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**GitHub Link:** <https://github.com/garvit-joshi/OS_Scheduling>

**Code:**

#include<bits/stdc++.h>

#include<iostream>

#include<windows.h>                                    //Sleep() function

using namespace std;

long max\_arrival=-1,min\_arrival=INT\_MAX,warning=1;     //Global Variable

/\*

max\_arrival will store the maximim arrival time of a process

min\_arrival will store the minimul arrival time of a process

warning will store the no. of warning that came in during

program execution(due to user input and constraints)

\*/

struct Process

{

    long pid=0;                                       //Process ID

    long priority=0;                                  //the Priority 0 is highest priority

    long arrival\_time=0;                              //Time At Which Process Came

    long burst\_time=0;                                //The Total Time for which process should run

    long completion\_time=0;                           //Time at which CPU completed the whole process

    long turnaround\_time=0;                           //Turn\_Around\_Time=Completetion\_Time-Arrival\_Time

    long waiting\_time=0;                              //Waiting\_Time=Turn\_Around\_Time-Burst\_Time

    long response\_time=0;                             //RT=CPU got Process first time-Arrival Time

    long remaining\_time=0;                            //Time For Which Process Is Remaining to be Executed

    long CPUtime=-1;                                  //Stores When Process got CPU for first time

};

vector<long> ready\_queue;                             //for round robin(stores all the process Index no. for which remaining time is left)

bool comparison\_Priority(Process a, Process b)        //Driver Function-Sorting According to Priority

{

    return (a.priority < b.priority);

}

bool comparison\_ArrivalTime(Process a,Process b)      //Driver Function-Sorting According to Arrival Time(Acending Order)

{

    return (a.arrival\_time < b.arrival\_time);

}

bool comparison\_PID(Process a,Process b)              //Driver Function-Sorting According to PID(Acending Order)

{

    return (a.pid < b.pid);

}

bool comparison\_RemainingTime(Process a,Process b)    //Driver Function-Sorting According to Remaining Time(Acending Order)

{

    return (a.remaining\_time < b.remaining\_time);

}

/\*

The Above Four Functions Are Used As A Parameter In sort() functions.

They act as helping functions to sort the process according to our need

\*/

long display(bool prompt=false)

{

    /\*

    Display Function Used for displaying the question at the starting of program

    \*/

    time\_t now = time(0);

    char\* dt = ctime(&now);

    cout<< dt;

    cout<<"\n\n\n";

    cout<<"\t\t ||                                                                                         ||\n";

    cout<<"\t\t=================================================================================================\n";

    cout<<"\t\t ||                          Operating System Scheduling                                    ||\n";

    cout<<"\t\t ||                                                    --Garvit Joshi                       ||\n";

    cout<<"\t\t ||                                                                                         ||\n";

    cout<<"\t\t ||/\*Design a scheduling program to implements a Queue with two levels. Level 1 : Fixed     ||\n";

    cout<<"\t\t ||  priority preemptive Scheduling. Level 2 : Round Robin Scheduling For a Fixed priority  ||\n";

    cout<<"\t\t ||  the Priority 0 is highest priority. If one process P1 is scheduled and running, another||\n";

    cout<<"\t\t ||  process P2 with higher priority comes. The New process (high priority) process P2      ||\n";

    cout<<"\t\t ||  preempts currently running process P1 and process P1 will go to second level queue.    ||\n";

    cout<<"\t\t ||  Time for which process will strictly execute must be considered in the multiples of 2. ||\n";

    cout<<"\t\t ||  All the processes in second level queue will complete their execution according to     ||\n";

    cout<<"\t\t ||  round robin scheduling.                                                            \*/  ||\n";

    cout<<"\t\t ||                                                                                         ||\n";

    cout<<"\t\t=================================================================================================\n";

    cout<<"\t\t ||  /\*CONSIDER\*/                                                                           ||\n";

    cout<<"\t\t ||  1.Queue 2 will be processed after Queue 1 becomes empty.                               ||\n";

    cout<<"\t\t ||  2.Priority of Queue 2 has lower priority than in Queue 1.                              ||\n";

    cout<<"\t\t ||                                                                                         ||\n";

    cout<<"\t\t=================================================================================================\n";

    cout<<"\t\t ||                                                                                         ||\n";

    if(prompt==false)

    {

        cout<<"Please Wait While Program Loads . . . ";

        Sleep(5000);

        system("CLS");

        display(true);                       //Recursion

        return 0;

    }

    cout<<"\n";

    cout<<"Program Successfully Loaded\n";

    system("pause");

    system("CLS");

    return 0;

}

long Enter\_Process(long &temp,Process p[],long i)

{

    /\*

    Function To Enter All Processes. This Function will be called as much as

    time the number of Proccess.

