V

Operating System

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1 Introduction and Background of Operating System

Multiple Choice Questions

Q.1 The main objective of multiprogramming is
(a) maximize the device utilization
(b) minimize the response time of a job
(c) maximize the cpu utilization
(d) minimize the waiting time of a job.

Q.2 Which of the following is not a functionality of an operating system?
(a) allocating the memory to program
(b) scheduling the program under cpu
(c) correcting the logical errors in the program
(d) protecting the programs data not accessed by other programs

Q.3 Consider the following three statements:
S_1 : Interacting with hardware is trivial
S_2 : Main memory is unlimited
S_3 : Processing speed of the processor is unlimited.
Which of the above statements weakness the necessity of the OS?
(a) Only S_3 (b) Only S_2
(c) Only S_1 and S_2 (d) All S_1, S_2 and S_3

Q.4 A system with multiple cpu's called
(a) time sharing system
(b) desk top system
(c) client server system
(d) parallel system

Q.5 The primary goal of an operating system is?
(a) to make the most efficient use of the computer hardware
(b) to allow people to use the computer
(c) to keep systems programmers employed
(d) to make computers easier to use.
[ISRO : 2009]

Q.6 System calls are usually invoked by using
(a) a software interrupt
(b) polling
(c) as indirect jump
(d) a privileged instruction

Q.7 Match the pairs:

List-I	List-II
A. System call	1. Context switching
B. Command interpreter	2. Medium term schedule
C. Wwapper	3. Interrupt
D. Dispatcher	4. User mode

(a) A - 4, B - 2, C - 1, D - 3
(b) A - 3, B - 4, C - 2, D - 1
(c) A - 3, B - 1, C - 4, D - 2
(d) A - 3, B - 4, C - 1, D - 2

Q.8 In memory hierarchy moving from register to hard disk, which of the following is false?
(a) Memory size increases
(b) Cost per unit decreases
(c) Access time decreases
(d) None of the above

Q.9 When an interrupt occurs, then
(a) Process switching may be there
(b) Context saving must be there
(c) Both (a) and (b)
(d) None of the above

Q.10 RAM is
(a) volatile memory
(b) permanent memory
(c) associative memory
(d) none of the above

Q.11 Which of the following is the function of mid term scheduler in a time-sharing system?
(a) process creation
(b) context switching
(c) swapping
(d) controlling degree of multiprogramming
[JNU-2008]

Q.12 Special software to create a job queue is called as
(a) driver (b) spooler
(c) interpreter (d) linking editor
[ISRO-2009]

Q.13 On receiving an interrupt from an I/O device, the cpu
(a) Halts for a predetermined time
(b) Branches off to the interrupt service routine after completion of the current instruction.
(c) Branches off to the interrupt service routine immediately
(d) Hands over control of address bus and data bus to the interrupting device.

Q.14 Consider the following statements:
S_1 : Throughput always increases with increase in degree of multiprogramming
S_2 : Interrupt can be handled in between the execution of an instruction.
Which of the above are true?
(a) Only S_1
(b) Only S_2
(c) Both S_1 and S_2
(d) Neither S_1 nor S_2 is true

Q.15 System calls cannot be grouped into
(a) device management
(b) communications
(c) process control
(d) none of the above

Q.16 Which of the following instructions should privileged?
(a) set value of timer
(b) clear memory
(c) turn off interrupt
(d) all of the above

Q.17 Program counter specifies
(a) the current instruction to execute
(b) previous instruction to execute
(c) the address of the next instruction to execute
(d) the last instruction to execute

Q.18 Boot strap loader always stored in
(a) cache (b) ROM
(c) RAM (d) Disk

Q.19 Which of the following instructions should be allowed only in Kernel mode?
A : Disable all interrupts
B : Read the time of day clock
C : Set the time of day clock
D : Change the memory map
(a) 'A' and 'C' only (b) A, C and D only
(c) A, B and D only (d) All of them
[DRDO-2009]

Q.20 A multi user, multiprocessing OS cannot be implemented on hardware that does not support.
(a) Address translation
(b) DMA for Disk transfer
(c) At least two modes of CPU execution (privileged and non-privileged
(d) Demand paging

Q.21 Which of the following statements is false?
(a) The dual mode of operation provides a way for protecting the operating system from the errant users.
(b) At boot time the hardware starts in privileged mode
(c) The operating system always runs in privileged mode
(d) None of the above

Q.22 Distributed systems should
(a) meet prescribed time constraints
(b) aim better resource sharing
(c) aim better system utilization
(d) aim low system overhead

Q.23 The main function of shared memory is to
(a) use primary memory efficiently
(b) do intra process communication
(c) do inter process communication
(d) None of these

Try Yourself

T1. When a computer is switched on, where is the operating system loaded?
(a) BIOS (b) ROM
(c) POST (d) RAM
[Ans: (d)]

T2. Loading the OS into the memory of a PC is called
(a) thrashing (b) booting
(c) formatting (d) spooling
[Ans: (b)]

T3. Supervisor call
(a) is a call made by the supervisor of the system
(b) is a call with control functions
(c) are privileged calls that are used to perform resource management functions, which are controlled by OS
(d) is a call made by someone working in root directory
[Ans: (c)]

T4. Which of the following is NOT supported by the operating system?
(a) Protection (b) Accounting
(c) Compilation (d) I/O operation
[Ans: (c)]

T5. In a multiprogramming environment
(a) The processor executes more than one process at a time
(b) the programs are developed by the more than one person
(c) more than one process resides in the memory
(d) a single user can execute many programs at the same time
[Ans: (c)]

■■■■

2 Processes and Threads

Multiple Choice Questions

Q.1 Process is
(a) A program is high level language kept on disk
(b) Contents of main memory
(c) A program under execution
(d) A job in secondary memory

Q.2 Which is the correct definition of a valid process transition in an operating system?
(a) Wakeup : Ready → Running
(b) Dispatch : Ready → Running
(c) Block : Ready → Running
(d) Timer runout : Ready → Blocked
[ISRO - 2009]

Q.3 Process Control Block (PCB) of all running processes resides in which of the following ?
(a) RAM (b) Hard disk
(c) Cache (d) None of the above

Q.4 If a system contains 'n' processors and 'n' processes then what will be maximum and minimum processes in running state respectively.
(a) n, n (b) n, 0
(c) n^2, 0 (d) n^2, n^2

Q.5 If a process on the system could issue an I/O request then the process will be placed on which of the following ?
(a) Ready state (b) Running state
(c) Ready queue (d) I/O queue

Q.6 Match List-I with List-II select the correct answer using the codes given below the lists:

List-I
A. Run → Ready
B. Run → Blocked
C. Block → Run
D. Run → Terminated

List-II
1. Not possible
2. When a process terminate itself
3. When a process time quantum expires
4. When a process issues an input/output request.

