Process Management

1) Whenever there is an interrupt, the running process stops, and the ____________ is invoked every time to select another process for execution.

A) Short-term scheduler
B) Long-term scheduler
C) Medium-term scheduler
D) None of these

Solution A)
Whenever there is an interrupt, the running process stops, and the short-term scheduler is invoked every time to select another process for execution.

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2) The collection of user program, data section, stack, and the associated attributes is called the

A) Process control block (PCB)
B) Process environment
C) Process image
D) None

Solution C)
The process environment consists of a program (code), data section, and stack. However, this is not sufficient to control a process. The OS needs some attributes associated with the processes to implement and control them. The attributes are stored in the data structure known as process control block (PCB) or process descriptor. The collection of user program, data section, stack, and the associated attributes is called the process image.

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3) CPU bound jobs will hold CPU until exit or I/O. Long periods where no I/O requests are issued, and the CPU is held resulting in poor I/O device utilization. This degradation in performance can be seen in which of the following?

A) FCFS
B) SRTF
C) RR
D) SJF

Solution : (A)
This performance degradation is caused by convoy effect in FCFS.

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4) Consider a system having 10 processes where each process spends 75% time waiting in this system.What percent of time is the CPU busy (utilization)?

Solution:
Given that each process spends 0.75 fraction waiting, the probability that 10 processes will all wait at the same time is (.75) = .056 . So effective CPU utilization is 1 - 0.056
= 0.94. In general, if the waiting fraction is p for N processes then CPU utilization is 1–p^N.

5) Which one of the following is TRUE.

A) Priority scheduling minimizes average waiting time
B) During periods when the processor spends all of its cycles handling interrupts, the process scheduler is irrelevant to the machine's performance.
C) SRTF could maximize the CPU utilization
D) Round-robin scheduling minimizes average completion time.

Solution : (B)
A: False. If the high priority jobs take a long time and the low priority jobs take less time, then priority scheduling will do worse on the waiting time metric.
B: True. If the OS is always executing in the interrupt handler, then it is not running processes.
C: False. SRTF might have to spend time in context switches that a discipline that runs jobs to completion does not have to spend. The key here is that SRTF was listed as pre-emptive. Any preemptive discipline pays a context switching cost. SRTF optimizes average waiting time, not CPU utilization.
D : False. Round-robin is not optimized to get jobs out of the system quickly.

6) Which of the following are contents of PCB?

i)Process Number
ii)Registers
iii)Process State

A) Only i,ii
B) All i,ii,iii
C) Only i
D) Only ii,iii

Solution: (B) Refer to PCB diagram.

7) Which of the following is not part of the Process control block (PCB) ?

A) Process states
B) CPU scheduling information
C) I/O Status Information
D) None of these.

Solution (D)
All of them are part of PCB.

8) __________________ makes a decision about how many processes should be made to stay in the ready state.
.
A) Long term scheduler
B) Short term scheduler
C) Medium term scheduler
D) Swapper

Solution: (A)
Long term scheduler makes a decision about how many processes should be made to stay in the ready state, which decides the degree of multiprogramming.

9) The preemption of the running process using a software interrupt moves the process from run state to ________ ?

A) Block state
B) Suspended state
C) Ready state
D) Ready suspended state

Solution (C)
The preemption of the running process using a software interrupt such as completion of time quantum etc, moves the process from run state to ready state.

10) Assume four processes A, B, C and D with burst time a, b, c and d, respectively arrive at same time in that order. With no context switch delay involved the average turn around time using first come first serve scheduling algorithm is :

A) (3a+b+c+d)/4
B) (3b+2c+d)/4
C) (4a+3b+c+d)/4
D) (4a+3b+2c+d)/4

Solution D)
Process A finishes at time a, B finishes at time a+b, C at a+b+c and so on. The average turn around time is then: (4a+3b+2c+d)/ 4 .

11) If you want to separate scheduling policy and mechanism, you have to parameterize the scheduling algorithm to set the policy. What is the parameter(s) of First come first serve scheduling (FCFS) algorithm :

A) Burst size
B) Priority
C) Arrival time
D) FCFS is a non-parameterized scheduling algorithm.

Solution C)
Parameter here means based on what metric or value or criteria the processes are scheduled. Definitely in FCFS the processes are scheduled based on who has arrived first. Hence Arrival time is the parameter.

12) The collection of user program, data section, stack, and the associated attributes is called the

A) Process control block (PCB)
B) Process environment
C) Process image

D) None

Solution C)
The process environment consists of program (code), data section, and stack. However, this is not sufficient to control a process. The OS needs some attributes associated with the processes to implement and control them. The attributes are stored in the data structure known as process control block (PCB) or process descriptor. The collection of user program, data section, stack, and the associated attributes is called the process image.

13) Which is true regarding selection of time quantum in RR scheduling?

(a) 50% of the CPU bursts should be smaller than the time quantum.
(b) 70% of the CPU bursts should be greater than the time quantum.
(c) 80% of the CPU bursts should be smaller than the time quantum.
(d) none

Solution C)
The time quantum used in the round robin scheduling plays an important role in its performance. If the time quantum chosen is very large, it will be as good as the FCFS algorithm. The rule is that 80% of CPU bursts should be smaller than the time quantum. On the other hand, if it is too small, then there will be a large context switch time because after every time quantum, process switching will occur. The context switch time should not be more than the time quantum. Therefore, time quantum should be selected such that context switch time is a small fraction of time quantum.
For example, if there are six processes of burst time of 1 unit time and time quantum is 1, then there will be five context switches. If time quantum is two, then there will be two context switches. In this way, the size of time quantum affects the performance of the system, if context switch time increases.
It can be concluded that we cannot choose time quantum as too large or too short, because in both cases the performance of the algorithm will be degraded. Thus, it should be selected in a balanced range, keeping in view the two rules:

Rule 1: 80% of the CPU bursts should be smaller than the time quantum.
Rule 2: Context switch time is nearly 10 % of time quantum.

If the time quantum is selected optimally, then besides the context switch time reduction, the processes need not wait long for their execution and get more service as compared to a bad choice of time quantum. Therefore, it results in reduction of turnaround time, normalized turnaround time, and waiting time.

14) Match the following with correct advantages of each scheduling algorithm:

Scheduling	Advantage
a) FCFS	i) Minimizes average waiting time
b) SJF	ii) Provides reasonable response times to interactive jobs
c) SRTF	iii) Ensures fast completion of short jobs

d) RR	iv) Ensures fast completion of important jobs
e) Priority	v) Easy to implement

A) a – v, b – i , c – iii, d – ii, e- iv.
B) a – i, b – ii , c – iii, d – iv, e- v.
C) a – v, b – iv , c – iii, d – ii, e- i.
D) a – iii, b – i , c – ii, d – iv, e- v.

Solution A)

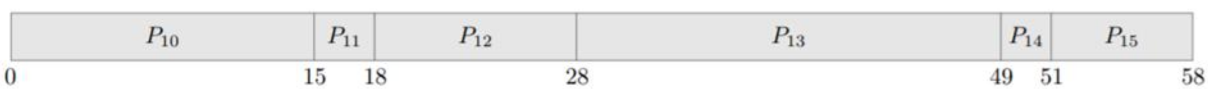
Algorithm	Policy Type	Disadvantages	Advantages
First Come, First Served	Nonpreemptive	Unpredictable turnaround times; has an element of chance	Easy to implement
Shortest Job Next	Nonpreemptive	Indefinite postponement of some jobs; requires execution times in advance	Minimizes average waiting time
Priority Scheduling	Nonpreemptive	Indefinite postponement of some jobs	Ensures fast completion of important jobs
Shortest Remaining Time	Preemptive	Overhead incurred by context switching	Ensures fast completion of short jobs
Round Robin	Preemptive	Requires selection of good time quantum	Provides reasonable response times to interactive users; provides fair CPU allocation
Multiple-Level Queues	Preemptive/ Nonpreemptive	Overhead incurred by monitoring queues	Flexible scheme; allows aging or other queue movement to counteract indefinite postponement; is fair to CPU-bound jobs

15) Consider the following processes arriving at the ready queue and dispatched. The average waiting time and average turnaround time using FCFS scheduling ___________ and _________, respectively. [NAT]

PID	Arrival Time	Burst (ms)	Priority
10	0	15	1
11	2	3	8
12	5	10	13
13	11	21	5
14	12	2	2
15	25	7	4

Solution: 19.3 and 27.16

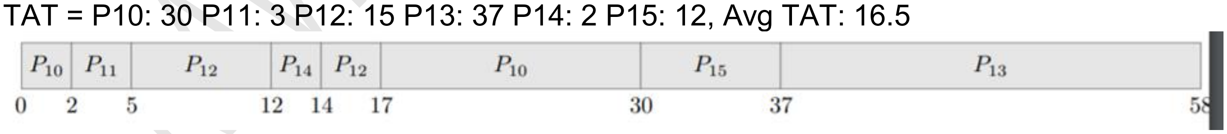
Waiting time = P10: 0 P11: 13 P12: 13 P13: 17 P14: 37 P15: 26. Avg Wait: 19.3
TAT = P10: 15 P11: 16 P12: 22 P13: 38 P14: 39 P15: 33, Avg TAT = 27.16



16) Consider the following processes arriving at the ready queue and dispatched. The average waiting time and average turnaround time using SRTF scheduling __________ and ________, respectively. [NAT]

PID	Arrival Time	Burst (ms)	Priority
10	0	15	1
11	2	3	8
12	5	10	13
13	11	21	5
14	12	2	2
15	25	7	4

Solution: 8.5 and 16.5
Waiting time = P10: 15 P11: 0 P12: 5 P13: 26 P14: 0 P15: 5, Avg Wait: 8.5
TAT = P10: 30 P11: 3 P12: 15 P13: 37 P14: 2 P15: 12, Avg TAT: 16.5



17) Consider a uniprocessor system with n processes in the ready queue. Round robin scheduling with time quantum x is used for process scheduling. Assume each process requires kx seconds to complete and the context switch takes 0 seconds. At what time the first process will complete the execution? (assume all the variables as integers).
A) nkx
B) k(nx-1)
C) k(nk+n)
D) x(nk-n+1)

Solution: (D)

Each process takes kx time and the quantum time is x seconds.
The $(k-1)$th round of the last process is at time $n(k-1)x$.
The next process scheduled is the first process, which takes the last x units of time to finish.
Hence, first process completes at $n(k-1)x + x = x(nk-n+1)$

18) Consider a system with round robin scheduling with a quantum of 4 units, and 50 processes present in a ready queue waiting to run on the CPU. Assuming each process requires 4 units of CPU to complete its execution, the average waiting time is _______ units [NAT]
Solution: 98
Every process completes its execution on the second time when it gets the CPU.
Assume, 50 processes P1-P50.
The waiting time for P1 is 0 = (1-1) * 4.
The waiting time for P2 is 4 = (2-1)* 4.
The waiting time for P3 is 8. = (3-1)*4
….
….
The waiting time for P50 is = (50-1)*4 = 196.
Therefore, the total waiting time = 0+4+8+ …… 196 = 4(1+ 2+ 3 + 49) = 4*49*(50)/(50*2)
= 98 units.