    \*/

    cout<<"Process:"<<i+1;

    temp++;                                      //Variable Gives Unique PID(Process ID) To each Process

    p[i].pid=temp;

    cout<<"\nEnter Priority:";

    cin>>p[i].priority;

    while(p[i].priority<0)

    {

        cout<<"\t\t\t\tWarning "<<warning<<": A Process Cannot Have Priority In Negative.\n";

        cout<<"Please Enter Priority Again:";

        cin>>p[i].priority;

        warning++;

    }

    cout<<"Enter Arrival Time:";

    cin>>p[i].arrival\_time;

    while(p[i].arrival\_time<0)

    {

        cout<<"\t\t\t\tWarning "<<warning<<": A Process Cannot Have Arrival Time In Negative.\n";

        cout<<"Please Enter Arrival Time Again:";

        cin>>p[i].arrival\_time;

        warning++;

    }

    if(p[i].arrival\_time<min\_arrival)

    {

        /\*

        Calculating Minimum Arrival time

        \*/

        min\_arrival=p[i].arrival\_time;

    }

    if(p[i].arrival\_time>max\_arrival)

    {

        /\*

        Calculating Maximum Arrival Time

        \*/

        max\_arrival=p[i].arrival\_time;

    }

    cout<<"Enter Burst Time:";

    cin>>p[i].burst\_time;

    while(p[i].burst\_time<0)

    {

        cout<<"\t\t\t\tWarning "<<warning<<": A Process Cannot Have Burst Time In Negative.\n";

        cout<<"Please Enter Burst Time Again:";

        cin>>p[i].burst\_time;

        warning++;

    }

    p[i].remaining\_time=p[i].burst\_time;

    cout<<"====================================================\n";

    return 0;

}

long Show\_Process(Process p[],long n,bool b=false)

{

    if(b==false)

    {

        /\*

        By Default This Conditional Statement Will Work,

        It Will Only Show PID,Priority,Arrival Time,Burst Time

        \*/

        cout<<"\nPID || Priority || Arrival Time || Burst Time\n";

        for(long i=0;i<n;i++)

        {

            cout<<p[i].pid<<"\t"<<p[i].priority<<"\t\t"<<p[i].arrival\_time<<"\t\t"<<p[i].burst\_time<<"\n";

        }

    }

    else if(b==true)

    {

        /\*

        This Works when the function call is called with a third

        parameter which must be true

        \*/

        cout<<"\nPID || Priority || Arrival Time || Burst Time || Completion Time || TurnAround Time || Waiting Time || Response Time\n";

        for(long i=0;i<n;i++)

        {

            cout<<p[i].pid<<"\t"<<p[i].priority<<"\t\t"<<p[i].arrival\_time<<"\t\t"<<p[i].burst\_time<<"\t\t"<<p[i].completion\_time<<"\t\t"<<p[i].turnaround\_time<<"\t\t"<<p[i].waiting\_time<<"\t\t"<<p[i].CPUtime<<"\n";

        }

    }

    return 0;

}

long calculation(Process p[],long n)

{

    /\*

    Function Calculates TurnAround Time,Waiting Time,

    Response Time.

    \*/

    for(long i=0;i<n;i++)

    {

        if(p[i].burst\_time==0)

        {

            p[i].turnaround\_time=0;

            p[i].waiting\_time=0;

            p[i].response\_time=0;

        }

        else

        {

            p[i].turnaround\_time=p[i].completion\_time-p[i].arrival\_time;

            p[i].waiting\_time=p[i].turnaround\_time-p[i].burst\_time;

            p[i].response\_time=p[i].CPUtime-p[i].arrival\_time;

        }

    }

    return 0;

}

long FPPS(Process p[],long n,long &time)

{

    /\*

    Fixed Priority Preemtive Scheduling:Processes are

    Executed in the oreder of there priority

    Less Priority Number=More Priority For That Process

    \*/

    system("CLS");

    if(n==1)

    {

        /\*

        If No Of Processes is One OS we have o just execute

        it in FPPS.

        \*/

        time=p[0].arrival\_time+p[0].burst\_time;

        p[0].completion\_time=time;

        p[0].CPUtime=p[0].arrival\_time;

        return 0;

    }

    time=min\_arrival;

    sort(p, p + n, comparison\_Priority);

    sort(p, p + n, comparison\_ArrivalTime);

    long min\_priority,k,current,small\_priority\_index;

    while(time<=max\_arrival)

    {

        long small\_priority=INT\_MAX;

        for(long i=0;i<n;i++)

        {

            /\*

            loop to find how many processes are in ready queue.