Codes:

	A	B	C	D
(a)	1	4	3	2
(b)	2	1	3	4
(c)	3	4	1	2
(d)	1	4	3	2

Q.7 The difference of the time you get the first results to the time of submission of the job is known as
(a) completion time (b) turn award time
(c) response time (d) waiting time

Q.8 Only one of the following is initiated by the user program all other are initiated by external entities
(a) Transition from ready state to running state
(b) Transition from running state to ready state
(c) Transition from running state to block state
(d) Transition from blocked state to ready state

Q.9 The purpose of suspending a process is
(a) The process requires I/O operation
(b) The process time quantum expires
(c) A high priority process enters the ready device
(d) The system falls short of resources

Q.10 Which of the following is normally stored in process control block (PCB)
(a) PC
(b) Process id
(c) Process state
(d) All the above

Q.11 Which of the following controls the degree of multiprogramming?
(a) CPU scheduler
(b) Dispatcher
(c) medium term scheduler
(d) long term scheduler

Q.12 A process executes the following code:
for (i = 0; $i < n$; i ++)
fork ( );
The total number of child processes created is
(a) n (b) $2^n - 1$
(c) 2^n (d) $2^{n+1} - 1$

[GATE- 2008]

Q.13 Consider the following code fragment:
```
if (fork ( ) = = 0)
{     a = a + 5 ;
      printf( "%d,% d/n", a, & a);
}
else
{     a = a – 5;
      printf("%d,%d/n", a, & a);
}
```
Let u, v be values printed by the parent process, and x, y be the values printed the child process. Which one of the TRUE?
(a) $u = x + 10$ and $v = y$
(b) $u = x + 10$ and $v \neq y$
(c) $u + 10 = x$ and $v = y$
(d) $u + 10 = x$ and $v \neq y$

[GATE- 2005]

Q.14 Consider the following statements about user level threads and Kernel level threads, which one of the following statements is FALSE
(a) Context switch time is longer for Kernel level threads than for user level threads
(b) User level threads do not need any hardware support
(c) Related Kernel level thread can be scheduled on different processors in a multiprocessor system
(d) Blocking one Kernel level thread blocks all related threads

[GATE - 2007]

Q.15 Which of the following should be allowed only in Kernel mode?
1. Changing mapping from virtual to physical address
2. Mask and unmask interrupts
3. Disabling all interrupts
4. Reading status of processor
5. Reading time of day

(a) 1, 2 and 3 (b) 1, 2, 4 and 5
(c) 2, 3 and 5 (d) All of the above

Q.16 Which of the following statements about Synchronous and Asynchronous I/O is NOT true?
(a) An ISR is invoked on completion of I/O in Synchronous I/O but not in asynchronous I/O.
(b) In both Synchronous and asynchronous I/O an ISR (Interrupt Service Routine) is invoked after completion of the I/O.
(c) A process making a Synchronous I/O call waits until I/O is complete, but a process making an asynchronous I/O call does not wait for completion of the I/O.
(d) In case of Synchronous I/O, the process waiting for the completion of I/O is woken up by the ISR that is invoked after the completion of I/O.

[GATE-2008]

Q.17 Which of the following statements is false about threads?
(a) Since there is sharing among threads there is a potential problem of security
(b) The Kernel level threads are slow
(c) User level threads cannot be implemented on an OS that does not support threads
(d) Kernel level threads are good for applications that frequently get blocked.

Q.18 Which of the following state is/are private/ specific to the thread?
(*i*) Program counter
(*ii*) stack pointer
(*iii*) Execution stack
(*iv*) Memory
(a) Only (*i*), (*ii*) and (*iii*)
(b) Only (*i*) and (*ii*)
(c) Only (*iii*)
(d) All of the above

Q.19 Determine the correctness or otherwise of the following assertion [A] and Reason [R].
Assertion [A] : Application program can perform its own i/o while executing in user mode.
Reason [R] : I/o instructions are user mode instruction.
(a) Both [A] and [R] are true and [R] is the correct reason for [A]
(b) Both [A] and [R] are true and [R] is not the correct reason for [A]
(c) [A] is true but [R] is false
(d) Both [A] and [R] are false.

Q.20 Threads of a process share
(a) global variables but not heap
(b) heap but not global variables
(c) neither global variables nor heap
(d) both heap and global variables
[GATE-2017]

Multiple Select Questions

Q.21 Consider the following statements and select the correct options.
(a) A fork ( ) system call return ids of child process upon successful creation of child.
(b) A fork ( ) system call returns 0 during unsuccessful execution of fork ( ).
(c) Parent process can terminate only after completion of all child processes.
(d) The total number of child process created for *n*-fork ( ) statements is 2^n.

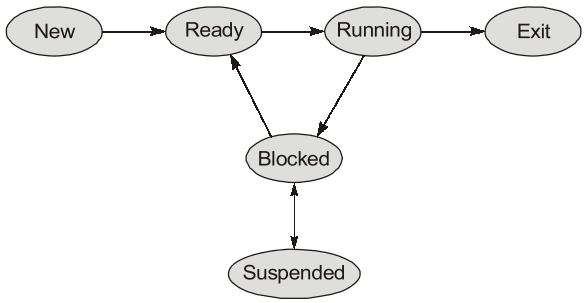
Q.22 Which of the following is correct?
(a) Threads of the same process does not share the stack.
(b) Context switch time is longer for Kernel level threads than for user level threads.
(c) Threads of a process share global variables but not heap.
(d) Kernel level threads can not share the code segments.