19) Consider a uniprocessor system with 100 processes in the ready queue. Round robin scheduling with time quantum 4 seconds is used for process scheduling. Assume each process requires 24 seconds to complete and no context switch overhead.The time at which the first process will complete the execution is ________ seconds. [NAT]
Solution: 2004.
Each process takes kx time and the quantum time is x seconds.
The $(k-1)$th round of the last process is at time $n(k-1)x$.
The next process scheduled is the first process, which takes the last x units of time to finish.
Hence, first process completes at $n(k-1)x + x = x(nk-n+1)$
$x(nk-n+1) = 4*(100*6-100+1) = 2004$.

20) Consider three processes P1, P2, and P3 scheduled in same order starting at time 0. It is known that each process takes a total of 40, 50 and 60 ms to complete, respectively. For each of the processes the first 20% time is spent on IO, and all IO devices are readily available. Assuming that an FCFSscheduling is used, the total time for which the CPU remains idle is _______ ms. [NAT]

Solution: 8

Process	IO Time	Burst Time
P1	8	32

P2	10	40
P3	12	48

No process	P1	P2	

0 8 40 80 128

The CPU is idle for 8 ms.

21) Consider the set of processes with given information. Non preemptive priority scheduling is used with low priority number as high priority.

Process	Arrival Time	Burst Time	Priority
P1	0	10	4
P2	0	3	1
P3	3	8	2
P4	4	16	3
P5	7	2	5

The average turn turn around time is __________ [NAT]

Solution: 20.6

Process	Arrival Time (AT	Burst Time (BT)	Priority	Completion time (CT)	Turnaround Time (TAT)
P1	0	10	4	37	37
P2	0	3	1	3	3
P3	3	8	2	11	8
P4	4	16	3	27	23
P5	7	2	5	39	32

Calculation:

Average turnaround time = $\frac{37+3+8+23+32}{5} = 20.6$

22) Consider a system with a round robin algorithm for process scheduling. It is given that the time slice for every process is K units and the context switch overhead takes C units. The

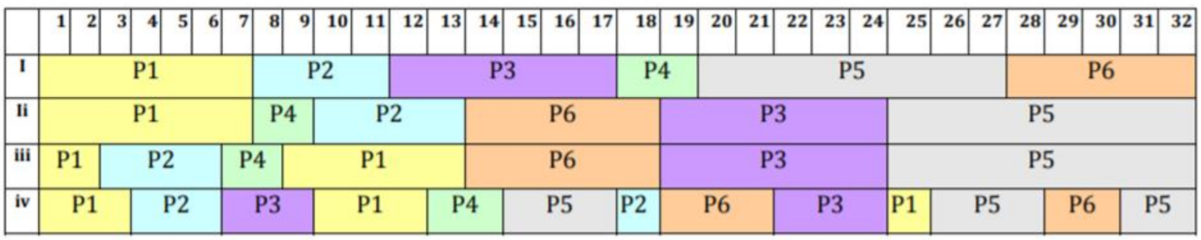
percentage overhead on the CPU can be calculated as: A) C/(C+K) B) K/(C+K) C) C/K D) K/C Solution: (A) One context switch occurs every K time slice. So, in a time of K+C time units, C units are spent on context switching (overhead). Therefore, the percentage overhead is C/(C+K).
23) Which of the following statements are correct? [MSQ] A) The FCFS scheduling algorithm can lead to increased waiting time for processes if a long process starts executing, leading to starvation of smaller processes. B) FCFS scheduling algorithm can lead to convoy effect. C) HRRN scheduling algorithm tries to reduce the waiting time of the processes and at the same time avoids starvation. D) The SJF algorithm can lead to starvation. Solution: B, C, D FCFS has no starvation, but leads to convoy effect. In HRRN, the priority of a process increases as its waiting time increases. Also, the rate of increase of priority is faster for short CPU burst processes as compared to long CPU burst processes. Hence, the algorithm gives preference to short CPU burst processes and avoids starvation. SJF leads to starvation if smaller processes keep on arriving.
24) Consider a time sharing operating system that uses the round-robin scheduling algorithm. Suppose there are N processes in the ready queue, with time quantum D and context-switch overhead of d. Assume that the average CPU burst time of a process is B. The average waiting time for a process before it again gets a chance to run on the CPU ? A) (N-1) * [d + min(D,B)] B) (N-1) * [D + min(d,B)] C) (N-1) * [d - max(D,B)] D) (N-1) * [D + max(d,B)] Solution: A After a process gets time to run on the CPU, it will be waiting for all the remaining (N-1) processes to run before it gets back the CPU again. On the average, a process will be using the CPU for min(D,B) time before it relinquishes the CPU. Hence, average waiting time = (N – 1) * [d + min(D,B)]
25) Consider the following set of process information. Which of the following is in increasing order of average waiting time for the following scheduling algorithms:

(i) FCFS
(ii) SJF
(iii) SRTF
(iv) RR with quantum = 3.

Process	P1	P2	P3	P4	P5	P6
Arrival Time (msec)	0	2	3	5	6	8
CPU Burst (msec)	7	4	6	2	8	5

A) FCFS, SJF, SRTF, RR
B) SRTF, SJF, RR, FCFS
C) SJF , RR, SRTF, FCFS
D) SRTF, SJF, FCFS, RR

Solution: (D)



(i) FCFS
AWT = (0 + 5 + 8 + 12 + 13 + 19) / 6 = 9.5
(ii) Non-preemptive SJF
AWT = (0 + 7 + 15 + 2 + 18 + 5) / 6 = 7.83
(iii) Preemptive SJF
AWT = (6 + 0 + 15 + 1 + 18 + 5) / 6 = 7.5
(iv) Round-robin
AWT = (18 + 12 + 15 + 7 + 18 + 17) / 6 = 14.5

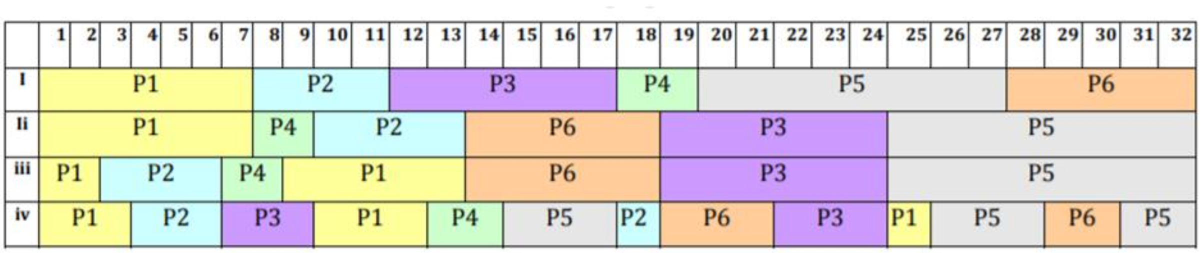
26) Consider the following set of process information. Which of the following is in increasing order of average turnaround time for the following scheduling algorithms:
(i) FCFS
(ii) SJF
(iii) SRTF
(iv) RR with quantum = 3.

Process	P1	P2	P3	P4	P5	P6
Arrival Time (msec)	0	2	3	5	6	8
CPU Burst (msec)	7	4	6	2	8	5

A) FCFS, SJF, SRTF, RR
B) SRTF, SJF, RR, FCFS
C) SJF , RR, SRTF, FCFS

D) SRTF, SJF, FCFS, RR

Solution: (D)



(i) FCFS
ATT = (7 + 9 + 14 + 14 + 21 + 24) / 6 = 14.83
(ii) Non-preemptive SJF
ATT = (7 + 11 + 21 + 4 + 26 + 10) / 6 = 13.17
(iii) Preemptive SJF
ATT = (13 + 4 + 21 + 3 + 26 + 10) / 6 = 12.83
(iv) Round-robin
ATT = (25 + 16 + 6 + 9 + 26 + 22) / 6 = 17.33

27) Which of the following scheduling algorithms will tend to schedule I/O bound jobs before CPU bound jobs?

Process	P1	P2	P3	P4	P5	P6
Arrival Time (msec)	0	2	3	5	6	8
CPU Burst (msec)	7	4	6	2	8	5

A) SRTF
B) FCFS
C) Round Robin
D) None of these.

Solution: (D)

SRTF schedules are based on the shortest remaining burst time.
FCFS scheduling based on arrival time.
RR based on time quantum, gives a fair chance.

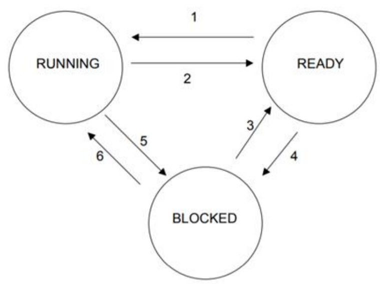
28) Which of the following are correct? [MSQ]

A) FCFS results in its minimum average response time possible, if the processes arrive in the increasing order of the burst time.
B) FCFS results in its minimum average response time possible, if the processes have the same burst time.
C) If there are N processes of all the same length L, the first process will finish at N*(L – T),

where T is the length of the time slice.
D) Round robin scheduling behaves identically to FCFS, when the burst size is the same for all the processes.

Solution: (A)(B)
If the processes happen to arrive in the ready queue with the shortest burst times first (or, as a special case, if all processes have the same burst time, then FCFS results in its minimum average response time.
If there are N jobs all the same length L, the first job will finish at approximately N*L – (N-1)*T, where T is the length of the time slice.
If the process bursts are no longer than the length of the time slice, then RR behaves the same as FCFS.

29) Consider the following state-transition diagram and identify correct set of statement(s):[MSQ]



A) Transition 2 is possible in FCFS scheduling.
B) Transition 4 is not possible.
C) Transition 6 is possible when a process sleeping over a Semaphore is invoked.
D) Transition 5 is not possible.

Solution: (B)

Transition 2 is only possible for preemptive scheduling.
Transition 4 is not possible, as ready processes cannot be blocked.
Transition 6 is not possible, a blocked process cannot run on CPU directly.
Transition 5 is possible on a IO request by the process.

30) Identify the correct statement(s): [MSQ]

A) Ignoring the overhead of context switching, the I/O utilization of a round robin system increases as the time-slice length is increased.
B) Ignoring the overhead of context switching, the I/O utilization of a round robin system decreases as the time-slice length is increased.
C) Ignoring the overhead of context switching, some processes may take longer to finish, if the time-slice length is decreased in a round robin system.
D) Ignoring the overhead of context switching, if the time-slice length is decreased in a round robin system then some process may starve.

