elements of matrix B");
        matB = obj.input(matB);
        Thread threads[] = new Thread[r1];
        for(int i =0;i<r1;i++){
            threads[i] = new Thread(new
Multiplication(matA,matB,matC,r1,i));
            threads[i].start();
        }
        for(int i =0;i<r1;i++){
            try {
                threads[i].join();
            } catch (InterruptedException e) {
                e.printStackTrace();
            }
        }
        System.out.println("The output matrix is:");
        obj.output();
    }
}
```

Output:



```
PS D:\java\multithreading&OS> cd "d:\java\multithreading&OS\" ; if ($?) { javac MatrixMultiplica
tion.java } ; if ($?) { java MatrixMultiplication }
Enter the no of rows and column of matrix A
4
4
Enter the no of rows and column of matrix B
4 4
Enter the elements of matrix A
3 4 2 23
4 12 9 21
32 7 6 5
9 8 6 5
Enter the elements of matrix B
4 6 3 2
7 4 12 3
7 4 23 1
3 1 5 8
The output matrix is:
123 65 218 204
226 129 468 221
234 249 343 131
149 115 286 88
PS D:\java\multithreading&OS>
```

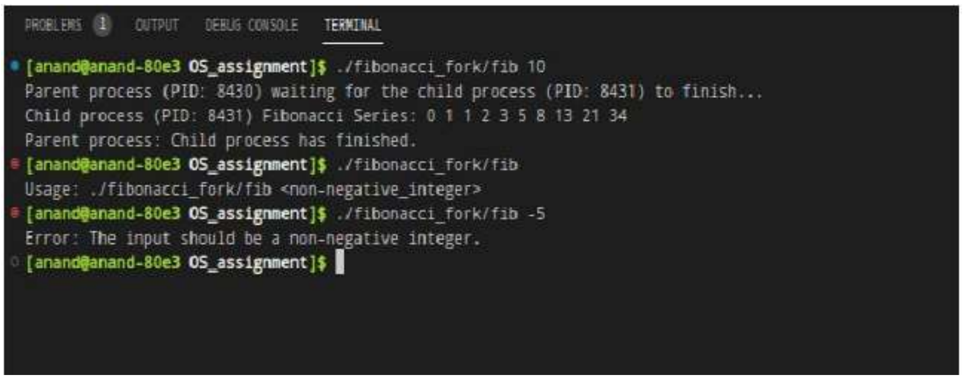
Question 5

Develop a program to generate and print the n Fibonacci Series in the child process using fork(). Perform the necessary error checking to ensure that a non negative sequence number n will be provided in the command line.

Program:

```
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
void generate_fibonacci(int n) {
    int a = 0, b = 1;
    int i;
    for (i = 0; i < n; i++) {
        printf("%d ", a);
        int next = a + b;
        a = b;
        b = next;
    }
    printf("\n");
}
int main(int argc, char* argv[]) {
    if (argc != 2) {
        printf("Usage: %s <non-negative_integer>\n", argv[0]);
        return 1;
    }
    int n = atoi(argv[1]);
    if (n < 0) {
        printf("Error: The input should be a non-negative
integer.\n");
        return 1;
    }
    pid_t pid = fork();
    if (pid < 0) {
        printf("Error: Forking failed.\n");
        return 1;
    }
    else if (pid == 0) {
        // Child process
        printf("Child process (PID: %d) Fibonacci Series: ",
getpid());
        generate_fibonacci(n);
    }
    else {
        // Parent process
        printf("Parent process (PID: %d) waiting for the child
process (PID: %d) to finish...\n", getpid(), pid);
        wait(NULL);
        printf("Parent process: Child process has
finished.\n");
    }
    return 0;
}
```

Output:



```
[anand@anand-80e3 OS_assignment]$ ./fibonacci_fork/fib 10
Parent process (PID: 8430) waiting for the child process (PID: 8431) to finish...
Child process (PID: 8431) Fibonacci Series: 0 1 1 2 3 5 8 13 21 34
Parent process: Child process has finished.
[anand@anand-80e3 OS_assignment]$ ./fibonacci_fork/fib
Usage: ./fibonacci_fork/fib <non-negative_integer>
[anand@anand-80e3 OS_assignment]$ ./fibonacci_fork/fib -5
Error: The input should be a non-negative integer.
[anand@anand-80e3 OS_assignment]$
```

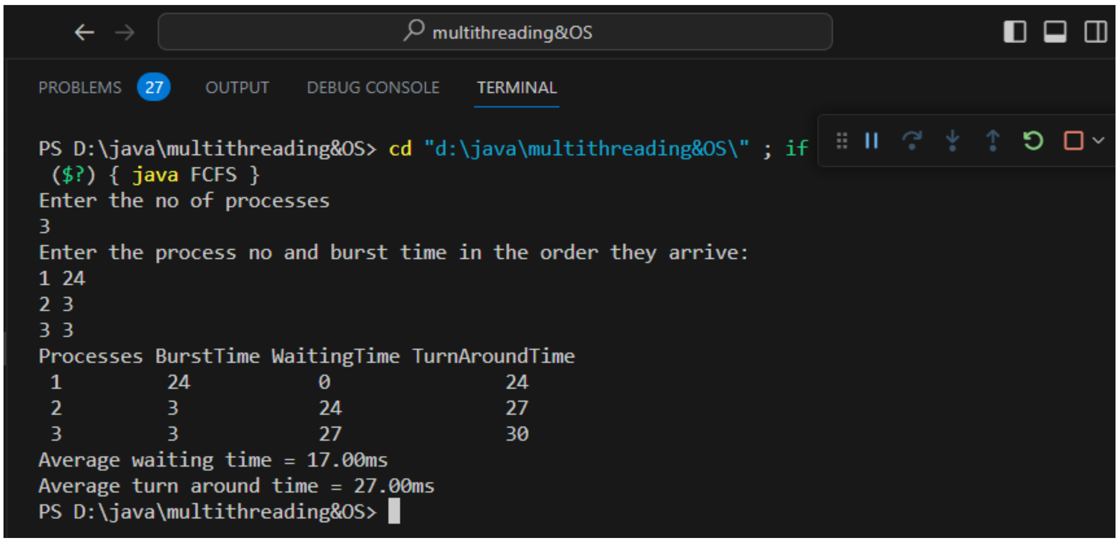
Question 6

Develop a Java /Python program to implement FCFS scheduling algorithm.

Program:

```
import java.util.Scanner;
class FCFS {
    static void findWaitingTime(int processes[], int n,
            int bt[], int wt[]) {
        // waiting time for first process is 0
        wt[0] = 0;
        // calculating waiting time
        for (int i = 1; i < n; i++) {
            wt[i] = bt[i - 1] + wt[i - 1];
        }
    }

    // Function to calculate turn around time
    static void findTurnAroundTime(int processes[], int n,
            int bt[], int wt[], int tat[]) {
        // calculating turnaround time by adding
        // bt[i] + wt[i]
        for (int i = 0; i < n; i++) {
            tat[i] = bt[i] + wt[i];
        }
    }

    //Function to calculate average time
    static void findavgTime(int processes[], int n, int bt[])
{
        int wt[] = new int[n], tat[] = new int[n];
        int total_wt = 0, total_tat = 0;

        //Function to find waiting time of all processes
        findWaitingTime(processes, n, bt, wt);

        //Function to find turn around time for all processes
        findTurnAroundTime(processes, n, bt, wt, tat);

        //Display processes along with all details
        System.out.printf("Processes BurstTime WaitingTime
TurnAroundTime\n");

        // Calculate total waiting time and total turn
        // around time
        for (int i = 0; i < n; i++) {
            total_wt = total_wt + wt[i];
            total_tat = total_tat + tat[i];
            System.out.printf(" %d ", (i + 1));
            System.out.printf("\t   %d ", bt[i]);
            System.out.printf("\t\t%d", wt[i]);
            System.out.printf("\t\t%d\n", tat[i]);
        }
        float s = (float)total_wt /(float) n;
        float t = (float)total_tat / (float)n;
        System.out.printf("Average waiting time = %.2fms", s);
        System.out.printf("\n");
        System.out.printf("Average turn around time = %.2fms
", t);
    }

    // Driver code
    public static void main(String[] args) {
        Scanner sc = new Scanner(System.in);
        System.out.println("Enter the no of processes");
        int n = sc.nextInt();
        //process id's
        int processes[] = new int[n];
        //Burst time of all processes
        int bursttime[] = new int[n];
        System.out.println("Enter the process no and burst
time in the order they arrive:");
        for(int i =0;i<n;i++){
            processes[i] = sc.nextInt();
            bursttime[i] = sc.nextInt();
        }
        findavgTime(processes, n, bursttime);
    }
}
```

Output:



```
PS D:\java\multithreading&OS> cd "d:\java\multithreading&OS\" ; if
 ($?) { java FCFS }
Enter the no of processes
3
Enter the process no and burst time in the order they arrive:
1 24
2 3
3 3
Processes BurstTime WaitingTime TurnAroundTime
 1         24          0              24
 2         3           24             27
 3         3           27             30
Average waiting time = 17.00ms
Average turn around time = 27.00ms
PS D:\java\multithreading&OS>
```

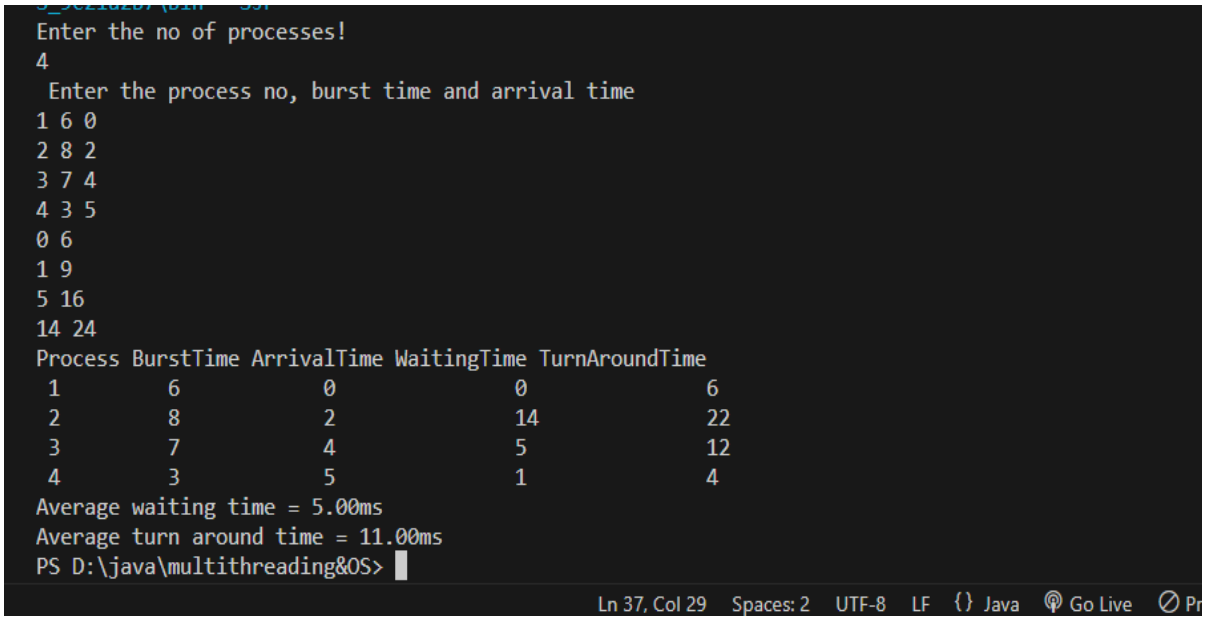
Question 7

Develop a Java /Python program to implement non- preemptive SJF scheduling Algorithm

Program:

```
import java.util.*;
class Process{
  int id,bt, art;
  public Process(int id, int bt, int art){
    this.id= id;
    this.bt= bt;
    this.art = art;
  }
}
 class SJF
 {
   public static void main(String args[])
   {
    Scanner sc = new Scanner(System.in);
    System.out.println("Enter the no of processes! ");
    int n = sc. nextInt() ;
    Process process[] = new Process[n];
    int wt[] = new int[n];
    int tat[] = new int[n];
    System.out.println(" Enter the process no, burst time and
arrival time");
    for(int i=0;i<n;i++){
      int id= sc.nextInt();
      int bt = sc.nextInt();
      int art = sc.nextInt();
      process[i]= new Process(id, bt, art);
    }
    findWaitingTime(process,n,wt);
    findtat(process,n,wt,tat);
    int totalWaitingTime =0, totalTAT= 0;
    System.out.printf("Process BurstTime ArrivalTime
WaitingTime TurnAroundTime\n");
    for (int i = 0; i < n; i++) {
      totalWaitingTime += wt[i];
            totalTAT += tat[i];
      System.out.printf(" %d\t", (i + 1));
      System.out.printf("   %d ", process[i].bt);
      System.out.printf("\t\t%d ", process[i].art);
      System.out.printf("\t\t%d", wt[i]);
      System.out.printf("\t\t%d\n", tat[i]);
    }
    float s = (float)totalWaitingTime /(float) n;
    float t = (float)totalTAT / (float)n;
    System.out.printf("Average waiting time = %.2fms", s);
    System.out.printf("\n");
    System.out.printf("Average turn around time = %.2fms ",t);
   }
   public static void findWaitingTime(Process[] process, int
n, int[] wt){
     int [] rt = new int[n];
     boolean check = false;
     int min=
Integer.MAX_VALUE,shortest=0,t=0,finishTime,complete=0;
     for(int i=0;i<n;i++){
       rt[i]= process[i].bt;
     }
    while(complete != n){
     for(int i=0;i<n;i++){
       if(rt[i] <= min && rt[i]>0 && process[i].art <=t){
         check=true;
         min = rt[i];
         shortest = i;
       }
     }
       if(check == false){
         t++;
         continue;
       }
       finishTime = t+ rt[shortest];
       complete++;
       wt[shortest]= finishTime - process[shortest].bt -
process[shortest].art;
       System.out.println(wt[shortest] + " " + finishTime);
       rt[shortest]=0;
       check = false;
       min = Integer.MAX_VALUE;
       t = finishTime;
     }
   }
   public static void findtat(Process[] process, int n, int[]
wt,int[] tat){
     for(int i=0;i<n;i++){
       tat[i] = wt[i]+ process[i].bt;
     }
   }
 }
```

Output:



```
Enter the no of processes!
4
 Enter the process no, burst time and arrival time
1 6 0
2 8 2
3 7 4
4 3 5
0 6
1 9
5 16
14 24
Process BurstTime ArrivalTime WaitingTime TurnAroundTime
 1         6          0             0               6
 2         8          2             14              22
 3         7          4             5               12
 4         3          5             1               4
Average waiting time = 5.00ms
Average turn around time = 11.00ms
PS D:\java\multithreading&OS>
```

Question 8

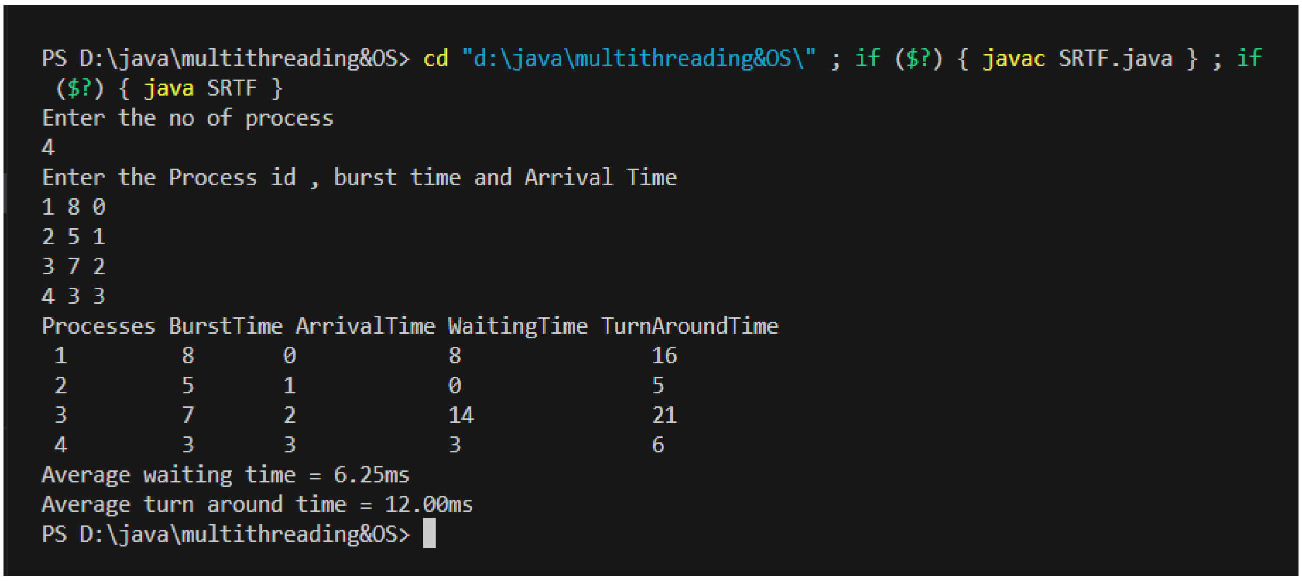
Develop a Java /Python program to implement SRTF scheduling algorithm.

Program:

```
import java.util.Scanner;
class Process{
    int pid,bt,art;
    Process(int pid,int bt,int art){
        this.pid = pid;
        this.bt = bt;
        this.art = art;
    }
}
public class SRTF {
    public static void main(String[] args){
        Scanner sc = new Scanner(System.in);
        System.out.println("Enter the no of process");
        int n = sc.nextInt();
        Process[] process = new Process[n];
        int wt[] = new int[n];
        int tat[] = new int[n];
        int totalWaitingTime =0, totalTAT= 0;
        System.out.println("Enter the Process id , burst time
and Arrival Time");
        for(int i=0;i<n;i++){
            int pid = sc.nextInt();
            int bt = sc.nextInt();
            int art = sc.nextInt();
            process[i] = new Process(pid,bt,art);
        }
        findWaitingTime(process,wt,n);
        findTurnAroundTime(process, wt,tat, n);
        System.out.printf("Processes BurstTime ArrivalTime
WaitingTime TurnAroundTime\n");