Try Yourself

T1. Identify the scheduler which involves only in the decision for selection of partially serviced jobs?
(a) Short-term scheduler
(b) Long-term scheduler
(c) Medium-term scheduler
(d) None of these
[Ans: (c)]

T2. Identify the correct statement from the following
(a) Job may transit from "Ready" to "Suspend ready"
(b) Job may transit from "Suspend blocked" to "Suspend ready"
(c) Job may transit from "Suspend ready" to "Ready"
(d) All of these
[Ans: (d)]

T3. Consider the following six-state model.



Identify the states in which processes are in the secondary memory (disk).

(a) New
(b) New, Suspended
(c) New, Suspended, blocked
(d) New, Suspended, blocked, Ready

[Ans: (b)]

T4. Kernel is
(a) considered as the critical part of the operating system
(b) the software which monitors the operating system
(c) the set of primitive functions upon which the rest of the operating system functions are build up
(d) None of the above

[Ans: (c)]

T5. Which of the following actions is/are typically not performed by the operating system when switching context from process A to process B?
(a) saving current register values and restoring saved register values for process B
(b) changing address translation tables
(c) swapping out the memory image of process A to the disk
(d) invalidating the translation look aside buffer

[Ans: (c)]

T6. Which of the following is False?
(a) User level threads are not scheduled by the Kernel
(b) When a user level thread is blocked, all the other threads of its process are blocked
(c) Context switching between user level threads is faster than context switching between Kernel level threads
(d) None of the above

[Ans: (d)]

T7. When an interrupt occurs, an operating system
(a) ignores the interrupt
(b) always changes the stage of the interrupted process after processing the interrupt
(c) always resumes execution of the interrupted process after processing the interrupt
(d) may change the state of the interrupted process to "blocked" and schedule another process

[Ans: (d)]

T8. Consider the following code

```
main( )
{
        for (int k = 1; k<=5; k++)
        {
            pid[k] = fork( );
        }
}
```

In the given code, all fork( ) statements executed successfully and all pid variables initialized to 0. What will be the total number of processes created by the above code?

[Ans: (32)]

■■■■

3 CPU Scheduling

Multiple Choice Questions

Q.1 The correct matching for the following pair is

A.	Disk check	**1.**	Round Robin
B.	Batch processing	**2.**	SCAN
C.	Time sharing	**3.**	LIFO
D.	Stack operation	**4.**	FIFO

	A	B	C	D
(a)	3	4	2	1
(b)	4	3	2	1
(c)	3	4	1	2
(d)	2	4	1	3

[ISRO-2009]

Q.2 Consider three CPU-intensive processes, which require 10, 20 and 30 time units and arrive at times 0, 2 and 6 respectively. How many context switches are needed if the operating system implements a SRTF scheduling algorithm? Do not count the context switches at time zero and at the end.

(a) 1 (b) 2
(c) 3 (d) 4

[ISRO-2009]

Q.3 The performance of Round Robin algorithm depends heavily on

(a) Size of the process
(b) The I/O bursts of the process
(c) The CPU bursts of the process
(d) The size of the time quantum.

[ISRO-2009]

Q.4 Five Jobs are waiting to be run. Their expected run times are 9, 6, 3, 5 and 10. Which Job scheduling technique will result in minimum average response time ?

(a) SJF (b) FCFS
(c) Priority (d) Round-Robin

[DRDO-2009]

Q.5 Consider a set of 5 processes whose arrival time, CPU time needed and the priority are given below.

Process priority	Arrival Time	CPU Time Needed	Priority
P_1	0	10	5
P_2	0	5	2
P_3	2	3	1
P_4	5	20	4
P_5	10	2	3

(smaller the number, higher the priority)
If the CPU scheduling policy is priority scheduling without pre-emption, the average waiting time will be

(a) 12.8 (b) 11.8
(c) 10.8 (d) 09.8

[ISRO-2009]

Q.6 Which of the following algorithm favor CPU-bound processes?

1. Round-Robin
2. FCFS
3. Multi level feedback queue

(a) 1 only (b) 2 only
(c) 1 and 2 only (d) 1 and 3 only

Q.7 If a system contains 'n' processes then there are how many ways to schedule these 'n' processes?

(a) $\lfloor n$ (b) n

(c) n^2 (d) $\frac{n}{2}$

Q.8 Consider a system, which has a CPU bound process, which require the burst time of 40 seconds. The multi level Feed Back Queue scheduling algorithm is used and the Queue time quantum '2' seconds and in each level it is incremented by '5' seconds. Then how many times the process will be interrupted and on which Queue the process will terminate the execution?

(a) 5, 4 (b) 4, 5

(c) 3, 4 (d) 4, 3

Q.9 Starvation can be avoided by which of the following statements.

1. By using shortest job first resource allocation policy
2. By using first come first serve resource allocation policy

(a) 1 only (b) 2 only

(c) 1 and 2 only (d) None of these

Q.10 Suppose a system contains 'n' processes and system uses the round Robin algorithm for CPU scheduling then which data structure is best suited for ready queue of these processes

(a) stack (b) queue

(c) circular queue (d) free

Q.11 An operating system uses the round-Robin Scheduling algorithm. Let T represent the time needed to perform a process switch, Q represent the time quantum and 'R' is the I/O wait. What will be CPU efficiency in terms of T, Q and R if $T < Q < R$.

(a) $\frac{Q}{(Q+T)}$ (b) $\frac{Q}{(T+R)}$

(c) $\frac{Q}{T}$ (d) $\frac{T}{(Q+T)}$

Q.12 Consider a system contains two types of processes CPU bound and I/O bound. What may be the condition when ready queue becomes empty?

(a) If all processes are CPU bound

(b) If all processes are I/O bound

(c) If half of the processes are CPU bound and half are I/O bound

(d) None of the above

Q.13 1. Activation of Interactive programs
2. Interrupts and I/O completions
3. Most operational OS calls

Whenever one of the above event occurs OS invokes which one of the scheduler

(a) Long term scheduler

(b) Short term scheduler

(c) Mid term scheduler

(d) None of the above.