Solution: (B) (C)

CPU-bound processes will dominate the processor, and I/O bound processes (which require very short CPU bursts) will execute quickly and move back to the I/O queues. This means that total I/O utilization will decrease.

Some processes may take longer to finish. In particular, processes that used to finish within the time slice, but now needing to be switched out will spend time waiting on the queue, causing them to take longer to finish. Not all processes will take longer to finish.
For example, say 2 processes, one needing 2 time units and the other needing 4 time units. Assume that the smaller process gets the CPU first. If the quantum is 2 time units, the first process will finish in 2 time units, and the second in 6. If we decrease the time-slice length to 1 time unit, the first process will finish in 3 time units, but the second will still finish in 6.

31) What state information and content do you need to save/restore about processes when performing a context switch [MSQ]

A) Stack
B) Program Counter
C) Registers
D) Stack Pointer

Solution: (B)(C)(D).
A stack is a separate location in main memory. During a context switch only the stack pointer (SP) is saved or restored. The actual stack contains remains on the stack.

32) Identify the correct statement(s): [MSQ]

A) Timer Interrupt may lead to context switch.
B) Round-Robin scheduling tends to favor IO bound processes.
C) A scheduling algorithm which gives priority to processes based on how much CPU time they have consumed (processes whose total CPU time is higher have higher priority) may lead to starvation.
D) Medium term scheduler is complex and not time critical when compared to short term scheduler.

Solution: (A) (D).

An timer interrupt may lead context switch, for example, Round robin scheduling.

In Round robin scheduling, each process gets put back at the end of the queue no matter how much or how little of the quantum was used. I/O bound processes tend to run for a short period of time and then block which means they might have to wait in the queue a long time.

The starvation is not possible in a scheduling algorithm which gives priority to processes based on how much CPU time they have consumed (processes whose total CPU time is higher have higher priority). Always new processes (CPU used time is 0) are scheduled based on arrival times.

Short term scheduler schedules the CPU with runnable processes. Time scale is in the order of mili-seconds.
The medium term schedules process to memory so it can be more complex and it is not as time critical. Time scale is of order of seconds.

33) Assume three processes arrive at the same time 0, of length 30,20,and10(they arrive in the same order). Assume that Sort() procedure is used to sort these processes. The time involved in Sort() takes Number of processes x 10 units of time, and that Switch() function is used for context switching (when one process ends and another begins, or to switch in a new process for the first time), which takes 10 units of time. Assume non--preemptive SJF Policy is used.

The average turn-around time is ________ units [NAT]

Solution: 83

Sort () functions take 3x10 = 30 units.
Context () function for each switch takes 10 units.

Let P1=30, P2=20 and P3= 10 units. After Sort(), the schedule order is P3, P2 and P1.

Therefore, P3 turnaround time = 30 + 10 + 10 = 50.
P2 turnaround time = 50 + 10 + 20 = 80.
P1 turnaround time = 80+10+30 = 120.

Average turnaround time: (50 + 80 + 120) / 3 = 83

34) Assume three processes arrive at the same time 0, of length 30,20,and10(they arrive in the same order). Assume that Sort() procedure is used to sort these processes. The time involved in Sort() takes Number of processes x 10 units of time, and that Switch() function is used for context switching (when one process ends and another begins, or to switch in a new process for the first time), which takes 10 units of time. Assume Round Robin Policy with a time slice of 10 units is used.

The average turn-around time is ________ units [NAT]

Solution: 93.33

There is no sorting required in RR scheduling.
Sort () functions take 0 units.
Context () function for each switch takes 10 units.

Let P1=30, P2=20 and P3= 10 units.

CS (10)	P1 (10)	CS (10)	P2 (10)	CS (10)	P3 (10)	CS (10)	P1 (10)	CS (10)	P2 (10)	CS (10)	P1 (10)

Average TAT = (120 + 100 + 60) = 280/3 = 93.33

35) Assume we have three processes that enter a system and need to be scheduled. The first Process A needs 10 seconds of CPU time. The second Process B, which arrives just after A, needs 15 seconds of CPU time. The third, Process C, arrives just after B, and needs 10 seconds of CPU time. Assume that there is no cost to context switching and Round Robin Scheduling is used. What is the minimum integer value of the time -slice for which Process B finishes before C? [NAT]

Solution: 8

Scheduling Order, A = 10, B = 15, C = 10.

The Process B can complete before C only if both B and C can complete in the same round.
This is possible when Time Slice >= ceil(B/2) and < C.
Therefore, the minimum time slice = ceil(B/2) = 15/2 = 8.

36) Which of the following is/are TRUE: [MSQ]

A) On a uniprocessor machine, multiple processes can be in running state at the same time.
B) Performing I/O could cause a process's state to be changed from ready to waiting
C) Performing I/O could cause a process's state to be changed from running to waiting
D) OS uses timer interrupts to prevent a process from using the CPU forever.

Solution: (C) (D)

On a Uniprocessor system only processes can be in running state.
Performing I/O could cause a process's state to be changed from running to waiting.
OS uses timer interrupts to prevent a process from using the CPU forever and gain back the control.

37) Consider the set of processes with given information:

Process	Arrival Times	Burst Time
A	1	3
B	2	3
C	5	1
D	8	3

In terms of tie, the first arrival process is scheduled. The difference between the average turn around time using FCFS scheduling and SRTF scheduling is __________ units [NAT]

Solution: 0.25

▼Current Time / Scheduler →	FIFO	*SRTF*
1	A	A
2	A	A
3	A	A
4	B	*B*
5	B	*C*
6	B	*B*
7	C	*B*
8	D	*D*
9	D	*D*
10	D	*D*
Avg Turnaround Time	3.5	*3.25*

38) Consider the following process information with arrival times and the service times (burst time). A first come first serve scheduling algorithm is used. The average turn around time and the average waiting time are ___________ and__________, respectively. **[NAT]**

Process:	A	B	C	D	E
Arrival time:	0	1	2	3	4
Service time:	5	2	4	1	2

Solution: 7.8 and 5

t:	0	1	2	3	4	5	6	7	8	9	10	11	12	13
CPU	A 1/5	A 2/5	A 3/5	A 4/5	A 5/5	B 1/2	B 2/2	C 1/4	C 2/4	C 3/4	C 4/4	D 1/1	E 1/2	E 2/2
	↑ A	↑ B	↑ C	↑ D	↑ E									

Order of service (table):

Process	Arrival	Service	Priority	Started	Completion	turnaround time (TAT)	waiting time (WAT)
A	0	5	0	0	5	5	0
B	1	2	0	5	7	6	4
C	2	4	0	7	11	9	5
D	3	1	0	11	12	9	8
E	4	2	0	12	14	10	8
Avg:	-	2.8	-	-	-	7.8	5

39) Consider the following process information with arrival times and the service times (burst time). A first come first serve scheduling algorithm is used. The average turn around time and the average waiting time are ___________ and__________, respectively. **[NAT]**

Process:	A	B	C	D	E
Arrival time:	0	1	2	3	10
Service time:	3	1	4	1	5

Solution: 4.6 and 1.8

t:	0	1	2	3	4	5	6	7	8	9	10	11	12	13
CPU	A 1/3	A 2/3	A 3/3	B 1/1	C 1/4	C 2/4	C 3/4	C 4/4	D 1/1	- 0/0	E 1/5	E 2/5	E 3/5	E 4/5
	↑ A	↑ B	↑ C	↑ D							↑ E			

Order of service (table):

Process	Arrival	Service	Priority	Started	Completion	turnaround time (TAT)	waiting time (WAT)
A	0	3	0	0	3	3	0
B	1	1	0	3	4	3	2
C	2	4	0	4	8	6	2
D	3	1	0	8	9	6	5
E	10	5	0	10	15	5	0
Avg:	-	2.8	-	-	-	4.6	1.8

40) Consider the following process information with arrival times and the service times (burst time). A first come first serve scheduling algorithm is used. In case of same arrival times, the process is scheduled in lexicographical order. The average turn around time and the average waiting time are __________ and_________, respectively. **[NAT]**

Process:	A	B	C	D	E
Arrival time:	0	1	1	3	4
Service time:	3	1	4	1	5

Solution: 5.8 and 3

t:	0	1	2	3	4	5	6	7	8	9	10	11	12	13
CPU	A 1/3	A 2/3	A 3/3	B 1/1	C 1/4	C 2/4	C 3/4	C 4/4	D 1/1	E 1/5	E 2/5	E 3/5	E 4/5	E 5/5
	↑ A	↑ BC		↑ D	↑ E									

Order of service (table):

Process	Arrival	Service	Priority	Started	Completion	turnaround time (TAT)	waiting time (WAT)
A	0	3	0	0	3	3	0
B	1	1	0	3	4	3	2
C	1	4	0	4	8	7	3
D	3	1	0	8	9	6	5
E	4	5	0	9	14	10	5
Avg:	-	**2.8**	-	-	-	**5.8**	**3**

41) Consider the following process information with arrival times and the service times (burst time). A first come first serve scheduling algorithm is used. The completion time of process C is _________. **[NAT]**

Process:	A	B	C	D	E
Arrival time:	0	1	2	3	4
Service time:	3	1	4	1	5

Solution: 8

t:	0	1	2	3	4	5	6	7	8	9	10	11	12	13
CPU	A 1/3	A 2/3	A 3/3	B 1/1	C 1/4	C 2/4	C 3/4	C 4/4	D 1/1	E 1/5	E 2/5	E 3/5	E 4/5	E 5/5
	↑ A	↑ B	↑ C	↑ D	↑ E									

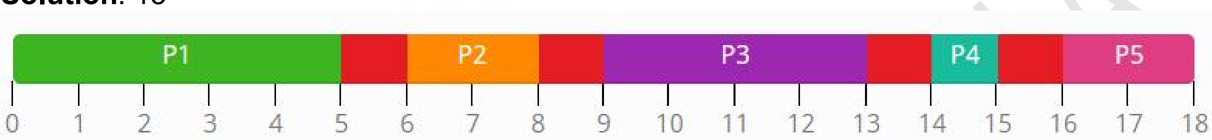
Order of service (table):

Process	Arrival	Service	Priority	Started	Completion	turnaround time (TAT)	waiting time (WAT)
A	0	3	0	0	3	3	0
B	1	1	0	3	4	3	2
C	2	4	0	4	8	6	2
D	3	1	0	8	9	6	5
E	4	5	0	9	14	10	5
Avg:	-	**2.8**	-	-	-	**5.6**	**2.8**

42) Consider the following process information with arrival times and the service times (burst time). A first come first serve scheduling algorithm is used. The scheduling incurs a context switch delay of 1 unit (ignore the first and last context switch). The completion time of process P3 is _________. **[NAT]**