            \*/

            if(p[i].arrival\_time<=time)

            {

                current=i;

                continue;

            }

            else

            {

                /\*

                Value of current signifies the processes index

                which can be executed in the CPU.

                \*/

                break;

            }

        }

        long s=0;

        while(s<=current)

        {

            /\*

            Loop Finds Out The Smallest Priority Of The Current

            Ready Processes

            \*/

            if(p[s].priority<small\_priority && p[s].remaining\_time!=0)

            {

                small\_priority=p[s].priority;

                small\_priority\_index=s;

            }

            s++;

        }

        /\*

        Executes The Process for 1 unit time

        \*/

        p[small\_priority\_index].remaining\_time--;

        if(p[small\_priority\_index].CPUtime==-1)

        {

            /\*

            This Conditional Statement tells

            what was the time when the process

            was first time executed.

            \*/

            p[small\_priority\_index].CPUtime=time;

        }

        time++;

        if(p[small\_priority\_index].remaining\_time==0)

        {

            /\*

            Saves the time when a process was fully executed

            \*/

            p[small\_priority\_index].completion\_time=time;

        }

    }

    /\*

    The Statement Below This Comment Executes a last partially

    Running Process and then exits the function

    \*/

    long remaining\_time=p[small\_priority\_index].remaining\_time;

    if(p[small\_priority\_index].remaining\_time==0)

    {

        /\*

        As Remaining Time is 0,So No Advantage of

        going further

        \*/

        return 0;

    }

    p[small\_priority\_index].remaining\_time=0;

    if(p[small\_priority\_index].CPUtime==-1)

    {

        /\*

        This Conditional Statement Gives

        tells what was the time when the process

        was first time executed.

        \*/

        p[small\_priority\_index].CPUtime=time;

    }

    time+=remaining\_time;

    if(p[small\_priority\_index].remaining\_time==0)

    {

        /\*

        Gives the time when a process was fully executed

        \*/

        p[small\_priority\_index].completion\_time=time;

    }

    return 0;

}

long Round\_Robin(Process p[],long n,long tq,long &time)    //Round Robin Scheduling

{

    if(n==1)

    {

        /\*

        If there is only one process, the Process has been executed in FPPS

        \*/

        return 0;

    }

    /\*Round Robin Scheduling\*/

    long start=-1,remaining\_time=-1,cur=-1;

    sort(p,p+n,comparison\_RemainingTime);              //sort according to Remaining\_time

    for(long i=0;i<n;i++)

    {

        /\*

        Finds the index of Process which does

        not have remaining time as 0.

        \*/

        if(p[i].remaining\_time==0)

        {

            continue;

        }

        else

        {

            start=i;

            break;

        }

    }

    sort(p+start,p+n,comparison\_ArrivalTime);                //sort according to Remaining\_time

    for(long i=0;i<n;i++)

    {

        if(p[i].remaining\_time==0)

        {

            /\*

            If A Process Has Remaining time as zero

            We take a partially running process from

            ready\_queue and execute it

            \*/

            if(!ready\_queue.empty())

            {

                cur=ready\_queue[0];

                ready\_queue.erase(ready\_queue.begin());

                if(p[cur].remaining\_time<=tq)

                {

                    /\*

                    If remaining time is less then or equal to

                    time quantum, then execute the whole process

                    \*/

                    remaining\_time=p[cur].remaining\_time;

                    p[cur].remaining\_time=0;

                    time+=remaining\_time;

                    p[cur].completion\_time=time;

                }

                else

                {

                    /\*

                    If remaining time is more then time quantum,

                    then execute the process for time quantum

                    and then store it in ready\_queue

                    \*/

                    p[cur].remaining\_time-=tq;

                    time+=tq;

                    ready\_queue.push\_back(cur);

                }

            }

            continue;

        }

        else

        {

            if(p[i].arrival\_time<=time)

            {

                if(p[i].remaining\_time<=tq)

                {

                    /\*

                    If remaining time is less then or equal to

                    time quantum, then execute the whole process

                    \*/

                    remaining\_time=p[i].remaining\_time;

                    p[i].remaining\_time=0;

                    if(p[i].CPUtime==-1)

                    {

                        /\*

                        This Conditional Statement Gives

                        tells what was the time when the process

                        was first time executed.