Q.14 Increasing in time slice in a Round Robin scheduling the average turn around time will

(a) decrease (b) increase

(c) remains unchanged (d) varies

Q.15

Process	CPU Time	Arrival Time
P_1	5	0
P_2	3	1
P_3	4	2
P_4	1	3

Above process arrive in the order P_1, P_2, P_3 and P_4 are served in FCFS order.

The average turn around time and average waiting times are respectively?

(a) 4.5, 6.25 (b) 3.5, 4.75

(c) 8, 4.75 (d) 4.75, 8

Q.16 Consider following set of processes with CPU burst time given in milli seconds, arrival time and priority

Process	Arrival Time	Burst Time	Priority
A	0	8	4
B	1	4	3
C	2	6	1
D	3	1	2

(smaller number as highest priority)

Average turn around time using pre-emptive and non pre-emptive is?
(a) 12.5 ms, 10.5 ms (b) 11.5 ms, 13.5 ms
(c) 10.5 ms, 12.5 ms (d) 13.5 ms, 11.5 ms

Q.17 Suppose there are five processes in the ready queue as shown below.

P.No.	Arrival Time	Burst time	Priority
1	0	350	5 → lowest
2	0	125	2
3	0	475	3
4	0	250	1 → highest
5	0	75	4

If FCFS, SJF and priority scheduling algorithms are used, for which algorithms is the average waiting time is minimum? Assume lower integer indicates higher priority. Assume all arrives at time zero.
(a) FCFS (b) SJF
(c) Priority (d) None of the above

Q.18 If the time slice used in the Round Robin Scheduling policy is more than maximum time required to execute any process. Then the policy will
(a) degenerate the shortest job first
(b) degenerate to priority scheduling
(c) degenerate to first come first serve
(d) None of the above.

Q.19 Consider we have four processes P_1, P_2, P_3 and P_4 and consider the following table. Consider the $a < b < c < d$ where a, b, c, d are the execution times of P_1, P_2, P_3 and P_4 respectively.

Process	Execntion Time
P_1	a
P_2	b
P_3	c
P_4	d

What is the average turn around time when shortest job first CPU scheduling algorithm is used.
(a) $(3a + 4b + c + d)/4$
(b) $(4a + 3b + 2c + d)/4$
(c) $(a + 2b + 3c + 4d)/4$
(d) None of the above

Q.20 If there are 'n' process and 'q' is the time quantum in Round-Robin scheduling then
(a) No process waits more than $(n-1)*q$ time units until the next quantum
(b) All process must wait $n*q$ unit of time
(c) All process will wait atleast $(n-1)*q$ unit of time
(d) None of these

Q.21 Suppose that jobs are arrive according to the following schedule.

Process	Arrival Time	Run Time
A	0	12
B	3	7
C	6	2
D	8	5
E	9	2
F	12	12

Now give the sequence of the processes as they gets share of CPU if the scheduler used is shortest remaining time first.
(a) A, B, C, B, E, B, D, A, F
(b) A, B, C, B, E, B, D, B, A, F
(c) A, B, C, B, E, D, A, F
(d) None of the above.

Q.22 Dispatch latency is
(a) Time taken to swap a process
(b) The time taken to the submission and completion of the process
(c) The time taken to stop a process and start another process
(d) Time taken to switch from one thread to another.

Q.23 Which is the correct sequence for the following functions?
(a) scheduling, dispatching, context save
(b) context save, scheduling, dispatching
(c) scheduling, context save, dispatching
(d) dispatching, context save, scheduling

Q.24 Which of the following statements is incorrect?
(a) Threads are bound to a single process
(b) It's much easier to communicate between processes than between threads
(c) Process consumes more resources
(d) It's easy for threads to in advertently disrupt each other since they share the entire address space.

Q.25 Consider the below table with the processes, arrival times the is burst times.

Process	Arrival Time	Burst Time
P_1	0	20
P_2	15	25
P_3	30	10
P_4	45	15

What is the total waiting time of process P_2 using SRTF scheduling algorithm?
(a) 55 (b) 40
(c) 15 (d) 5

[GATE-2007]

Q.26 Consider the below table with the process, arrival times and their burst times

Process	Arrival Time	Burst Time
P_1	3	2
P_2	9	4
P_3	12	9
P_4	2	3
P_5	14	8
P_6	3	1

what is the throughput of the system using FCFS scheduling.
(a) 0.214
(b) 0.222
(c) 0.230
(d) None of these

Q.27 Group-1 contains some CPU scheduling algorithms and Group-2 contains some applications. Match entries in Group-1 entries in Group-2.

Group - 1	Group - 2
P : Gang scheduling	1. Guaranteed scheduling
Q : Rate monotonic scheduling	2. Real time scheduling
R : Fair share sheduling	3. Thread scheduling

(a) P–3, Q–2, R–1
(b) P–1, Q–2, R–3
(c) P–2, Q–3, R–1
(d) P–1, Q–3, R–2

[GATE-2007]

Q.28 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 the 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 get 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 what percentage of the does the CPU remain idle?
(a) 0% (b) 10.6%
(c) 30.0% (d) 89.4%

[GATE-2006]

Q.29 A uni-processor computer system only has two processes, both of which alternate 10 ms CPU bursts with 90 ms I/O bursts. Both the processes were created at nearly the same time. The I/O of both processes can proceed in parallel. Which of the following scheduling strategies will result in the least CPU utilization over a long period of time for this system?
(a) First come first serve
(b) Shortest remaining time first scheduling
(c) Static priority scheduling with different priorities for the two processes
(d) Round Robin scheduling with time quantum 5 ms.

[GATE-2003]

Q.30 The arrival time, priority and durations of the CPU and I/O bursts for each of three processes P_1, P_2 and P_3 are give in the table below. Each process has a CPU burst followed by an I/O burst followed by another CPU burst. Assume that each process has its own I/O resource.

P. No	Arrival Time	Priority	Burst Durations		
			CPU	I/O	CPU
P_1	0	2	1	5	3
P_2	2	3 (lowest)	3	3	1
P_3	3	1 (highest)	2	3	1

The multiprogrammed operating system uses pre-emptive priority scheduling. What are the finish times of the processes P_1, P_2 and P_3 respectively.