Process:	Arrival Time:	Burst Time:
P1	0	5
P2	1	2
P3	2	4
P4	3	1
P5	4	2

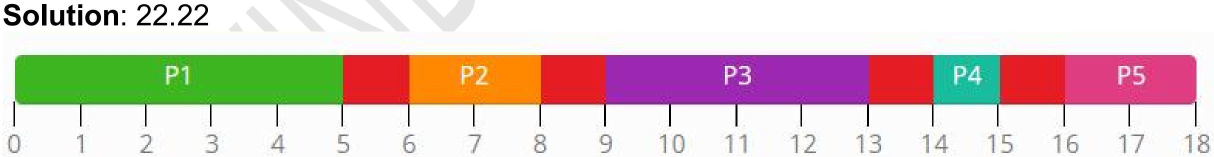
Solution: 13



6) Consider the following process information with arrival times and the service times (burst time). A first come first serve scheduling algorithm is used. The scheduling incurs a context switch delay of 1 unit (ignore the first and last context switch). The percentage overhead on the CPU is __________. **[NAT]**

Process:	Arrival Time:	Burst Time:
P1	0	5
P2	1	2
P3	2	4
P4	3	1
P5	4	2

Solution: 22.22

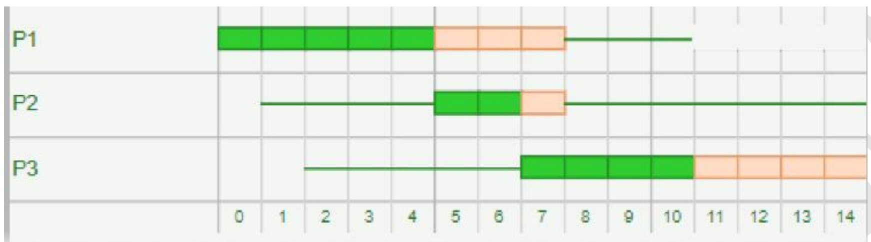


Total CPU time = 18 units.
Total Overhead = 4 units (Context switches).
Percentage overhead = (4/18)*100 = 22.22%

43) Consider the following process information with arrival times and the service times (burst time). All the IO devices are available. A first come first serve scheduling algorithm is used. The Process P2 completes its IO at __________ units. **[NAT]**

Process name	Arrival	CPU burst	IO burst
P1	0	5	3
P2	1	2	1
P3	2	4	4

Solution: 8

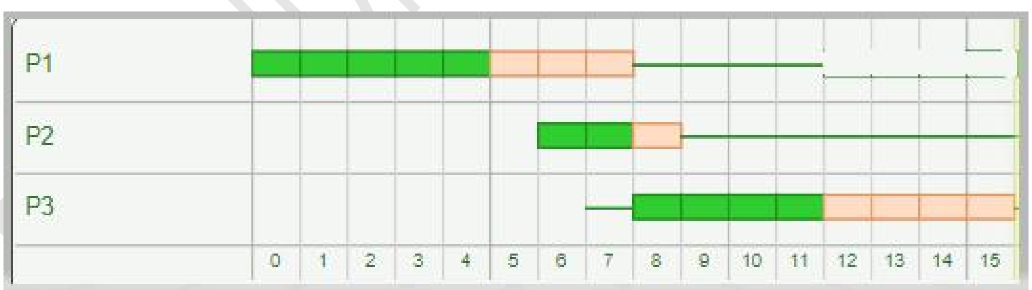


Green: CPU burst, and Red: IO Time

44) Consider the following process information with arrival times and the service times (burst time). All the IO devices are available. A first come first serve scheduling algorithm is used. The CPU is idle for _________ units. **[NAT]**

Process name	Arrival	CPU burst	IO burst
P1	0	5	3
P2	6	2	1
P3	7	4	4

Solution: 1



The CPU is idle for one time unit (At t=5 in above chart)

45) Consider the following information about five processes, P0,P1,P2,P3 and P4. Using FCFS Scheduling algorithm, calculate the CPU utilization (in %) by assuming context switch delay of 1 unit (Consider first context delay and ignore the last context switch). **[NAT]**

PID	Arrival Time	Burst Time

0	0	2
1	1	6
2	2	4
3	3	9
4	4	12

Solution: 86.84%

CS	P0	CS	P1	CS	P2	CS	P3	CS	P4
0	1	3	4	10	11	15	16	25	26 38

CPU Utilization = 1-overhead = 1-(5/38) = 0.8684 = 86.84%.

46) Consider the following preemptive priority-scheduling algorithm based on dynamically changing priorities. Larger priority numbers imply higher priority. When a process is waiting for CPU (in the ready queue, but not running), its priority changes at a rate of a (i.e., P(t) = P0 +a * (t - t0) where t0 is the time at which the process joins the ready queue) . Similarly, when it is running, its priority changes at a rate b. All processes are given a priority 0 when they enter the ready queue. The parameters a and b can be set to obtain many different scheduling algorithms.

Prove that when b > a > 0, it results in an FCFS scheduling algorithm.

Proof:

a - the rate at which the priority of the process changes in the ready queue. (a>0)
b - the rate at which the priority of the process changes when on CPU (running). (b>0)
t0 - time at which the process enters the ready queue.
P0 - priority of each process when entering the ready queue = P0 = 0.
At any point of time t, the priority of each process in ready queue is P(t) = P0 + a(t-t0) = a(t-t0)
At any point of time t, the priority of each process in running is P(t) = P0 + b(t-t0) = b(t-t0).

Let us consider four processes A, B, and C with arrival times 0, 1, and 2 respectively.
Let the burst time be A=2, B=2, and C =1.
Let a=0.1 units, and b = 0.2 units (b>a). ie, a and b increases by 0.1 and 0.2 units evert t=1 unit, respectively.

Time (t)	Arrived (t0)	Ready Queue P(t) = a(t-t0)	Running P(t) = b(t-t0)	Comments
t=0	A: t0=0	A: P(0) = 0.1*0 =0	A	A runs on CPU as no other process
t=1	B:t0=1	B: P(1) = 0.1*(1-	A: P(1) = 0.4(1-0)	A continued on CPU as

		1)=0.	=0.4	priority of B is 0.
t=2	C:t0=2	C: P(2) = 0.1*(2-0)=0. B: P(2) = 0.2*(2-1)=0.2.	A: Completed. B: is scheduled	Priority of B is more than C hence B is scheduled.
t=3		C: P(3) = 0.2*(3-2)=0.2	B: P(3) = 0.4(3-1) =0.8	B continues to run CPU as priority of B is more than C.
It can be observed that the newly arrived process will always have lower priority than processes that have arrived earlier. Therefore, PREEMPTION is not possible.Hence, the algorithm behaves as FCFS.				

47) The traditional UNIX scheduler enforces an inverse relationship between priority numbers and priorities: The higher the number, the lower the priority. The scheduler recalculates process priorities once per second using the following formula:

Priority = (Recent CPU usage / 2) + Base

where Base = 6 and recent CPU usage refers to a value indicating how often a process has used the CPU since priorities were last recalculated. Assume that recent CPU usage for process P1 is 4, for process P2 is 2 and for process P3 is 0 (just arrived). Which process will be given higher priority once the new priorities for these three processes are recalculated?

A) P1
B) P2
C) P3
D) P1 and P3 have equal priority.

Solution: (C)

Priority = (Recent CPU usage / 2) + Base
P1: = 6 + 4/2 = 8.
P2: = 6 + 2/2 = 7.
P3: = 6 + 0/2 = 6.
Therefore, P3 is given the higher priority. (inverse relationship between priority numbers and priorities)

48) Identify the correct statement(s) from the following: **[MSQ]**

A) FCFS can *always* be used to implement a non-preemptive priority scheduling algorithm.
B) Non-preemptivePriority scheduling can *always* be used to implement a FCFS scheduling algorithm.
C) SJF can *always* be used to implement a non-preemptive priority scheduling algorithm.
D) Non-preemptive Priority scheduling can *always* be used to implement a SJF scheduling algorithm.

Solution: (B) (D)
FCFS is based on arrival time criteria. Therefore, it can implement priority scheduling only if the processes arrive in sorted order of priorities. Hence, (A) is not always true.

Priority can be set based on the arrival time. First arrival process has high priority and so on. Hence, (B) is true.

SJF is based on the smallest burst time criteria. Therefore, it can implement priority scheduling only if the processes arrive in sorted order of burst time. Hence, (C) is not always true.

Priority can be set based on the burst time. Smallest burst time has high priority and so on. Hence, (D) is true.

49) Consider a set of processes with given information. A non-preemptive priority scheduling is used. The average waiting time was found to be 4.8 units, which is minimum among any non preemptive scheduling (FCFS and SJF).

Process	Arrival Time	Burst Time
P1	3	1
P2	1	4
P3	4	2
P4	0	6
P5	2	3

The priority of each process in correct order (Highest priority to lowest priority) is:

A) P4>P1>P3>P5>P2
B) P4>P2>P1>P5>P3
C) P2<P5<P3<P1<P4
D) P4>P2>P5>P1>P3

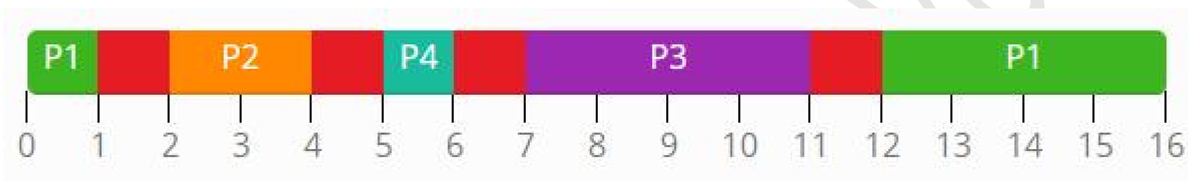
Solution: (A)
The waiting is 4.8 units and its minimum possible value among non-preemptive versions (SJF and FCFS). The minimum can occur when a shortest job is run first. Here, at t=0, only P4 has arrived so schedule it.
At t=6, all the processes have arrived. To get the minimum average waiting time, the priority scheduling should assign high priority to the shortest job.

50) Consider the following set of process information. The IO devices are available as requested. A preemptive priority scheduling is used (lower number indicates higher priority). The scheduling incurs a context switch delay of 1 unit (ignore the first and last context switch).

The completion time of process P1 is__________ **[NAT]**

Process:	Arrival Time:	Burst Time:	Priority:
P1	0	5	4
P2	1	2	2
P3	2	4	3
P4	4	1	1

Solution: 16



51) Consider a uniprocessor system executing three tasks T1, T2 and T3, each of which is composed of an infinite sequence of jobs (or instances) which arrive periodically at intervals of 3, 7 and 20 milliseconds, respectively. The priority of each task is the inverse of its period and the available tasks are scheduled in order of priority, with the highest priority task scheduled first. Each instance of T1, T2 and T3 requires an execution time of 1, 2 and 4 milliseconds, respectively. Given that all tasks initially arrive at time 0 and task preemptions are allowed, the first instance of T3 completes its execution at the end of ______________ milliseconds. **[NAT]**

Solution: 12

TIme of T1, T2 and T3 are 3ms, 7ms and 20ms.
Since priority is inverse of period:

T1 priority = 1/3.
T2 priority = 1/7.
T3 priority = 1/20.