                        \*/

                        p[i].CPUtime=time;

                    }

                    time+=remaining\_time;

                }

                else

                {

                    /\*

                    If remaining time is more then time quantum,

                    then execute the process for time quantum

                    and then store it in ready\_queue

                    \*/

                    p[i].remaining\_time-=tq;

                    if(p[i].CPUtime==-1)

                    {

                        /\*

                        This Conditional Statement Gives

                        tells what was the time when the process

                        was first time executed.

                        \*/

                        p[i].CPUtime=time;

                    }

                    time+=tq;

                    ready\_queue.push\_back(i);

                }

            }

            else

            {

                if(!ready\_queue.empty())

                {

                    cur=ready\_queue[0];

                    ready\_queue.erase(ready\_queue.begin());

                    if(p[cur].remaining\_time<=tq)

                    {

                        /\*

                        If remaining time is less then or equal to

                        time quantum, then execute the whole process

                        \*/

                        remaining\_time=p[cur].remaining\_time;

                        p[cur].remaining\_time=0;

                        time+=remaining\_time;

                        p[cur].completion\_time=time;

                    }

                    else

                    {

                        /\*

                        If remaining time is more then time quantum,

                        then execute the process for time quantum

                        and then again store it in ready\_queue

                        \*/

                        p[cur].remaining\_time-=tq;

                        time+=tq;

                        ready\_queue.push\_back(cur);

                    }

                }

            }

        }

    }

    while(!ready\_queue.empty())

    {

        /\*

        Executes all the processes in ready queue

        \*/

        cur=ready\_queue[0];

        ready\_queue.erase(ready\_queue.begin());

        if(p[cur].remaining\_time<=tq)

        {

            /\*

            If remaining time is less then or equal to

            time quantum, then execute the whole process

            \*/

            remaining\_time=p[cur].remaining\_time;

            p[cur].remaining\_time=0;

            time+=remaining\_time;

            p[cur].completion\_time=time;

        }

        else

        {

            /\*

            If remaining time is more then time quantum,

            then execute the process for time quantum

            and then again store it in ready\_queue

            \*/

            p[cur].remaining\_time-=tq;

            time+=tq;

            ready\_queue.push\_back(cur);

        }

    }

    return 0;

}

int main()

{

    display();

    /\*

    Just Comment The above function call if you are testing the code:

    this function may take upto more then 5 seconds

    \*/

    long n,temp=0,time\_q,time=0;

    cout<<"\t\t\tOperating System Scheduling\n\t\t\t\t\t\t-Garvit Joshi\n";

    cout<<"Enter No. Of Processes:";

    cin >>n;

    while(n<=0)

    {

        cout<<"\t\t\t\tWarning "<<warning<<": Number Of Processes Cannot Be less Then or Equal to 0.\n";

        cout<<"Please Enter No. Of Processes Again:";

        cin>>n;

        warning++;

    }

    Process p[n];

    cout<<"====================================================\n";

    for(long i=0;i<n;i++)

    {

        Enter\_Process(temp,p,i);

    }

    cout<<"Successfully Added The Process:";

    Show\_Process(p,n);

    cout<<"Enter Time Quantum(Multiples Of Two):";

    cin>>time\_q;

    while(time\_q%2!=0)

    {

        /\*

        Time Quantum Should Be In Multiples Of Two

        \*/

        cout<<"\t\t\t\tWarning "<<warning<<": Time Quantum Should In Multiples Of Two:\n";

        cout<<"Enter Time In Multiples Of 2:";

        cin>>time\_q;

        warning++;

    }

    FPPS(p,n,time);                        //Fixed Priority Preemtive Scheduling

    Round\_Robin(p,n,time\_q,time);          //Round Robin Scheduling

    calculation(p,n);

    sort(p,p+n,comparison\_PID);

    Show\_Process(p,n,true);

    cout<<"\n";

    cout<<"All Process Completed In "<<time<<" unit time.\n\n";

    system("pause");

    return 0;

}

**Questions:**

**Question 1:** Explain the problem in terms of operating system concept? (Max 200 word)

**Answer 1:** Some Scheduling Algorithm, are non-pre-emptive in nature which means, if a process starts, the CPU executes the process until it ends. Because of this problem, if a process has a very large Burst Time, the process waiting in the queue will have to wait for a long time before they get a chance to be executed, this problem is called Starvation. This happens Mostly in First Come First Serve Scheduling.