        // Calculate total waiting time and total turn
        // around time
        for (int i = 0; i < n; i++) {
            totalWaitingTime += wt[i];
            totalTAT += tat[i];
            System.out.printf(" %d ", (i + 1));
            System.out.printf("\t   %d ", process[i].bt);
            System.out.printf("\t   %d ", process[i].art);
            System.out.printf("\t\t%d", wt[i]);
            System.out.printf("\t\t%d\n", tat[i]);
        }
        float s = (float)totalWaitingTime /(float) n;
        float t = (float)totalTAT / (float)n;
        System.out.printf("Average waiting time = %.2fms", s);
        System.out.printf("\n");
        System.out.printf("Average turn around time = %.2fms
", t);
}


    public static void findTurnAroundTime(Process[] process,
int[] wt,int[] tat,int n){
        for(int i=0;i<n;i++)
            tat[i] = process[i].bt +wt[i];
    }
    private static void findWaitingTime(Process[] process,
int[] wt,int n) {
        boolean check = false;
        int finish_time , shortest =0 ,minm =
Integer.MAX_VALUE,t=0,complete =0;
        //To store the remaining time
        int [] rt = new int[n];
        for(int i =0;i<n;i++)
            rt[i] = process[i].bt ;
        while(complete != n){
            //To find the shortest process out of all the
processes that have arrived
            for(int i=0;i<n;i++){
                if(process[i].art<=t && rt[i]<minm && rt[i]
>0){
                    minm = rt[i];
                    shortest = i;
                    check = true;
                }
            }
            //If no process has arrived at the given time
            if(check == false){
                t++;
                continue;
            }
            //Update remaining time and minmalprocess
            rt[shortest]--;
            minm = rt[shortest];
            if(minm == 0){
                minm = Integer.MAX_VALUE;
            }
            //remaining time of given process is zero,so
process complete
            if(rt[shortest]==0){
                complete++;
                check = false;
                finish_time = t+1;
```

```
                    wt[shortest] = finish_time - 
process[shortest].bt - process[shortest].art;
                    if(wt[shortest]<0)
                        wt[shortest] =0;
                }
                t++;
            }
        }
    }
```

Output:



```
PS D:\java\multithreading&OS> cd "d:\java\multithreading&OS\" ; if ($?) { javac SRTF.java } ; if
 ($?) { java SRTF }
Enter the no of process
4
Enter the Process id , burst time and Arrival Time
1 8 0
2 5 1
3 7 2
4 3 3
Processes BurstTime ArrivalTime WaitingTime TurnAroundTime
 1         8       0            8               16
 2         5       1            0               5
 3         7       2            14              21
 4         3       3            3               6
Average waiting time = 6.25ms
Average turn around time = 12.00ms
PS D:\java\multithreading&OS>
```

Question 9

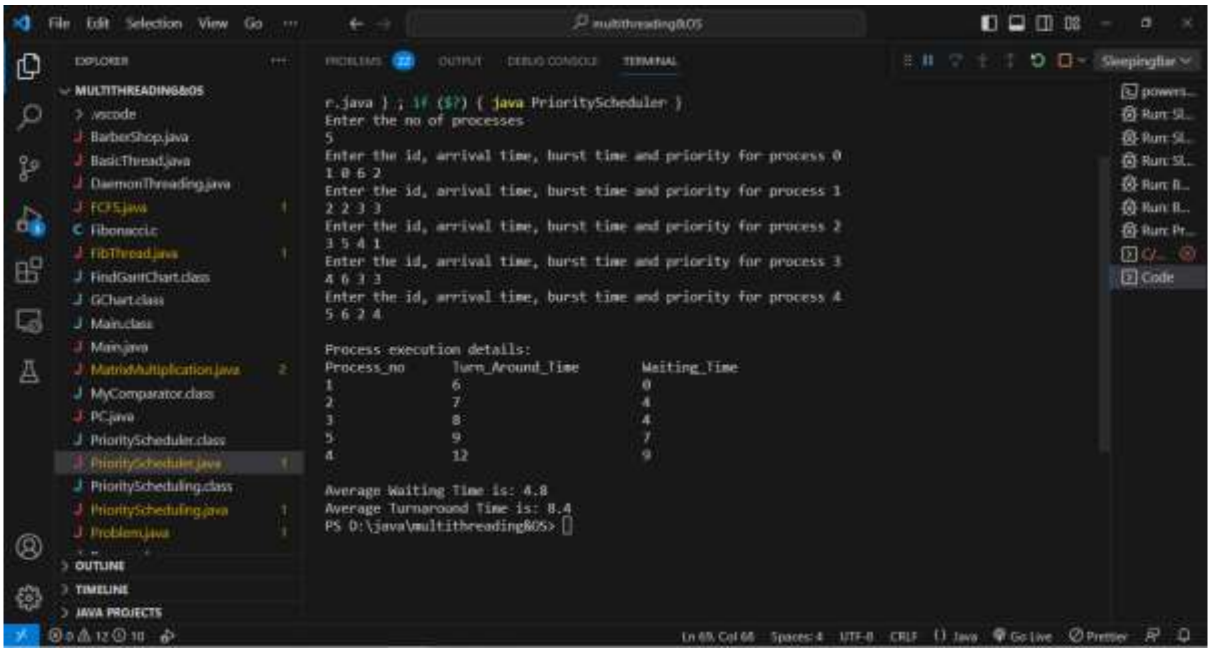
Develop a Java /Python program to implement priority scheduling algorithm for a given set of process, burst time and their priority.

Program:

```
import java.util.*;
class Process {
    int at, bt, pri, pno;
    Process(int pno, int at, int bt, int pri) {
        this.pno = pno;
        this.pri = pri;
        this.at = at;
        this.bt = bt;
    }
}
class GChart {
    int pno, stime, ctime, wtime, ttime;
}
class MyComparator implements Comparator<Process> {
    public int compare(Process p1, Process p2) {
        if (p1.at < p2.at)
            return -1;
        else if (p1.at == p2.at && p1.pri > p2.pri)
            return -1;
        else
            return 1;
    }
}
class FindGantChart {
    void findGc(LinkedList<Process> queue) {
        int time = 0;
        TreeSet<Process> prique = new TreeSet<>(new
MyComparator());
        LinkedList<GChart> result = new LinkedList<>();

        while (!queue.isEmpty())
            prique.add(queue.removeFirst());