Therefore, T1 has the highest priority followed by T2 and T3, respectively.

Process	Arrival time	Burst time	Priority
T_1	0, 3, 6, 9, ….	1	1/3 (Highest)
T_2	0, 7, 14, 21, ….	2	1/7
T_3	0, 20, 40, 60 ……	4	1/20

```
Time-Interval  Tasks
 0-1            T1
 1-2            T2
 2-3            T2
 3-4            T1  [Second Instance of T1 arrives]
 4-5            T3
 5-6            T3
 6-7            T1  [Third Instance of T1 arrives]
                    [Therefore T3 is preempted]
 7-8            T2  [Second instance of T2 arrives]
 8-9            T2
 9-10           T1  [Fourth Instance of T1 arrives]
10-11           T3
11-12           T3 [First Instance of T3 completed]
```

52) Consider the following set of process information. The IO devices are available as requested. A Round Robin scheduling is used with a time quantum of 3 units. The average turn around time and the average waiting time are ___________ and__________, respectively. [NAT]

Process:	A	B	C	D	E
Arrival time:	0	1	2	3	4
Service time:	3	4	2	1	5
Priority:	0	0	0	0	0

Solution: 7.6 and 4.6

t:	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CPU	A 1/3	A 2/3	B 1/4	B 2/4	C 1/2	C 2/2	A 3/3	D 1/1	E 1/5	E 2/5	B 3/4	B 4/4	E 3/5	E 4/5	E 5/5
	↑ A	↑ B	↑ C	↑ D	↑ E										

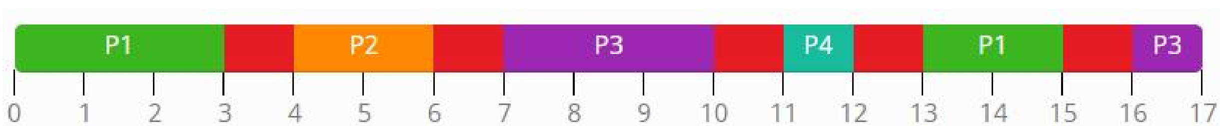
Order of service (table):

Process	Arrival	Service	Priority	Started	Completion	turnaround time (TAT)	waiting time (WAT)
C	2	2	0	4	6	4	2
A	0	3	0	0	7	7	4
D	3	1	0	7	8	5	4
B	1	4	0	2	12	11	7
E	4	5	0	8	15	11	6
Avg:	-	**3**	-	-	-	**7.6**	**4.6**

53) Consider the following set of process information. The IO devices are available as requested. A Round Robin scheduling is used with a time quantum of 3 units. The scheduling incurs a context switch delay of 1 unit (ignore the first and last context switch). The completion time of process P4 is _________. [NAT]

Process:	Arrival Time:	Burst Time:
P1	0	5
P2	1	2
P3	2	4
P4	3	1

Solution: 12



54) Consider the following set of process information. The IO devices are available as

requested. A Round Robin scheduling is used with a time quantum of 1.5 units. The scheduling incurs a context switch delay of 0.5 unit (ignore the first and last context switch). The completion time of process P3 is _________. [NAT]

Process:	Arrival Time:	Burst Time:
P1	0	5
P2	1	2
P3	2	4
P4	3	1

Solution: 15.5

55) The state transition diagram (finite automata transitions) for five processes A, B, C, D and E is given below:

Start	Stop	Q1
0	1	$\{B_{0/4}, A_{1/3}\}$
1	2	$\{A_{1/3}, C_{0/2}, B_{1/4}\}$
2	3	$\{C_{0/2}, B_{1/4}, D_{0/1}, A_{2/3}\}$
3	4	$\{B_{1/4}, D_{0/1}, A_{2/3}, E_{0/5}, C_{1/2}\}$
4	5	$\{D_{0/1}, A_{2/3}, E_{0/5}, C_{1/2}, B_{2/4}\}$
5	6	$\{A_{2/3}, E_{0/5}, C_{1/2}, B_{2/4}\}$
6	7	$\{E_{0/5}, C_{1/2}, B_{2/4}\}$
7	8	$\{C_{1/2}, B_{2/4}, E_{1/5}\}$
8	9	$\{B_{2/4}, E_{1/5}\}$
9	10	$\{E_{1/5}, B_{3/4}\}$
10	11	$\{B_{3/4}, E_{2/5}\}$
11	12	$\{E_{2/5}\}$
12	14	$\{E_{4/5}\}$

Start: is in time units
Stop: is in time units
Q1: Represents the Queue.
Ax/y : Process A completed x units out of its y units (burst). When x=0, the process has arrived at Queue Q1.

Find the scheduling algorithm used.

A) First Come First Serve
B) Round Robin with quantum = 1
C) Round Robin with quantum = 2
D) Insufficient data.

Solution: (B)

At t=1, the process A has completed 1 unit (x) out of its 3 units (y) burst. And, B has arrived and placed in front of the queue.
At t=2, the process B has completed 1 unit (x) out of its 4 units (y) burst. And, C has arrived and placed in the queue after A.

At t=3, the process A has completed 2 units (x) out of its 3 units (y) burst. D has arrived and C

is waiting to be scheduled next.
Therefore, we can observe that there is a context switch every 1 unit of time and the processes are scheduled by queuing. Hence, it is a RR scheduling with 1 unit of time quantum.

56) The state transition diagram (finite automata transitions) for five processes A, B, C, D and E is given below:

Start	Stop	Q1
0	1	$\{B_{0/4}, A_{1/3}\}$
1	2	$\{A_{1/3}, C_{0/2}, B_{1/4}\}$
2	3	$\{C_{0/2}, B_{1/4}, D_{0/1}, A_{2/3}\}$
3	4	$\{B_{1/4}, D_{0/1}, A_{2/3}, E_{0/5}, C_{1/2}\}$
4	5	$\{D_{0/1}, A_{2/3}, E_{0/5}, C_{1/2}, B_{2/4}\}$
5	6	$\{A_{2/3}, E_{0/5}, C_{1/2}, B_{2/4}\}$
6	7	$\{E_{0/5}, C_{1/2}, B_{2/4}\}$
7	8	$\{C_{1/2}, B_{2/4}, E_{1/5}\}$
8	9	$\{B_{2/4}, E_{1/5}\}$
9	10	$\{E_{1/5}, B_{3/4}\}$
10	11	$\{B_{3/4}, E_{2/5}\}$
11	12	$\{E_{2/5}\}$
12	14	$\{E_{4/5}\}$

Start: is in time units
Stop: is in time units
Q1: Represents the Queue.
Ax/y : Process A completed x units out of its y units (burst). When x=0, the process has arrived at Queue Q1.

The average turnaround time for the above schedule is _____________ units [NAT]

Solution: 7.8
The scheduling algorithm is irrelevant to calculate the avg TAT in this case.
Find the arrival time of each process and completion time. We can calculate TAT as
Turn around time = Completion time - Arrival Time

Process A: At t=1, process A has x=1, therefore it has to be arrived at 1.

From the description table A completes at t=7 (Because at t=6, A has completed x=2 out y=3 units). So, the turn around time = 7-0 = 7.

Similarly, calculate for process B, C, D and E.

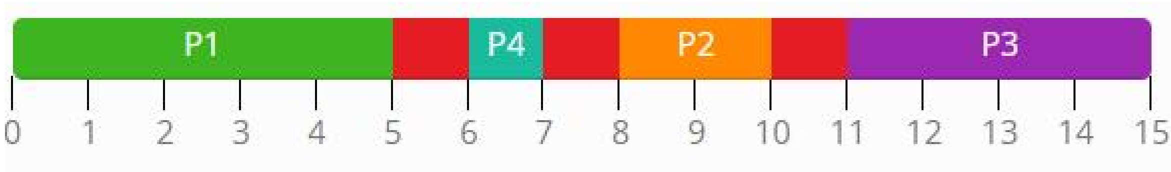
The average = (7 +11 + 7 + 3 + 11)/5 = 7.8

Process	Level	Start	Stop	Q1	TAT
A	1	0	1	$\{B_{0/4}, A_{1/3}\}$	
B	1	1	2	$\{A_{1/3}, C_{0/2}, B_{1/4}\}$	
A	1	2	3	$\{C_{0/2}, B_{1/4}, D_{0/1}, A_{2/3}\}$	
C	1	3	4	$\{B_{1/4}, D_{0/1}, A_{2/3}, E_{0/5}, C_{1/2}\}$	
B	1	4	5	$\{D_{0/1}, A_{2/3}, E_{0/5}, C_{1/2}, B_{2/4}\}$	
D	1	5	6	$\{A_{2/3}, E_{0/5}, C_{1/2}, B_{2/4}\}$	3
A	1	6	7	$\{E_{0/5}, C_{1/2}, B_{2/4}\}$	7
E	1	7	8	$\{C_{1/2}, B_{2/4}, E_{1/5}\}$	
C	1	8	9	$\{B_{2/4}, E_{1/5}\}$	7
B	1	9	10	$\{E_{1/5}, B_{3/4}\}$	
E	1	10	11	$\{B_{3/4}, E_{2/5}\}$	
B	1	11	12	$\{E_{2/5}\}$	11
E	1	12	14	$\{E_{4/5}\}$	11

57) Consider the following set of process information. The IO devices are available as requested. A Shortest Job First scheduling is used. The scheduling incurs a context switch delay of 1 unit (ignore the first and last context switch). The average average waiting time is__________ **[NAT]**

Process:	Arrival Time:	Burst Time:
P1	0	5
P2	1	2
P3	2	4
P4	3	1

Solution: 4.75



Avg WT = 0 + 3 + 7 + 9 = 19/4 = 4.75

58) Consider the following set of process information. The IO devices are available as requested.A Shortest Job First scheduling is used. The average turn around time and the average waiting time are __________ and_________, respectively. **[NAT]**

Process:	A	B	C	D	E
Arrival time:	0	1	2	3	4
Service time:	3	4	1	4	5

Solution: 6.8 and 3.4

t: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

CPU	A 1/3	A 2/3	A 3/3	C 1/1	B 1/4	B 2/4	B 3/4	B 4/4	D 1/4	D 2/4	D 3/4	D 4/4	E 1/5	E 2/5	E 3/5	E 4/5	E 5/5

↑ A ↑ B ↑ C ↑ D ↑ E

Order of service (table):

Process	Arrival	Service	Priority	Started	Completion	turnaround time (TAT)	waiting time (WAT)
A	0	3	0	0	3	3	0
C	2	1	0	3	4	2	1
B	1	4	0	4	8	7	3
D	3	4	0	8	12	9	5
E	4	5	0	12	17	13	8
Avg:	-	3.4	-	-	-	6.8	3.4

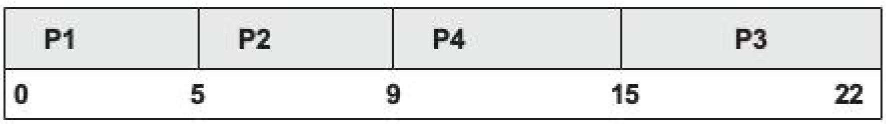
59) Consider the following scenario of processes:

Process	Arrival time	Execution

		time
P1	0	5
P2	2	4
P3	3	7
P4	5	6

The normalized turnaround time for process P3 using Shortest Job First (SJF) scheduling algorithm is____________. (Normalized turn around time of the process is the ratio of turn around time of the process over the burst length). **[NAT]**

Solution: 2.71



P1 starts at 0 and P2, which appears at 2, is of shorter execution time. But it cannot start until P1 finishes, since SPN is a non-pre-emptive scheduling algorithm. During this period, P3 and P4 have also appeared. It means now there are three processes P2, P3, and P4 in the ready queue. But P2 will be executed first at time 5, as it has the shortest execution time among all the processes. After P2 finishes the execution at 9, P4 gets preference over P3, as shown in the Gantt chart.
Normalized turnaround time of P3 = 19/7 = 2.71

60) Six jobs are waiting to be run, which have arrived at time 0. Their expected running times are 10, 8, 6, 3, 1, and X. Which one of the following orders of scheduling will NOT minimize average waiting time using Shortest Job First (SJF)?