(a) 11, 15, 9 (b) 10, 15, 9
(c) 11, 16, 10 (d) 12, 17, 11

[GATE-IT-2006]

Q.31 Consider three processes shown in the table:

Process	Arrival Time	Burst Time
P_1	0	5
P_2	1	7
P_3	3	4

The completion order of the three processes under the policies FCFS and Round Robin with time quantum of 2 units.

(a) FCFS : P_1, P_2, P_3 R.R : P_1, P_2, P_3
(b) FCFS : P_1, P_3, P_2 R.R : P_1, P_3, P_2
(c) FCFS : P_1, P_2, P_3 R.R : P_1, P_3, P_2
(d) FCFS : P_1, P_3, P_2 R.R : P_1, P_2, P_3

[GATE-2012]

Common Data Questions Q.32 to Q.33

Consider the following P_1, P_2, P_3 and P_4 processes arrive in the same order with the length of CPU burst time given in milli seconds.

Process	Burst Time
P_1	5
P_2	8
P_3	3
P_4	5

Q.32 If τ_1 is 10 and the parameter that controls the relative weight of recent and past history (α) = 0.5, then what is the expected burst time of process P_5 if it is SJF scheduling?

(a) 5.1875 (b) 4.8132
(c) 5.625 (d) None of the above

Q.33 If the parameter that controls the relative weight of recent and past history is unity, then what is the expected burst time of process P_5?

(a) 4 (b) 3
(c) 5 (d) 4.5

Numerical Answer Type Questions

Q.34 Assume that the following jobs are to be executed on a single processor system.

Job ID	CPU Burst Time
1	3
2	4
3	5
4	1

Assume that the jobs are arrived at the time 0 and in the order 1, 2, 3, 4. For Round Robin Scheduling with time slice '1', what is the completion time for the job 2?

Q.35 Consider the following jobs are given below:

Job ID	Arrival Time	CPU Time
1	0	4
2	3	7
3	7	4
4	1	1

What is the average turn around time with non-pre-emptive shortest job first scheduling algorithm?

Q.36 Assume that the following jobs are to be executed on a single processor system with pre-emptive scheduling

Job ID	Arrival Time	CPU Time	Priority
1	0	6	8
2	5	3	6
3	2	2	3
4	7	4	1

(smaller number as highest priority)
At what time instance job 2 will finish the execution?

Q.37 What is the average waiting time (in ms) if pre-emptive SJF scheduling algorithm is used in following case.

Process	Arrival Time	Burst Time
P_1	0	8
P_2	1	4
P_3	2	9
P_4	3	5

Q.38 What will be the average waiting time (in ms) in round Robin Scheduling algorithm if the time quantum of 5 milliseconds and all processes arrive at time zero.

Procers	Burst Time
P_1	25
P_2	4
P_3	5

Common Data Questions Q.39 to Q.40
Consider the following four processes with the length of the CPU burst time given in milliseconds

Process	Arrive Time	Burst Time
P_1	0	5
P_2	1	3
P_3	2	3
P_4	4	1

Q.39 Average response time (in ms) for SRTF scheduling

Q.40 The average response time (in ms) for non-pre-emptive SJF scheduling is?

Q.41 Consider the following set of processes, with the arrival times and the CPU - burst times given in the milliseconds.

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

What is the average turnaround time (in ms) for these processes with the SRTF scheduling?

Multiple Select Questions

Q.42 Consider a arbitrary set of CPU bound processes with unequal CPU burst lengths. All processes are submitted at the same time. Which of the following is correct?
(a) Average waiting time will be minimal when shortest job first is used.
(b) Average waiting time will be minimal when shortest remaining time first (preemptive) is used.
(c) Average waiting time will be minimal when highest priority first with priority proportional to CPU burst length.
(d) Operating system is aware of user level thread.

Q.43 Consider the following table:

Process	Arrival time	Process time
A	0	3
B	1	6
C	4	4
D	6	2

Which of the following is correct?
(a) The average turn around time is 7.25 when FCFS is used.
(b) Round-Robin is best here for minimum average waiting time.
(c) Shortest remaining time first gives the minimum average waiting time compared to FCFS.
(d) B finished last when round robin is used.

Q.44 Which of the following options are correct?

(a) If the time slice used in the round robin scheduling policy is more than the minimum time required to execute any process then the policy will be degenerate to FCFS.

(b) Gang scheduling is used in thread.

(c) Shortest remaining time first scheduling may cause starvation.

(d) Round robin is better than FCFS in terms of response time.

Try Yourself

T1. Consider the following set of processes with CPU burst times. The system uses highest response ratio next scheduling to schedule the processes.

Process	P_1	P_2	P_3	P_4
CPU burst time	5	7	2	4

What is the average turnaround time of processes when all processes are arrived at the same time? Assume the processes are entered into the order queue (in order) P_1, P_2, P_3 and P_4.

(a) 9.7 (b) 10.2

(c) 11.3 (d) 12.4

[Ans: (b)]

T2. Assume a process has CPU burst times for last three runs as 4, 5 and 4 (last). Given that last predict burst time was 5 and $\alpha = 0.8$. What is the next predict of CPU burst time for the process when CPU scheduler is shortest process next with exponential averaging?

(a) 4.2 (b) 3.4

(c) 4 (d) 3

[Ans: (a)]

T3. Round Robin scheduler implemented a version with feedback queues. There are two Ready queues in the system. All new processes are placed in the higher priority Ready Queue and interrupted processes are placed in the lower priority ready queue. If there are any processes in the higher priority ready queue then first scheduled them by RR before scheduling lower priority ready queue processes.

Consider the following processes with the arrival times and burst times.

Process	P_1	P_2	P_3	P_4	P_5
Arrival time	0	2	3	5	6
CPU burst time	3	5	2	4	3

What is the average turn around time of all processes in the given system with time quantum of 2 units for the both ready queues?

(a) 10 (b) 8.2

(c) 7.3 (d) 9.8

[Ans: (d)]

T4. Which of the following condition is used for every process by "Highest Response Ratio Next" scheduling to select the process with highest response ratio?