        Iterator<Process> it = prique.iterator();
        time = prique.first().at;

        while (it.hasNext()) {
            Process obj = it.next();

            GChart gc1 = new GChart();
            gc1.pno = obj.pno;
            gc1.stime = time;
            time += obj.bt;
            gc1.ctime = time;
            gc1.ttime = gc1.ctime - obj.at;
            gc1.wtime = gc1.ttime - obj.bt;

            result.add(gc1);
        }

        new ResultOutput(result);
    }
}

class ResultOutput {
    ResultOutput(LinkedList<GChart> result) {
        int totalWaitingTime = 0;
        int totalTurnaroundTime = 0;

        System.out.println("\nProcess execution details:");
        System.out.println("Process_no\tTurn_Around_Time\tWait
ing_Time");
        for (GChart gc : result) {
            totalWaitingTime += gc.wtime;
            totalTurnaroundTime += gc.ttime;
            System.out.println(gc.pno + "\t\t" + gc.ttime +
"\t\t\t" + gc.wtime);
        }
        double averageWaitingTime = (double) totalWaitingTime
/ result.size();
        double averageTurnaroundTime = (double)
totalTurnaroundTime / result.size();

        System.out.println("\nAverage Waiting Time is: " +
averageWaitingTime);
        System.out.println("Average Turnaround Time is: " +
averageTurnaroundTime);
    }
}
```

```java
public class PriorityScheduler {
    public static void main(String[] args) {
        Scanner sc = new Scanner(System.in);
        LinkedList<Process> processes = new LinkedList<>();

        System.out.println("Enter the no of processes");
        int n = sc.nextInt();

        for(int i = 0; i < n; i++) {
            System.out.println("Enter the id, arrival time,
burst time and priority for process " + i);
            int pid = sc.nextInt();
            int at = sc.nextInt();
            int bt = sc.nextInt();
            int pri = sc.nextInt();
            processes.add(new Process(pid, at, bt, pri));
        }
        FindGantChart obj = new FindGantChart();
        obj.findGc(processes);
    }
```

Output:



```
r.java } ; if ($?) { java PriorityScheduler }
Enter the no of processes
5
Enter the id, arrival time, burst time and priority for process 0
1 0 6 2
Enter the id, arrival time, burst time and priority for process 1
2 2 3 3
Enter the id, arrival time, burst time and priority for process 2
3 5 4 1
Enter the id, arrival time, burst time and priority for process 3
4 6 3 3
Enter the id, arrival time, burst time and priority for process 4
5 6 2 4

Process execution details:
Process_no      Turn_Around_Time        Waiting_Time
1               6                       0
2               7                       4
3               8                       4
5               9                       7
4               12                      9

Average Waiting Time is: 4.8
Average Turnaround Time is: 8.4
PS D:\java\multithreading&OS> 
```

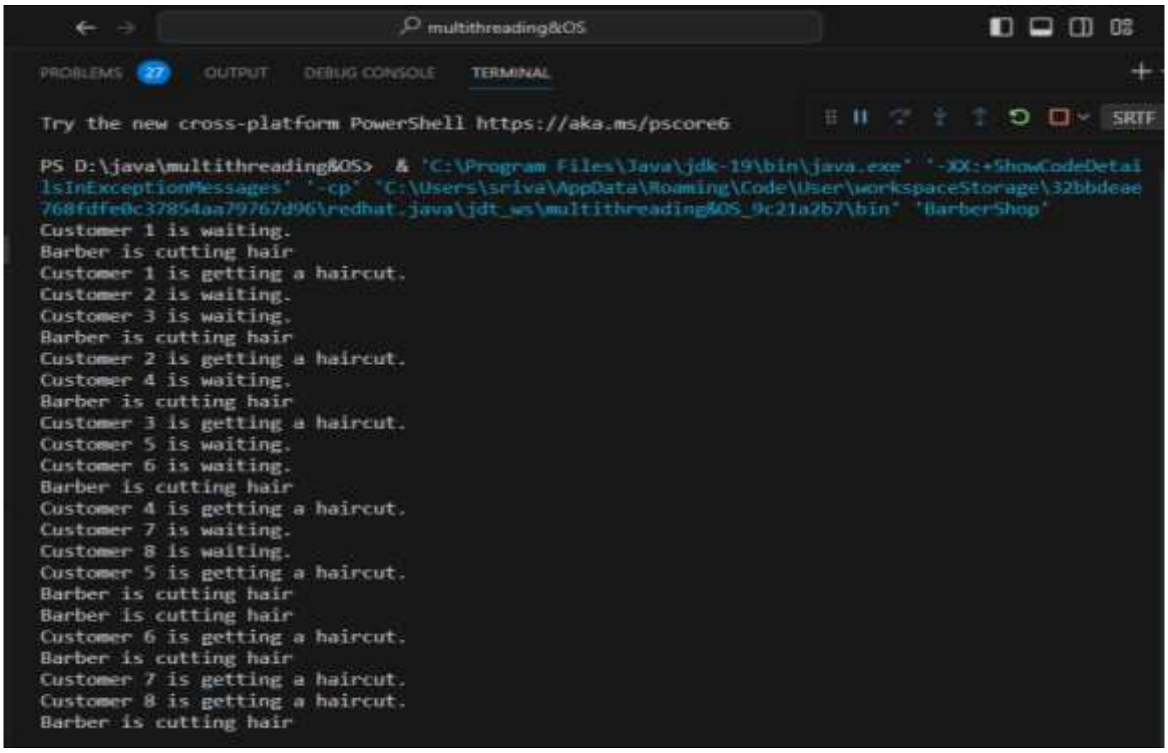
Question 12

Consider a Sleeping-Barber Problem. A barbershop consists of a waiting room with n chairs and the barber room containing the barber chair. If there are no customers to be served, the barber goes to sleep. If a customer enters the barbershop and all chairs are occupied, then the customer leaves the shop. If the barber is busy but chairs are available, then the customer sits in one of the free chairs. If the barber is asleep, the customer wakes up the barber. Write a program to coordinate the barber and the customers.

Program:

```
import java.util.concurrent.*;

class BarberShop {
    static final int CHAIRS = 4;
    static Semaphore barber = new Semaphore(0);
    static Semaphore customer = new Semaphore(0);
    static Semaphore mutex = new Semaphore(1);
    static int waitingCustomers = 0;

    static class Barber implements Runnable {
        public void run() {
            while (true) {
                try {
                    customer.acquire(); // Wait for a customer
                    mutex.acquire();
                    waitingCustomers--;
                    barber.release(); // Wake up the barber
                    mutex.release();
                    cutHair(); // Barber cuts hair
                } catch (InterruptedException ex) {
                    ex.printStackTrace();
                }
            }
        }

        public void cutHair() {
            System.out.println("Barber is cutting hair");
            try {
                Thread.sleep(2000);
            } catch (InterruptedException ex) {
                ex.printStackTrace();
            }
        }
    }

    static class Customer implements Runnable {
        private int id;

        public Customer(int id) {
            this.id = id;
        }

        public void run() {
            try {
                mutex.acquire();
                if (waitingCustomers < CHAIRS) {
                    waitingCustomers++;
                    System.out.println("Customer " + id + " is
waiting.");
                    customer.release(); // Wake up the barber
if sleeping
                    mutex.release();
                    barber.acquire(); // Wait for the barber
to finish
                    getHaircut(); // Get haircut
                } else {
                    mutex.release(); // No available chairs,
leave
                    System.out.println("Customer " + id + "
left due to no available chairs.");
                }
            } catch (InterruptedException ex) {
                ex.printStackTrace();
            }
        }
        public void getHaircut() {
            System.out.println("Customer " + id + " is getting
a haircut.");
            try {
                Thread.sleep(3000);
            } catch (InterruptedException ex) {
                ex.printStackTrace();
            }
        }
    }

    public static void main(String[] args) {
        Thread barberThread = new Thread(new Barber());
        barberThread.start();

        for (int i = 1; i <= 8; i++) {
            Thread customerThread = new Thread(new
Customer(i));
            customerThread.start();

            try {
                Thread.sleep(1000); // Time between customer
arrivals
            } catch (InterruptedException ex) {
                ex.printStackTrace();
            }
        }
    }
}
```

Output:



```
Try the new cross-platform PowerShell https://aka.ms/pscore6

PS D:\java\multithreading&OS>  & 'C:\Program Files\Java\jdk-19\bin\java.exe' '-XX:+ShowCodeDetai
lsInExceptionMessages' '-cp' 'C:\Users\sriva\AppData\Roaming\Code\User\workspaceStorage\32bbdeae
768fdfe0c37854aa79767d96\redhat.java\jdt_ws\multithreading&OS_9c21a2b7\bin' 'BarberShop'
Customer 1 is waiting.
Barber is cutting hair
Customer 1 is getting a haircut.
Customer 2 is waiting.
Customer 3 is waiting.
Barber is cutting hair
Customer 2 is getting a haircut.
Customer 4 is waiting.
Barber is cutting hair
Customer 3 is getting a haircut.
Customer 5 is waiting.
Customer 6 is waiting.
Barber is cutting hair
Customer 4 is getting a haircut.
Customer 7 is waiting.
Customer 8 is waiting.
Customer 5 is getting a haircut.
Barber is cutting hair
Barber is cutting hair
Customer 6 is getting a haircut.
Barber is cutting hair
Customer 7 is getting a haircut.
Customer 8 is getting a haircut.
Barber is cutting hair
```

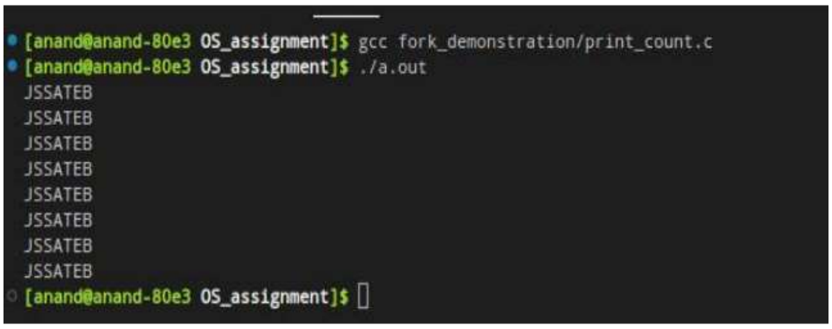
Question 13

Calculate the number of times JSSATEB is printed.

```
#include<stdio.h>
#include<sys/types.h>
#include<unistd.h>
int main(){
        fork();
        fork();
        fork();
        printf("JSSATEB\n");
        return 0;
}
```

Output:

The Fork system call is used for creating a new process in Linux, and Unix systems, which is called the child process, which runs concurrently with the process that makes the fork() call (parent process). After a new child process is created, both processes will execute the next instruction following the fork() system call. The number of times 'JSSATEB' is printed is equal to the number of processes created. Total Number of Processes = 2^n, where n is the number of fork system calls. So here n = 3, 2^3 = 8.