A) 1, 3, 6, 8, X, 10 and 8 < X <= 10
B) 1, 3, X, 6, 8, 10 and 3 < X <= 6
C) 1, 3, 6, 8, 10, X and X > 10
D) X, 1, 3, 6, 8, 10 and X <= 2

Solution: (D)

Possible orders are: (scheduling X by ordering the processes in ascending order by running times will minimize waiting time)

When X <= 1, the order should be: X, 1, 3, 6, 8, 10
When 1 < X <= 3, the order should be: 1, X, 3, 6, 8, 10
When 3 < X <= 6, the order should be: 1, 3, X, 6, 8, 10
When 6 < X <= 8 , the order should be: 1, 3, 6, X, 8, 10
When 8 < X <= 10, the order should be: 1, 3, 6, 8, X, 10
When X > 10 , the order should be: 1, 3, 6, 8, 10, X.

Therefore, Option D violates this property.

61) Choose the correct statement(s) among the following **[MSQ]**

A) Shortest Job first has the advantage of having a minimum average response time among all scheduling algorithms.
B) Shortest Job first is a Greedy Algorithm.
C) Shortest Job first is starvation free.
D) Shortest job first can be implemented by approximation or prediction methods.

Solution: (B) (D)

Shortest Job first has the advantage of having a minimum average waiting time among all scheduling algorithms.
SJF is a greedy algorithm which selects a smaller process to minimize waiting time.
SJF may lead to starvation if the smaller processes keeps on arriving.
SJF can imletemed using moving averages, or prediction schemes to predict the burst, which are approximate for actual burst size.

62) Consider the following set of process information. The IO devices are available as requested. A Shortest Remaining Time First scheduling is used. The scheduling incurs a context switch delay of 1 unit (ignore the first and last context switch). The average average waiting time is___________ **[NAT]**

Process:	Arrival Time:	Burst Time:
P1	0	5
P2	1	2
P3	2	4
P4	3	1

Solution: 4.75

Average Wait Time: $\dfrac{6+1+10+2}{4}$

$= 4.75$

63) Consider the following set of process information. The IO devices are available as requested.A Shortest Remaining Time First scheduling is used. The average turn around time

and the average waiting time are __________ and_________, respectively. **[NAT]**

Process:	A	B	C	D	E
Arrival time:	0	1	2	3	4
Service time:	3	4	1	4	5

Solution: 6.8 and 3.4

t:	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
CPU	A 1/3	A 2/3	A 3/3	C 1/1	B 1/4	B 2/4	B 3/4	B 4/4	D 1/4	D 2/4	D 3/4	D 4/4	E 1/5	E 2/5	E 3/5	E 4/5	E 5/5
	↑ A	↑ B	↑ C	↑ D	↑ E												

Order of service (table):

Process	Arrival	Service	Priority	Started	Completion	turnaround time (TAT)	waiting time (WAT)
A	0	3	0	0	3	3	0
C	2	1	0	3	4	2	1
B	1	4	0	4	8	7	3
D	3	4	0	8	12	9	5
E	4	5	0	12	17	13	8
Avg:	-	3.4	-	-	-	6.8	3.4

64) Consider the following set of process information. The IO devices are available as requested.A Shortest Remaining Time First scheduling is used.

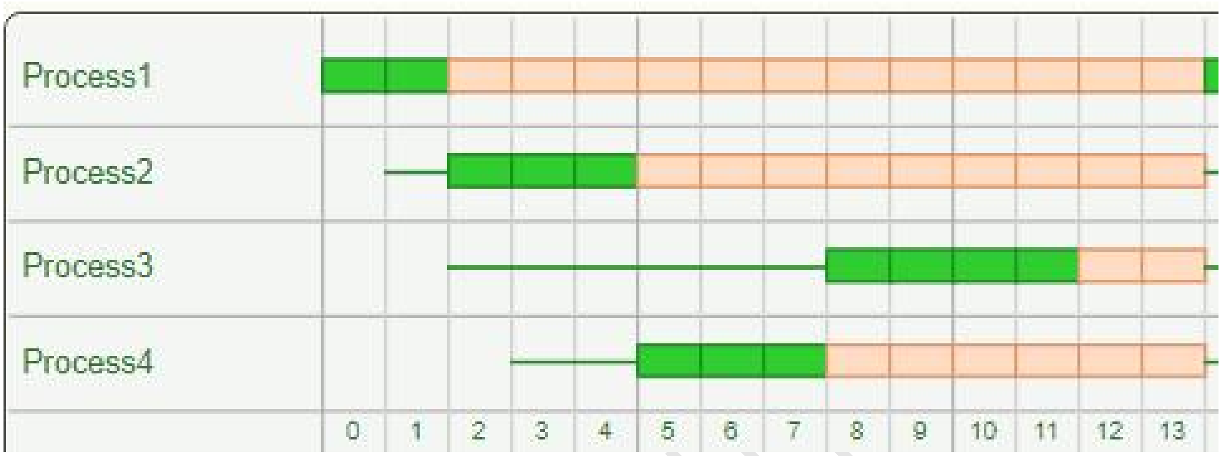
Process name	Arrival	CPU burst	IO burst
Process1	0	2	12
Process2	1	3	9
Process3	2	4	2
Process4	3	3	6

Which of the following processes completes first (including IO respective IO). ?

A) Process 1 completes first.

B) Process 2 and Process3 complete at the same time.
C) Process 1 and Process4 complete at the same time.
D) All the processes complete at the same time.

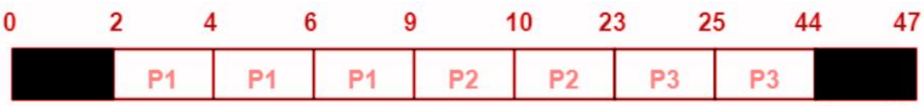
Solution: (D)



65) Consider three processes, all arriving at time zero, with total execution time of 10, 20 and 30 units respectively. Each process spends the first 20% of execution time doing I/O, the next 70% of time doing computation, and the last 10% of time doing I/O again. The operating system uses a shortest remaining compute time first scheduling algorithm and schedules a new process either when the running process gets blocked on I/O or when the running process finishes its compute burst. Assume that all I/O operations can be overlapped as much as possible. For __________ percentage of the CPU remains idle. **[NAT]**

Solution: 10.63%

	Total Burst Time	I/O Burst	CPU Burst	I/O Burst
Process P1	10	2	7	1
Process P2	20	4	14	2
Process P3	30	6	21	3



Percentage of time the CPU remains idle = (5 / 47) x 100 = 10.638%.

66) The state transition diagram (finite automata transitions) for five processes A, B, C, D and E is given below:

Start	Stop	Q1
0	3	$\{C_{0/1}, B_{0/4}, D_{0/4}\}$
3	4	$\{B_{0/4}, D_{0/4}, E_{0/5}\}$
4	8	$\{D_{0/4}, E_{0/5}\}$
8	12	$\{E_{0/5}\}$
12	17	

Start: is in time units
Stop: is in time units
Q1: Represents the Queue.
Ax/y : Process A completed x units out of its y units (burst). When x=0, the process has arrived at Queue Q1.

The average turnaround time for the above schedule is _____________ units **[NAT]**

Solution: 6.8

Process	Level	Start	Stop	Q1	TAT
A	1	0	3	$\{C_{0/1}, B_{0/4}, D_{0/4}\}$	3
C	1	3	4	$\{B_{0/4}, D_{0/4}, E_{0/5}\}$	2
B	1	4	8	$\{D_{0/4}, E_{0/5}\}$	7
D	1	8	12	$\{E_{0/5}\}$	9
E	1	12	17		13

At t=3, A is not in the queue, so it has completed.

Therefore, Average turnaround time (ATAT) = 6.8.

67) Which of the following is not a function of dispatcher ?

A) Switching context
B) Switching to user mode
C) Jumping to the proper location in the newly loaded program.
D) It selects a process in the ready queue that should be scheduled for execution

Solution: (D)
Dispatcher starts functioning once the scheduler's functions are over. It takes the process to the desired state or queue. When the short term scheduler selects the process from the ready queue, the dispatcher performs the task of allocating the selected process to the CPU. When the running process goes to the waiting state than CPU is allocated to some other process. The switching of CPU from one process to another is called context switching.
Dispatcher function involves: Switching context, Switching to user mode and Jumping to the proper location in the newly loaded program.

68) Suppose a new process in a system arrives at an average of 6 processes per minute and each such process requires an average of 8 seconds of service time. The fraction of time the CPU is busy in a system with a single processor is_____.
A) 0.8
B) 0.6
C) 0.75
D) 0.5

Solution: (A)
Given that there are on an average 6 processes per minute.
So the arrival rate = 6 process/min.
i.e. every 10 seconds a new process arrives on an average.
Or we can say that every process stays for 10 seconds with the CPU
Service time = 8 sec.
Hence the fraction of time CPU is busy = service time / staying time = 8 / 10 =0.8

69) Consider a scheduling algorithm (at the level of a short-term scheduler) favors those processes which have used little processor (CPU) time in the recent past. Which of the following statement(s) regarding the above algorithm is/are correct? [MSQ]

A) This algorithm favors I/O bound processes.
B) This algorithm starves CPU bound processes.
C) This algorithm favors CPU bound processes.
D) This algorithm does not starve CPU bound processes

Solution: (A) (D)
Since I/O bound processes use little processor time due to their blocking for I/O, they will be favored over CPU bound processes, which use large amounts of CPU time. However, if I/O bound processes repeatedly use the CPU and thereby prevent CPU bound jobs from acquiring it, then the amount of processor time used by CPU bound processes in the recent past drops; eventually it will be low enough so the CPU bound process gets the CPU.Hence this algorithm will not starve CPU bound programs.