(a) Response ratio = $\frac{\text{Wait time} + \text{Service time}}{\text{Service time}}$

(b) Response ratio = $\frac{\text{Wait time} + \text{Service time}}{\text{Wait time}}$

(c) Response ratio = $\frac{\text{Service time}}{\text{Wait time} + \text{Service time}}$

(d) Response ratio = $\frac{\text{Wait time}}{\text{Wait time} + \text{Service time}}$

[Ans: (a)]

T5. Match the following groups:

Group-I

A. FCFS

B. Round Robin

C. SRTF

D. Priority scheduler

Group-II

1. Important processes get execute first.
2. Minimizes the average waiting time.
3. The processes run in the order they arrived.
4. Every process get a chance to execute.

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	4	3	2	1
(c)	3	4	2	1
(d)	2	1	3	4

[Ans: (c)]

T6. Consider the following set of processes that need to be scheduled on a single CPU. All the time values are given in ms.

Process Name	Arrival Time	Execution Time
A	0	6
B	3	2
C	5	4
D	7	6
E	10	3

Using SRTF scheduling algorithm, the average process turnaround time (in ms) is _____.

[Ans: (7.2)]

T7. Three processes A, B, C each execute a loop of 100 iteration. In each iteration of the loop, a process perform a single computation that requires t_c CPU milliseconds and then initiates a single I/O operation that lasts for t_{i0} ms. It is assumed that the computer where the processes execute has sufficient number of I/O devices to each process. Also the scheduling overhead of the OS is negligible. The process have the following characteristics.

Process id	t_c	t_{io}
A	100 ms	500 ms
B	350 ms	500 ms
C	200 ms	500 ms

The processes A, B, C started at times 0, 5, 10 ms respectively, in a pure time sharing system (round robin scheduling) that uses a time slice of 50 ms.

The time in ms at which process C would complete its first I/O operation is _____.

[Ans: (1000)]

T8. Consider a uniprocessor system executing 3 tasks T_1, T_2 and T_3, each of which is composed of an infinite sequence of jobs which arrive periodically at intervals of 3, 7 and 20 ms 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 T_1, T_2 and T_3 requires an execution time of 1, 2 and 4 ms respectively.

Given that all tasks initially arrive at beginning of 1st ms and task preemptions are allowed, the first instance of T_3 completes its execution at end of _____ ms.

[GATE-2015, Ans: (12)]

T9. Consider the following processes, with the arrival time and the length of the CPU burst given in milliseconds. The scheduling algorithm used is preemptive shortest remaining-time first.

Process	Arrival Time	Burst Time
P_1	0	10
P_2	3	6
P_3	7	1
P_4	8	3

The average turn around time of these processes is _____ milliseconds.

[GATE-2016, Ans: (8.25)]

■■■■

4 Process Synchronization

Multiple Choice Questions

Q.1 Which of these conditions must be satisfied in the classic readers/writers problem ?

A : Only one reader at a time may read a file

B : Only one writer at a time may write a file

C : Any number of writers may simultaneously write to a file

D : Any number of readers may simultaneously read a file

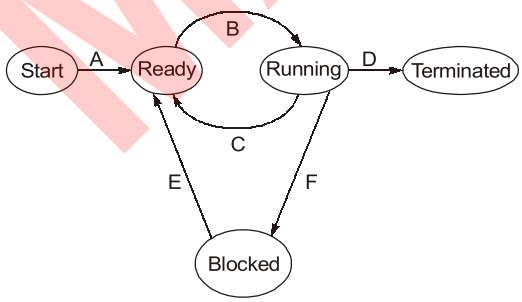
E : If a writer is writing to a file, no reader may read it.

F : If a reader is reading a file, no writer may write it.

(a) A, B, D, E and F only
(b) B, D, E and F only
(c) A, B, E and F only
(d) B, C, D and E only

[DRDO-2009]

Q.2 In the following process state diagram for a uniprocessor system, assume that there are always some processes in the ready state.



Now consider the following statements:

I. If a process makes a transition "D", it would result in another process making transition "A" immediately.

II. A process P_2 in blocked state can make transition "E" while another process "P_1" is in running state

III. The OS uses pre-emptive scheduling

IV. The OS uses Non-pre-emptive scheduling

Which of the above statements are true?

(a) I and II (b) I and III
(c) II and III (d) II and IV

[GATE-2009]

Q.3 The enter_CS ( ) and leave_CS ( ) functions to implement critical section of a process are realized using test and set instructions as follows

```
void enter_CS(X)
{
      while (test and set (X));
}
void leave_CS(X)
{
      X = 0;
}
```

In the above solution 'x' is a memory location associated with the CS and is initialized to '0'. Now consider the following statements.

I. The above solution to CS problem is deadlock free.

II. The solution is starvation free.

III. The processes enter CS in FIFO order

IV. More than one process can enter CS at the same time.

Which of the above statements are true?

(a) I only (b) I and II only
(c) II and III only (d) IV only

[GATE-2009]

Q.4 Consider a queue between the two processes indicated below. N is the length of queue and *e*, *f* are counting semaphores and *b* is the binary semaphore

$e = N, f = 0, b = 1;$

Process 1	Process 2
loop	loop
p(*e*)	*p*(*f*)
p(*b*)	*p*(*b*)
enqueue	dequeue
v(*b*)	*v*(*b*)
v(*f*)	*v*(*e*)
end loop	end loop

Which of the following statements are TRUE ?

1. The purpose of semaphore *f* is to ensure that dequeue is not executed on an empty queue.
2. The purpose of semaphore "*e*" is to ensure that deadlock doesn't occur.
3. The purpose of semaphore "*b*" is to provide mutual exclusion for queue operations.

(a) 1 only (b) 2 only
(c) 1 and 3 only (d) 2 and 3 only

Q.5 Consider the below consent program

```
int x = 0 ;
int y = 0;
par begin
  begin
  x = 1;
  y = y + x;
  end
  begin
  y = 4;
  x = x + 5;
  end
par end
```

What can be the final value of '*x*' and '*y*' after completions of the above concurrent program.

I. $x = 1, y = 5$
II. $x = 6, y = 10$
III. $x = 6, y = 5$
IV. $x = 1, y = 4$

Which of the above claims are possible?