So, the scheduling algorithm made by me uses multilevel queue scheduling algorithm, it uses two queues: the high priority queue uses modified Fixed Priority pre-emptive scheduling. The second level queue uses Round Robin Scheduling. When a process is running in Queue 1 and a high priority process comes, so the process that is running pre-empts and now it will run in second level queue i.e. Round Robin Scheduling. Round Robin Scheduling can have time quantum in multiples of two. Queue 2 can only be processed if queue 1 becomes empty.

**Question 2:** Write the algorithm for proposed solution of the assigned problem.

**Answer 2:**

**=>**Fixed\_Priority\_Preemtive\_Scheduling (Process p[],long n, long &time)

1. If n==1

1.1. There Is only One process Execute it.

2. time=minimum\_arival\_time of process

3. sort all the process according to Priority

4. sort all the process according to Arrival Time

5. loop until time <=max\_arrival

5.1. loop from i=0 to i=n;

5.1.1. find minimum arrival time

5.2. loop from i=0 to minimum arrival time

5.2.1 find smallest\_priority\_process whose remaining time is left

5.3. Execute it for 1 Unit time.

5.4.time =time +1

5.5. If It is executed for the first time

5.5.1. Store the time in process structure

5.6. If process.remaining time= 0

5.6.1. It is completed and store its completetion time

6. Execute the process that has run last at FPPS.

**=>**Round\_Robin\_scheduling(Process p[],long n,long tq,long &time)

1.if n==1

1.1 exit ,there is only one process that has been executed in FPPS

2. sort the process according to remaining time

3.loop from i=0 to i=n:

3.1Find The Index Of process Which do not have remaining time as 0.

3.2. Store that index

4. sort the process according to arrival time

5.loop from i=0 to i=n:

5.1. if remaining time==0

5.1.1. If Ready Queue is not empty

5.1.1.1. if remaining time<=time\_quantum

5.1.1.1.1 Execute the whole first process in ready queue

5.1.1.2. else

5.1.1.2.1 Execute the process for time quantum

5.2 else

5.2.1 If arrival time<= time

5.2.1.1. if remaining time<=time\_quantum

5.2.2.1.1.1 Execute the whole process

5.2.1.2. else

5.2.1.2.1. Execute the process for time quantum

5.2.1.2.2. Put the remaining process into ready queue

5.2.2. else

5.2.2.1. If Ready Queue is not empty

5.2.2.1.1. if remaining time<=time\_quantum

5.2.2.1.1.1. Execute the whole first process in ready queue

5.2.2.2. else

5.2.2.2.1. Execute the process for time quantum

5.2.2.2.2. Put the remaining process to ready queue

6. loop while ready queue does not become empty

6.1.take the first Process from ready queue.

6.2. if remaining time<=time\_quantum

6.2.1. Execute the whole first process in ready queue

6.3. else

6.3.1. Execute the process for time quantum

6.3.2. Put the remaining process to ready queue

7.exit.

**Question 3:** Explain all the constraints given in the problem. Attach the code snippet of the implemented constraint.

**Answer 3:** The Constraints are:

1. Time Quantum should be in the multiples of two.
2. Arrival Time, Priority, Burst Time Cannot Be in Negative.
3. All the variables are of long variable type that is there range can be between -2,147,483,647 to 2,147,483,647.

If the 1. And 2. Constraints are not met then a warning is shown that tells user about constraints.

Code Snippet:

1. When Time Quantum is not given in multiples of two,

cout<<"Enter Time Quantum (Multiples Of Two):";

cin>>time\_q;

while(time\_q%2!=0)

{

    /\*

    Time Quantum Should Be In Multiples Of Two

    \*/

    cout<<"\t\t\t\tWarning "<<warning<<": Time Quantum Should In Multiples Of Two:\n";

    cout<<"Enter Time In Multiples Of 2:";

    cin>>time\_q;

    warning++;

}

1. When Arrival time Is Gives Less Then 0, and

cout<<"Enter Arrival Time:";

cin>>p[i].arrival\_time;

while(p[i].arrival\_time<0)

{

cout<<"\t\t\t\tWarning "<<warning<<": A Process Cannot Have Arrival Time in Negative.\n";

cout<<"Please Enter Arrival Time Again:";

      cin>>p[i].arrival\_time;

      warning++;

}

1. All Variables Are long in type

long n,temp=0,time\_q,time=0;

struct Process

{

long pid=0;

     long priority=0;

     long arrival\_time=0;

     long burst\_time=0;

     long completion\_time=0;

     long turnaround\_time=0;

     long waiting\_time=0;

long response\_time=0;

long remaining\_time=0

long CPUtime=-1;

};