70) Which of the following event(s) may lead to mode switch? [MSQ]

A) Exception
B) Segmentation fault
C) Software interrupt

D) System call

Solution: (A) (B) (C) (D)

All of them require OS intervention hence requires to transit the mode from user to kernel.

71) During a Context Switch event, which of the following actions may take place? [MSQ]

A) Mode switch from Kernel mode to user mode.
B) Call the specific event handler
C) Restore the process's states
D) Mode switch from User mode to Kernel mode.

Solution: (A)(B)(C)(D).

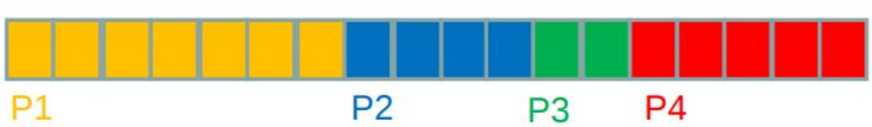
Once the CPU detects a context switch event, the following sequence of actions will take place:
1. switch from user-mode to kernel-mode (set Mode bit to kernel mode)
2. Saves user processes' states (PC, registers, etc.)
3. Call the specific event handler
4. Restore the process's states (other process)
5. Set mode bit to User Mode (other process)

72) Consider the set of process information.

Process	Arrival Time	Burst Time
P1	0	7
P2	0	4
P3	0	2
P4	0	5

The difference between the average waiting time and response time using FCFS scheduling is ___________ [NAT]

Solution: 0



Average Waiting Time = (0 + 7 + 11 + 13) / 4 = 7.75
Average Response Time = (0 + 7 + 11 + 13) / 4 = 7.75

73) Consider the set of process information.

Process	Arrival Time	Burst Time
P1	0	7
P2	2	4
P3	4	2
P4	7	1

The difference between the average waiting time and response time using SRTF scheduling is ___________ [NAT]

Solution: 1.75
Average wait time = (7 + 0 + 2 + 1) / 4 = 2.5
Average response time = (0 + 0 + 2 + 1) / 4 = 0.75

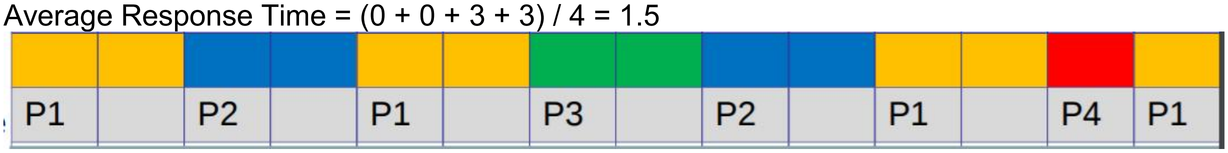
74) Consider the set of process information.

Process	Arrival Time	Burst Time
P1	0	7
P2	2	4
P3	3	2
P4	9	1

The difference between the average waiting time and response time using RR scheduling with time slice of 2 units is ___________ [NAT]

Solution: 2.75

Average Waiting time = (7 + 4 + 3 + 3) / 4 = 4.25
Average Response Time = (0 + 0 + 3 + 3) / 4 = 1.5



75) Consider the set of process information.

Process	Arrival Time	Burst Time
P1	0	7
P2	2	4
P3	3	2
P4	9	1

The total number of context switches (ignore the switch at beginning and completion) are ___________, if RR scheduling with a time slice of 1 unit is used. [NAT]

Solution: 11

P1		P2	P1	P3	P2	P1	P3	P2	P1	P4	P2	P1	P1

76) Which of the following is not a goal of a Scheduler?

A) Minimize waiting time.
B) Maximize CPU utilization.
C) Fairness.
D) None of these.

Solution: (D)
The goals of Scheduler are:
Minimize waiting time: Process should not wait long in the ready queue
Maximize CPU utilization: CPU should not be idle
Maximize throughput : Complete as many processes as possible per unit time
Minimize response time : CPU should respond immediately
Fairness : Give each process a fair share of CPU.

77) Which of the following scheduling algorithms will tend to schedule I/O bound jobs before CPU bound jobs?

A. Shortest-Remaining-time-first
B. Multilevel Feedback Queues
C. Round Robin
D. First Come First Serve

Solution: (B)

If a process blocks for I/O, it is 'promoted' one level, and placed at the end of the next-higher queue. This allows I/O bound processes to be favored by the scheduler

78) Which of the following statement is correct?

A. The scheduler runs on every context switch.
B. A context switch can occur in the middle of an instruction.
C. SRTF is the fairest scheduling algorithm.
D. Multiprogramming is unnecessary on single-user systems.

Solution: (B)
A scheduler need not run every context switch. For example, in RR scheduling based on the queue the next process takes the CPU.
A context switch (preemption) can occur in the middle of a non-atomic instruction.
SRTF favours shortest jobs, hence not fair.
Multiprogramming is required to run more than one process on a single-user system.

79) Which of the following is NOT TRUE regarding the parameters that define Multilevel Feedback-Queue Scheduling?

A) The number of queues.
B) The scheduling algorithm for each queue.
C) The method used to determine which queue a process enters initially.
D) None of these.

Solution: (D)

Some of the parameters which define one of these systems include:
The number of queues.
The scheduling algorithm for each queue.
The methods used to upgrade or demote processes from one queue to another. (Which may be different.)
The method used to determine which queue a process enters initially.

80) Consider the following information about five processes, P0,P1,P2,P3 and P4. Using FCFS Scheduling algorithm, the average normalized turnaround time is __________.

PID	Arrival Time	Burst Time
0	0	2
1	1	6
2	2	4
3	3	9
4	4	12

Solution: 1.71

PID	Arrival Time	Burst Time	CT	TAT	WT	Normalized TAT
0	0	2	2	2	0	2/2
1	1	6	8	7	1	7/6
2	2	4	12	8	4	8/4
3	3	9	21	18	9	18/9
4	4	12	33	29	17	29/12

Average NTAT = 1+1.16+2+2+2.41 / 5 = 1.71

81) Consider the following information about five processes, P0,P1,P2,P3 and P4. Using HRRN Scheduling algorithm, the difference between the average turnaround time and average waiting time is __________ [NAT]

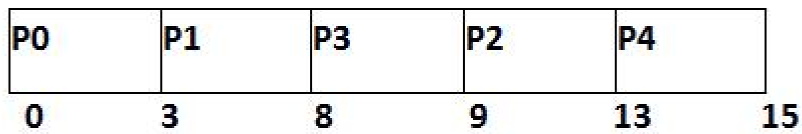
PID	Arrival Time	Burst Time
0	0	3
1	2	5
2	4	4
3	6	1
4	8	2

Solution: 3

At time 0, The Process P0 arrives with the CPU burst time of 3 units. Since it is the only process arrived till now hence this will get scheduled.
Process P1 arrives at time 2. This will get scheduled at t=3 .
P1 is executed for 5 units. At t=8, all the processes are available. We have to calculate the Response Ratio for all the remaining jobs.

Response Ratio P2 = ((8-4) +4)/4 = 2
Response Ratio P3 = (2+1)/1 = 3
Response Ratio P4 = (0+2)/2 = 1
Since, the Response ratio of P3 is higher hence P3 will be scheduled first.

At t=9,
Response Ratio P2 = (5+4)/4 = 2.25
Response Ratio P4 = (1+2)/2 = 1.5
The response ratio of P2 is higher hence P2 will be scheduled. At t=13, P4 will be scheduled.



Avg TAT = 28/5 =5.6, Avg WT = 13/5 = 2.6

82. Consider the process information for a set of processes, assuming the context switch delay to be 0, calculate the average waiting time, average turn around, average response time and throughput, using a first come first serve scheduling algorithm.

Process	Arrival time	Burst time
P1	0	5
P2	2	3
P3	6	2
P4	7	3

Solution : Average Turnaround Time = 5.25, Average Waiting Time = 2.00, Average Response Time = 2.00, Throughput = 0.31 process/unit time.

83. Consider the process information for set of processes, assuming the context switch delay to be 0, calculate the average waiting time, average turn around, average response time and throughput, using first come first serve scheduling algorithm.

Process	Arrival time	Burst time
P1	1	5
P2	2	3
P3	3	8
P4	7	3

Solution : Average Turnaround Time = 9.75, Average Waiting Time = 5.00, Average Response Time = 5.00, Throughput = 0.2 process/unit time

84. Consider the process information for set of processes, assuming the context switch delay to be 0, calculate the average waiting time, average turn around, average response time and throughput, using first come first serve scheduling algorithm.

Process	Arrival time	Burst time
P1	0	5
P2	7	3
P3	8	8
P4	9	3

Solution : Average Turnaround Time = 7.50, Average Waiting Time = 2.75, Average Response Time = 2.75, Throughput = 0.19 process/unit time

85. Consider the process information for set of processes, assuming the context switch delay to be 0, calculate the average waiting time, average turn around, average response time and throughput, using first come first serve scheduling algorithm.

Process	Arrival time	Burst time
P1	0	5
P2	7	3
P3	8	8

Solution : Average Turnaround Time = 6.00, Average Waiting Time = 0.67, Average Response Time = 0.67, Throughput = 0.17 process/unit time

86. Consider the process information for set of processes, assuming the context switch delay to be 0, calculate the average waiting time, average turn around, average response time and throughput, using first come first serve scheduling algorithm.

Process	Arrival time	Burst time
P1	0	5
P2	7	8
P3	8	8

Solution : Average Turnaround Time = 9.33, Average Waiting Time = 2.33, Average Response Time = 2.33, Throughput = 0.13 process/unit time

87. Consider the process information for set of processes, assuming the context switch delay to be 0, calculate the average waiting time and average waiting time using Shortest Job first scheduling algorithm.

Process	Arrival time	Burst time
P1	0	5
P2	2	3
P3	6	2
P4	7	3

Solution : Average Turnaround Time = 5.25, Average Waiting Time = 2.00, Average Response Time = 2.00, Throughput = 0.31 process/unit time

88. Consider the process information for set of processes, assuming the context switch delay to be 0, calculate the average waiting time and average waiting time using using Shortest Job first scheduling algorithm.

Process	Arrival time	Burst time
P1	1	5
P2	2	3
P3	3	8
P4	7	3

Solution : Average Turnaround Time = 8.5, Average Waiting Time = 3.75, Average Response Time = 3.75, Throughput = 0.2 process/unit time

89. Consider the process information for set of processes, assuming the context switch delay to be 0, calculate the average waiting time and average waiting time using using Shortest Job first scheduling algorithm.