(a) Only, I, II (b) Only I, II, III
(c) Only II, III (d) Only III, IV

Q.6 The atomic fetch and set X, Y instruction unconditionally sets the memory location 'X' to 1 and fetches the old value of X in Y without allowing any intervening access to the memory location 'X'. Consider the following implementation of "P" and "V" functions on a binary semaphore 'S'.

```
Void P (binary_semaphore *S)
{
    unsigned y;
    unsigned * x = &(s → value);
    do
    {
        fetch and set x, y;
    }   while (y);
}
void v(binary_semaphore * S)
{
    s → value = 0;
}
```

Which of the following is TRUE?

(a) The implementation may not work if context switching is disabled in P
(b) Instead of using fetch and set, a pair of normal load/store can be used.
(c) The implementation of "V" is wrong.
(d) The code does not implement a binary semaphore.

[GATE-2003]

Common Data for Q.7 & Q.8

Barrier is a synchronization construct where a set of processes synchronizes globally i.e. each process in the set arrives at the barrier and waits for all others to arrive and then all processes leave the barrier. Let the number of processes in the set be three and "*s*" be a binary semaphore with usual *p* and *v*, functions. Consider the following "*c*" implementation of a barrier with line shown the left.

```
void barrier (void) {
1.  p(s);
2.  process_arrived ++;
3.  v(s);
4.  while (process_arrived ! = 3) ;
5.  p(s);
6.  process_left++;
7.  If(process_left = = 3) {
8.  process_arrived = 0;
9.  process_left = 0;
10. }
11. v(s);
    }
```

The variables process_arrived and process_left are shared among all processes and are initialized to zero. In a concurrent program all the three processes call the barrier function when they need to synchronize globally. [Initial value of S = 1]

Q.7 The above implementation of barrier is incorrect. Which one of the following is true ?

(a) The barrier implementation is wrong due to the use of binary semaphore 'S'.
(b) The barrier implementation may lead to a deadlock if two barrier invocations are used in immediate succession.
(c) Lines 6 to 10 need not be inside a critical section.
(d) The barrier implementation is correct if there are only two processes instead of three.

[GATE-2006]

Q.8 Which one of the following rectifies the problem in the implementation?

(a) Lines 6 to 10 are simply replaced by process-arrived.
(b) At the beginning of the to barrier the first process to enter the barrier waits until process-arrived becomes zero before proceeding to execute P(S);
(c) Context switching is disabled at the beginning of the barrier and re-enabled at the end.
(d) The variable process-left is made private instead of shared.

[GATE-2006]

Q.9 Two processes P_1 and P_2 need to access a critical section of code. Consider the following synchronization construct used by the processes.

$\|*P_1*\|$	$\|*P_2*\|$
while (true) {	while (true) {
wants1 = true;	wants2 = true;
while (wants2 = = true);	while (wants1 = = true);
CS	CS
wants1 = false;	wants2 = false;
}	}

Here, wants1 and wants2 are shared variables, which are initialized to false. Which one of the following statements is TRUE about the above construct?

(a) It does not ensure mutual exclusion
(b) It does not ensure bounded waiting
(c) It requires that processes enter the critical section in strict alteration
(d) It does not prevent deadlocks, but ensures mutual exclusion.

[GATE-2007]

Q.10 The P and V operations on counting semaphores, where 'S' is a counting semaphore are defined as follows.

$P(s)$: S = S – 1;
if S < 0 then wait;
$V(s)$: S = S + 1;
if S < = 0 then wake-up a process waiting on S;

Assume that P_b and V_b, the wait and signal operations on binary semaphores provided. Two binary semaphores X_b and Y_b are used to implement the semaphore operations $P(s)$ and $V(s)$ as follows.

```
P(s) : Pb(Xb);
       S = S – 1;
       if (S < 0) {
           Vb(Xb);
           Pb(Yb);
       }
       else Vb(Xb);
```

$V(s)$: $P_b(X_b)$
S = S + 1;
if (S < = 0) {
$V_b(Y_b)$;
}
$V_b(X_b)$;

The initial values of X_b and Y_b are respectively
(a) '0' and '0' (b) '0' and '1'
(c) '1' and '0' (d) '1' and '1'

[GATE-2008]

Q.11 Consider the solution to the bounded buffer producer | consumer problem by using general semaphores S, F and E. The semaphore S is the mutual exclusion semaphore initialized to '1'. The semaphore 'F' corresponds to the number of Free slots in the buffer and is initialized to N. The semaphore 'E' corresponds to the number of elements in the buffer and is initialized to '0'.

Producer Process	Consumer Process
Produce in item;	Wait (E);
Wait (F);	Wait(S);
Wait (S);	Remove item from buffer
Add item to buffer;	Signal (S);
Signal (S);	Signal (F);
Signal (E);	Consume item;

Which of the following interchange operations may result in a deadlock?
1. Interchanging wait (F) and wait (S) in the producer process.
2. Interchanging signal (S) and signal (F) in the consumer process.

(a) Only 1 (b) Only 2
(c) Neither 1 nor 2 (d) Both '1' and '2'

[GATE-2006]

Q.12 Processes P1 and P2 use critical-flag in the following routine to achieve mutual exclusion. Assume that critical-flag is initialized to FALSE in the main program.

```
get-exclusive-access( )
{
  if (critical-flag = = FALSE) {
    critical-flag = TRUE;
    critical-region ( ) ;
    critical-flag = FALSE ;
  }
}
```

Consider the following statements:
1. It is possible for both P_1 and P_2 to access critical-region concurrently.
2. This may lead to deadlock

Which of the following holds?
(a) 1 is false and 2 is true
(b) Both 1 and 2 are false
(c) 1 is true and 2 is false
(d) Both 1 and 2 are true

[GATE-IT-2007]

Q.13 Synchronization in the classical readers and writers problem can be achieved through use of semaphores. In the following incomplete code for readers-writers problem, two binary semaphores mutex and wrt are used to obtain synchronization.

```
Wait (wrt);
Writing performed
Signal (wrt);
```

```
Wait (mutex)
    readcount = readcount + 1;
    if readcount = = 1 then S1;
S2;
    Reading performed;
S3;
    readcount = readcount – 1;
    if readcount = 0 then S4;
Signal (mutex);
```

The initial values of readcount = 0 ;
wrt = 1 and mutex = 1;
The values of S_1, S_2, S_3 and S_4 are?
(a) Signal (mutex), wait (wrt), signal (wrt), wait (mutex);
(b) Signal (wrt), wait (mutex), wait (mutex), wait (wrt)
(c) Wait (wrt), signal (mutex), wait (mutex), signal (wrt);
(d) Signal (mutex), wait (mutex), signal (mutex), wait (mutex);

[GATE-IT-2007]

Q.14 The following is a code with two threads, producer and consumer, that can run in parallel. Further, S and Q are binary semaphores equipped with the standard P and V operations.