```
[anand@anand-80e3 OS_assignment]$ gcc fork_demonstration/print_count.c
[anand@anand-80e3 OS_assignment]$ ./a.out
JSSATEB
JSSATEB
JSSATEB
JSSATEB
JSSATEB
JSSATEB
JSSATEB
JSSATEB
[anand@anand-80e3 OS_assignment]$ 
```

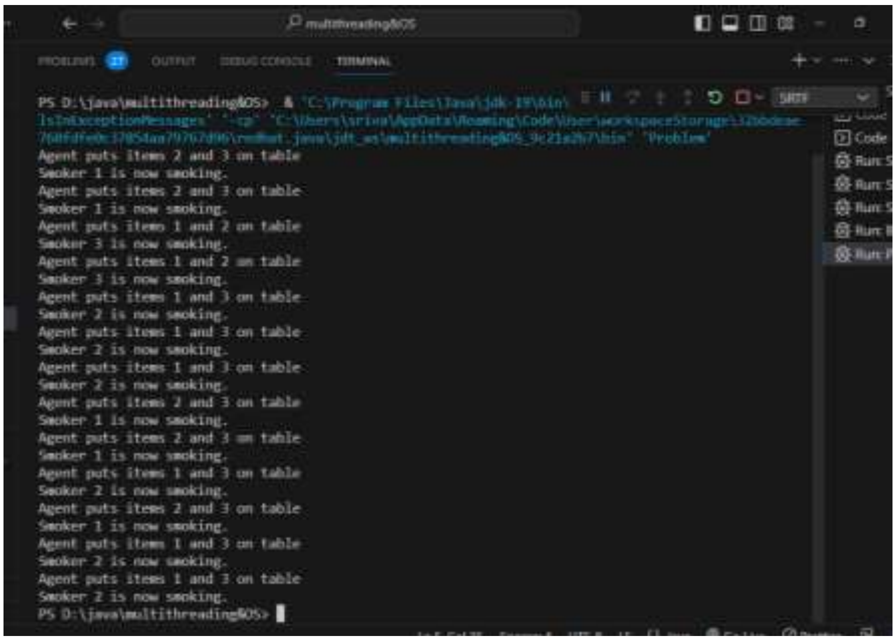
Question 14

Consider a set of 4 processes where three are smoker processes and an agent process. Each of the smoker processes will make a cigarette and smoke it. To make a cigarette requires tobacco, paper, and matches. Each smoker process has one of the three items. I.e., one process has tobacco, another has paper, and a third has matches. The agent has an infinite supply of all three. The agent places two of the three items on the table, and the smoker that has the third item makes the cigarette. Synchronize the processes and write the solution to it.

Program:

```
import java.util.concurrent.Semaphore;
public class Problem {
    public Problem() {
        currentState = TABLE_EMPTY;
        //So that agent places the items first
        mutex = new Semaphore(1);

        Thread[] thread = new Thread[4];

        thread[0] = new Agent(this, 0);

        // Second parameter to Smoker constructor is the item
the smoker _has_.

        thread[1] = new Smoker(this, PAPER, 1);
        thread[2] = new Smoker(this, TOBACCO, 2);
        thread[3] = new Smoker(this, MATCHES, 3);
        for (int i = 0; i < 4; i++)
            thread[i].start();
    }

    // Ignore the unused id parameters to these methods.  They
were needed
    // in the busy-wait-free version from which this was
ported.

    public void dispenseItems(int id) {
        int itemNotOnTable;

        while (true) {
            try {
                mutex.acquire();
                if (currentState == TABLE_EMPTY) {
                    itemNotOnTable = 1 + (int)(Math.random() *
3.0);
                    if (itemNotOnTable == 1) {
                        itemOnTable1 = 2;
                        itemOnTable2 = 3;
                    }
                    else if (itemNotOnTable == 2) {
                        itemOnTable1 = 1;
                        itemOnTable2 = 3;
                    }
                    else {
                        itemOnTable1 = 1;
                        itemOnTable2 = 2;
                    }

                    System.out.println("Agent puts items " +
itemOnTable1
                               + " and " + itemOnTable2 + " on
table");

                    currentState = ITEM_AVAILABLE;
                }
            } catch (InterruptedException e) {
                Thread.currentThread().interrupt();
            } finally {
                mutex.release();
                Thread.yield(); // these are necessary!
            }
        }
    }

    public void waitForItem(int item, int id) {
        boolean gotItem = false;

        while (!gotItem) {
            try {
                mutex.acquire();
                if (currentState == ITEM_AVAILABLE &&
(itemOnTable1 != item
                                                      &&
itemOnTable2 != item)) {
                    currentState = ITEM_IN_USE;
                    gotItem = true;
                }
            } catch (InterruptedException e) {
                Thread.currentThread().interrupt();
            } finally {
                mutex.release();
                Thread.yield();
            }
        }
    }

    public void finishSmoking(int id) {
        try {
            mutex.acquire();
            currentState = TABLE_EMPTY;
        } catch (InterruptedException e) {
            Thread.currentThread().interrupt();
        } finally {
            mutex.release();
        }
    }

    public static void main(String[] args) {
        Problem p = new Problem();
    }

    protected Semaphore mutex;

    protected int currentState;
    public final int ITEM_AVAILABLE = 1;
    public final int ITEM_IN_USE = 2;
    public final int TABLE_EMPTY = 3;

    protected int itemOnTable1;
    protected int itemOnTable2;
    public final int PAPER = 1;
    public final int TOBACCO = 2;
    public final int MATCHES = 3;
}
class Agent extends Thread {
    private Problem problem;
    private int id;

    public Agent(Problem problem, int id) {
        this.problem = problem;
        this.id = id;
    }

    @Override
    public void run() {
        while (true) {
            try {
                Thread.sleep(1000); // Simulate some time
before the agent dispenses items
                problem.dispenseItems(id);
            } catch (InterruptedException e) {
                Thread.currentThread().interrupt();
            }
        }
    }
}

class Smoker extends Thread {
    private Problem problem;
    private int item;
    private int id;

    public Smoker(Problem problem, int item, int id) {
        this.problem = problem;
        this.item = item;
        this.id = id;
    }

    @Override
    public void run() {
        while (true) {
            try {
                problem.waitForItem(item, id);
                System.out.println("Smoker " + id + " is now
smoking.");
                Thread.sleep(2000); // Simulate smoking
                problem.finishSmoking(id);
            } catch (InterruptedException e) {
                Thread.currentThread().interrupt();
            }
        }
        }
    }
```

Output:



```
PS D:\java\multithreading&OS> & 'C:\Program Files\Java\jdk-19\bin\
IsInExceptionMessages' '-cp' 'C:\Users\sriva\AppData\Roaming\Code\User\workspaceStorage\[illegible]
[illegible]\redhat.java\jdt_ws\multithreading&OS_9c21a2b7\bin' 'Problem'
Agent puts items 2 and 3 on table
Smoker 1 is now smoking.
Agent puts items 2 and 3 on table
Smoker 1 is now smoking.
Agent puts items 1 and 2 on table
Smoker 3 is now smoking.
Agent puts items 1 and 2 on table
Smoker 3 is now smoking.
Agent puts items 1 and 3 on table
Smoker 2 is now smoking.
Agent puts items 1 and 3 on table
Smoker 2 is now smoking.
Agent puts items 1 and 3 on table
Smoker 2 is now smoking.
Agent puts items 2 and 3 on table
Smoker 1 is now smoking.
Agent puts items 2 and 3 on table
Smoker 1 is now smoking.
Agent puts items 1 and 3 on table
Smoker 2 is now smoking.
Agent puts items 2 and 3 on table
Smoker 1 is now smoking.
Agent puts items 1 and 3 on table
Smoker 2 is now smoking.
Agent puts items 1 and 3 on table
Smoker 2 is now smoking.
PS D:\java\multithreading&OS>
```

Question 15

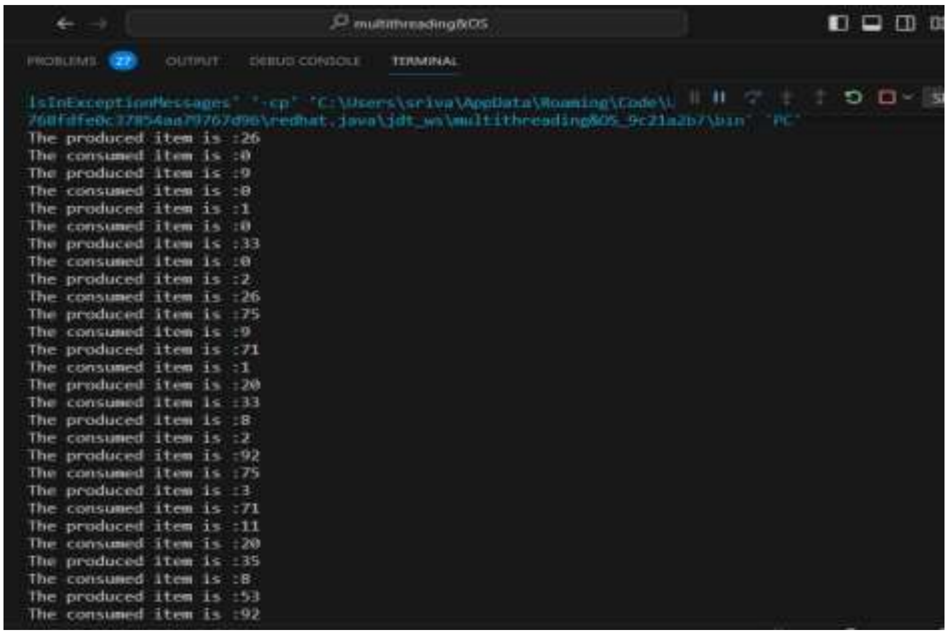
Develop a program to simulate producer consumer problem using semaphores

Program:

```
import java.util.concurrent.Semaphore;
import java.util.Random;
class SharedBuffer {
    private int buffersize;
    private int[] buffer;
    private int front,rear;

    public SharedBuffer(int size){
        buffersize = size;
        buffer = new int[size];
        front = rear = 0;
    }
    public void produce(int item){
        //Locks into the critical section and adds item into
the buffer
```

```
        //instance of the curent class is used as the lock
        synchronized(this){
            buffer[front] = item;
            rear = (rear+1)%buffersize;
        }
        System.out.println("The produced item is :" + item);
    }
    public int consume(){
        int item ;
        synchronized(this){
            item = buffer[rear];
            front = (front+1)%buffersize;
        }
        System.out.println("The consumed item is :"+ item);
        return item;
    }
}
class Producer implements Runnable{
    private SharedBuffer buffer;
    private Semaphore producerSemaphore;
    private Semaphore consumerSemaphore;

    public Producer(SharedBuffer buffer , Semaphore
producerSemaphore , Semaphore consumerSemaphore){
        this.buffer = buffer;
        this.producerSemaphore = producerSemaphore;
        this.consumerSemaphore = consumerSemaphore;
    }
    @Override
    public void run(){
        try{
            while(true){
                int item = produceItem();
                //blocks a permit(item) available
                producerSemaphore.acquire();
                buffer.produce(item);
                //increases the consumer permits
                consumerSemaphore.release();
                Thread.sleep(1000);
            }
        }
        catch(InterruptedException e){
            Thread.currentThread().interrupt();
        }
    }
    private int produceItem() {
        Random rand = new Random();
        return rand.nextInt(100); // Generate a random item
    }
}
class Consumer implements Runnable {
    private SharedBuffer buffer;
    private Semaphore producerSemaphore;
    private Semaphore consumerSemaphore;

    public Consumer(SharedBuffer buffer, Semaphore
producerSemaphore, Semaphore consumerSemaphore) {
        this.buffer = buffer;
        this.producerSemaphore = producerSemaphore;
        this.consumerSemaphore = consumerSemaphore;
    }

    @Override
    public void run() {
        try {
            while (true) {
                consumerSemaphore.acquire();
                buffer.consume();
                producerSemaphore.release();
            }
        } catch (InterruptedException e) {
            Thread.currentThread().interrupt();
        }
    }
}
public class PC {
    public static void main(String[] args){
        int buffersize = 5;
        SharedBuffer buffer = new SharedBuffer(buffersize);

        //to ensure that producer produces first
        Semaphore producerSemaphore = new
Semaphore(buffersize);
        Semaphore consumerSemaphore = new Semaphore(0);

        Thread producerThread  = new Thread(new
Producer(buffer,producerSemaphore,consumerSemaphore));
        Thread consumerThread  = new Thread(new
Consumer(buffer,producerSemaphore,consumerSemaphore));

        producerThread.start();
        consumerThread.start();
    }
}
```

Output :



```
lsInExceptionMessages' '-cp' 'C:\Users\sriva\AppData\Roaming\Code\U
768fdfe0c37854aa79767d96\redhat.java\jdt_ws\multithreading&OS_9c21a2b7\bin' 'PC'
The produced item is :26
The consumed item is :0
The produced item is :9
The consumed item is :0
The produced item is :1
The consumed item is :0
The produced item is :33
The consumed item is :0
The produced item is :2
The consumed item is :26
The produced item is :75
The consumed item is :9
The produced item is :71
The consumed item is :1
The produced item is :20
The consumed item is :33
The produced item is :8
The consumed item is :2
The produced item is :92
The consumed item is :75
The produced item is :3
The consumed item is :71
The produced item is :11
The consumed item is :20
The produced item is :35
The consumed item is :8
The produced item is :53
The consumed item is :92
```