Process	Arrival time	Burst time

P1	0	5
P2	7	3
P3	8	8
P4	9	3

Solution : Average Turnaround Time = 6.25, Average Waiting Time = 1.50, Average Response Time = 1.50, Throughput = 0.19 process/unit time

90. Consider the process information for set of processes, assuming the context switch delay to be 0, calculate the average waiting time and average waiting time using using Shortest Job first scheduling algorithm.

Process	Arrival time	Burst time
P1	0	5
P2	7	3
P3	8	8

Solution : Average Turnaround Time = 6.00, Average Waiting Time = 0.67, Average Response Time = 0.67, Throughput = 0.17 process/unit time

91. Consider the process information for set of processes, assuming the context switch delay to be 0, calculate the average waiting time, average turn around, average response time and throughput, using Non preemptive Priority scheduling algorithm. (Higher number implies higher priority)

Process	Arrival time	Burst time	Priority
P1	0	5	1
P2	2	3	2
P3	6	2	3
P4	7	3	4

Solution : Average Turnaround Time = 5.50, Average Waiting Time = 2.25, Average Response Time = 2.25, Throughput = 0.31 process/unit time

92. Consider the process information for set of processes, assuming the context switch delay to be 0, calculate the average waiting time, average turn around, average response time and throughput, using Non preemptive Priority scheduling algorithm.(Higher number implies higher priority)

Process	Arrival time	Burst time	Priority
P1	1	5	1
P2	2	3	3
P3	3	8	5
P4	7	3	2

Solution : Average Turnaround Time = 11.00, Average Waiting Time = 6.25, Average Response Time = 6.25, Throughput = 0.20 process/unit time

93. Consider the process information for set of processes, assuming the context switch delay to be 0, calculate the average waiting time, average turn around, average response time and throughput, using Non preemptive Priority scheduling algorithm.(Higher number implies higher priority)

Process	Arrival time	Burst time	Priority
P1	0	5	2
P2	7	3	1
P3	8	8	4
P4	9	3	0

Solution : Average Turnaround Time = 7.50, Average Waiting Time = 2.75, Average Response Time = 2.75, Throughput = 0.19 process/unit time

94. Consider the process information for set of processes, assuming the context switch delay to be 0, calculate the average waiting time, average turn around, average response time and throughput, using Non preemptive Priority scheduling algorithm.(Higher number implies higher priority)

Process	Arrival time	Burst time	Priority

P1	0	5	1
P2	7	3	2
P3	8	8	0

Solution : Average Turnaround Time = 6.00, Average Waiting Time = 0.67, Average Response Time = 0.67, Throughput = 0.17 process/unit time

95. Consider the process information for set of processes, assuming the context switch delay to be 0, calculate the average waiting time, average turn around, average response time and throughput, using Non preemptive Priority scheduling algorithm. (Higher number implies higher priority)

Process	Arrival time	Burst time	Priority
P1	0	5	3
P2	7	6	1
P3	7	8	0

Solution : Average Turnaround Time = 8.33, Average Waiting Time = 2.00, Average Response Time = 2.00, Throughput = 0.14 process/unit time

96. Consider the process information for set of processes, assuming the context switch delay to be 0, calculate the average waiting time, average turn around, average response time and throughput, using preemptive Priority scheduling algorithm. (Higher number implies higher priority)

Process	Arrival time	Burst time	Priority
P1	0	5	1
P2	2	3	2
P3	6	2	3
P4	7	3	4

Solution : Average Turnaround Time = 6.00, Average Waiting Time = 2.75, Average Response Time = 0.00, Throughput = 0.31 process/unit time

97. Consider the process information for set of processes, assuming the context switch delay to be 0, calculate the average waiting time, average turn around, average response time and throughput, using preemptive Priority scheduling algorithm.(Higher number implies higher priority)

Process	Arrival time	Burst time	Priority
P1	1	5	1
P2	2	3	3
P3	3	8	5
P4	7	3	2

Solution : Average Turnaround Time = 11.75, Average Waiting Time = 7.00, Average Response Time = 1.50, Throughput = 0.21 process/unit time

98. Consider the process information for set of processes, assuming the context switch delay to be 0, calculate the average waiting time, average turn around, average response time and throughput, using preemptive Priority scheduling algorithm.(Higher number implies higher priority)

Process	Arrival time	Burst time	Priority
P1	0	5	2
P2	7	3	1
P3	8	8	4
P4	9	3	0

Solution : Average Turnaround Time = 9.00, Average Waiting Time = 4.25, Average Response Time = 2.25, Throughput = 0.19 process/unit time

99. Consider the process information for set of processes, assuming the context switch delay to be 0, calculate the average waiting time, average turn around, average response time and throughput, using preemptive Priority scheduling algorithm.(Higher number implies higher priority)

Process	Arrival time	Burst time	Priority
P1	0	5	1
P2	7	3	2
P3	8	8	0

Solution : Average Turnaround Time = 6.00, Average Waiting Time = 0.67, Average Response Time = 0.67, Throughput = 0.17 process/unit time

100. Consider the process information for set of processes, assuming the context switch delay to be 0, calculate the average waiting time, average turn around, average response time and throughput, using preemptive Priority scheduling algorithm. (Higher number implies higher priority)

Process	Arrival time	Burst time	Priority
P1	0	5	3
P2	7	6	1
P3	7	8	0

Solution : Average Turnaround Time = 8.33, Average Waiting Time = 2.00, Average Response Time = 2.00, Throughput = 0.14 process/unit time

101. Consider the process information for set of processes, assuming the context switch delay to be 0, calculate the average waiting time, average turn around, average response time and throughput, using SRTF scheduling algorithm.

Process	Arrival time	Burst time
P1	0	5
P2	2	3
P3	6	2
P4	7	3

Solution : Average Turnaround Time = 5.25 Average Waiting Time = 2.00 Average Response Time = 2.00 Throughput = 0.31 process/unit time

102. Consider the process information for set of processes, assuming the context switch delay to be 0, calculate the average waiting time, average turn around, average response time and throughput, using SRTF scheduling algorithm.

Process	Arrival time	Burst time
P1	1	5
P2	2	3
P3	3	8
P4	7	3

Solution : Average Turnaround Time = 8.25, Average Waiting Time = 3.50, Average Response Time = 2.75, Throughput = 0.21 process/unit time

103. Consider the process information for set of processes, assuming the context switch delay to be 0, calculate the average waiting time, average turn around, average response time and throughput, using SRTF scheduling algorithm.

Process	Arrival time	Burst time
P1	0	5
P2	7	3
P3	8	8
P4	9	3

Solution : Average Turnaround Time = 6.25, Average Waiting Time = 1.50, Average Response Time = 1.50, Throughput = 0.19 process/unit time

104. Consider the process information for set of processes, assuming the context switch delay to be 0, calculate the average waiting time, average turn around, average response time and throughput, using SRTF scheduling algorithm.

Process	Arrival time	Burst time
P1	0	5

P2	7	3
P3	8	8

Solution : Average Turnaround Time = 6.00, Average Waiting Time = 0.67, Average Response Time = 0.67, Throughput = 0.17 process/unit time

105. Consider the process information for set of processes, assuming the context switch delay to be 0, calculate the average waiting time, average turn around, average response time and throughput, using SRTF scheduling algorithm.

Process	Arrival time	Burst time
P1	0	5
P2	7	8
P3	8	8

Solution : Average Turnaround Time = 9.33, Average Waiting Time = 2.33, Average Response Time = 2.33, Throughput = 0.13 process/unit time

106. Consider the process information for set of processes, assuming the context switch delay to be 0, calculate the average waiting time, average turn around, average response time and throughput, using RR scheduling algorithm, time quantum=2.

Process	Arrival time	Burst time
P1	0	5
P2	2	3
P3	6	2
P4	7	3

Solution : Average Turnaround Time = 6.00, Average Waiting Time = 2.75, Average Response Time = 1.00, Throughput = 0.31 process/unit time

107. Consider the process information for set of processes, assuming the context switch delay to be 0, calculate the average waiting time, average turn around, average response time and throughput, using RR scheduling algorithm, time quantum=3.

Process	Arrival time	Burst time
P1	1	5
P2	2	3
P3	3	8
P4	7	3

Solution : Average Turnaround Time = 10.25, Average Waiting Time = 5.50, Average Response Time = 2.75, Throughput = 0.29 process/unit time

108.Consider the process information for set of processes, assuming the context switch delay to be 0, calculate the average waiting time, average turn around, average response time and throughput, using RR scheduling algorithm, time quantum=2.

Process	Arrival time	Burst time
P1	0	5
P2	7	3
P3	8	8
P4	9	3

Solution : Average Turnaround Time = 8.25, Average Waiting Time = 3.50, Average Response Time = 0.75, Throughput = 0.24 process/unit time

109.Consider the process information for set of processes, assuming the context switch delay to be 0, calculate the average waiting time, average turn around, average response time and throughput, using RR scheduling algorithm, time quantum=2.

Process	Arrival time	Burst time
P1	0	5
P2	7	3
P3	8	8

Solution : Average Turnaround Time = 6.67, Average Waiting Time = 1.33, Average Response Time = 0.33, Throughput = 0.17 process/unit time

110. Consider the process information for set of processes, assuming the context switch delay to be 0, calculate the average waiting time, average turn around, average response time and throughput, using RR scheduling algorithm, time quantum=1.

Process	Arrival time	Burst time
P1	0	5
P2	7	8
P3	8	8

Solution : Average Turnaround Time = 11.67, Average Waiting Time = 4.67, Average Response Time = 0.00, Throughput = 0.13 process/unit time

111. Consider the process information for set of processes, assuming the context switch delay to be 0, calculate the average waiting time, and average turn around, using HRRN scheduling algorithm.

Process	Arrival time	Burst time
P1	0	5
P2	2	3
P3	6	2
P4	7	3

Solution : Average waiting time: 2.000000, Average Turn Around time: 5.250000

112. Consider the process information for set of processes, assuming the context switch delay to be 0, calculate the average waiting time, and average turn around, using HRRN scheduling algorithm.

Process	Arrival time	Burst time
P1	0	5
P2	7	3

P3	8	8
P4	9	3

Solution : Average waiting time:1.5, Average Turn Around time:6.25

113. Consider the process information for set of processes, assuming the context switch delay to be 0, calculate the average waiting time, and average turn around, using HRRN scheduling algorithm.

Process	Arrival time	Burst time
P1	0	5
P2	7	3
P3	8	8

Solution : Average Turnaround Time = 6.00, Average Waiting Time = 0.67

114. Consider the process information for set of processes, assuming the context switch delay to be 0, calculate the average waiting time, and average turn around, using HRRN scheduling algorithm.

Process	Arrival time	Burst time
P1	0	5
P2	7	8
P3	8	8

Solution : Average Turnaround Time = 9.33, Average Waiting Time = 2.33