Semaphore S = 1, Q = 0;
integer x:

Producer	Consumer
While (true) do P(S); X = produce( ); V(Q); done	While (true) do P(Q); Consume (X); V(S); done

Which of the following is TRUE about the program above?

(a) The process can deadlock
(b) One of the threads can starve
(c) Some of the items produced by the producer may be lost
(d) Values generated and stored in 'x' by the producer will always be consumed before the producer can generate a new value.

[GATE-IT-2008]

Q.15 Consider the methods used by processes P_1 and P_2 for accessing their critical sections whenever needed, as given below. The initial values of shared boolean variables S_1 and S_2 are randomly assigned.

Method used by P_1	Method used by P_2
While ($S_1 == S_2$); Critical section $S_1 = S_2$;	While ($S_1 != S_2$); Critical Section S_2 = not (S_1);

Which one of the following statements describes the properties achieved ?

(a) Mutual exclusion but not progress
(b) Progress but not mutual exclusion
(c) Neither mutual exclusion nor progress
(d) Both mutual exclusion and progress

[GATE - 2010]

Q.16 The following program consist of 3 concurrent processes and 3 binary semaphores. The semaphores are initialized as $S_0 = 1$, $S_1 = 0$, $S_2 = 0$;

Process P_0	Process P_1	Process P_2

While (true) {
Wait (S_0);
Print '0';
Release (S_1);
Release (S_2);
}
	Wait (S_1);
	Release (S_0);
		Wait (S_2);
		Release (S_0);

How many times will process P_0 print '0'?

(a) At least twice (b) Exactly twice
(c) Exactly thrice (d) Exactly once

[GATE-2010]

Q.17 Consider two processes P_1 and P_2 accessing the shared variables 'X' and 'Y' protected by two binary semaphores S_X and S_Y respectively, both initialized to 1. P and V denote the usual semaphore operations.

P_1	P_2

While true do {
L_1 : ——
L_2 : ——
$x = x + 1$;
$y = y - 1$;
$v(s_x)$;
$v(s_y)$;
}
	While true do {
	L_3 : ——
	L_4 : ——
	$y = y + 1$;
	$x = y - 1$;
	$v(s_y)$;
	$v(s_x)$;
	}

In order to avoid deadlock, the correct operations at L_1, L_2, L_3 and L_4 are respectively.

(a) $P(S_Y)$, $P(S_X)$, $P(S_X)$, $P(S_Y)$
(b) $P(S_X)$, $P(S_Y)$, $P(S_Y)$, $P(S_X)$
(c) $P(S_X)$, $P(S_X)$, $P(S_Y)$, $P(S_Y)$
(d) $P(S_X)$, $P(S_Y)$, $P(S_X)$, $P(S_Y)$

[GATE-2004]

Q.18 Fetch and add (x, i) is an atomic read modify write instructions that reads the value of memory location x, increments it by the value i, and returns the old value of x. It is used in the pseudo code shown below to implement a busy wait lock. L is an unsigned integer shared variable initialized to '0'. The value of '0' corresponds to lock being available, while any non-zero value corresponds to the Lock being not available.

```
Acquire Lock (L) {
      While (Fetch_And_Add (L, 1))
          L = 1;
}
Release Lock (L) { L = 0; }
```

This implementation

(a) Fails as L can overflow
(b) Fails as L can take on a non-zero value when the lock is actually available
(c) Works correctly but may starve some processes
(d) Works correctly without starvation.

[GATE-2012]

Common Data for Q.19 & Q.20

Consider the following code used by the classical readers and writers,

```
int R = 0, w = 0;
semaphore mutex = 1;

void reader (void)
 {
L1 : down (mutex);
     if (w == 1)
     {
     ⊣(1)
     goto L1 ;
     }
     else
     {
     R = R + 1;
     ⊣(2)
     }
     Data Base
     down (mutex);
     R = R – 1;
     up (mutex);
 }

void writer (void)
 {
L2 : down (mutex);
     if (⊣)(3)
     {
     up (mutex);
     goto L2 ;
     }
     w = 1;
     up (mutex);
     Data Base
     down (mutex);
      w = 0 ;
     up (mutex);
 }
```

Q.19 What should be the correct values in the blanks 1, 2, 3 respectively to synchronize the classical readers and writers?

(a) down(mutex), up(mutex), $w == 1$;
(b) up(mutex), down(mutex), $w == 1$;
(c) down(mutex), up(mutex), $w == 1$ or $R \geq 1$;
(d) up(mutex), up(mutex), $w == 1$ or $R \geq 1$;

Q.20 What happens if we interchange $w = 1$, up(mutex); in the writers code?

(a) No problem, the solution still works correct.
(b) Only multiple writers are allowed in to Database.
(c) Multiple readers are NOT allowed into Data Base.
(d) Both Reader and writer can enter into data base at the same time

Q.21 Let P and Q be processes and let S and *t* be semaphores. Initially, both S and *t* are 1. The two processes execute the steps shown below. Show a sequence of steps that leads to deadlock.

P :	Q :
Step P_1 : Down (s)	Step Q_1 : Down (s);
Step P_2 : Down(t)	Step Q_2 : Down (t);
Step P_3 : CS – PA	Step Q_3 : CS – QA
Step P_4 : UP(s)	Step Q_4 : UP(t)
Step P_5 : Down(s)	Step Q_5 : UP(s)
Step P_6 : CS – PB	
Step P_7 : UP(s)	
Step P_8 : UP(t)	

(a) P_1, P_2, Q_1, Q_2
(b) $P_1, P_2, P_3, P_4, Q_1, Q_2, P_5$
(c) Q_1, Q_2, Q_3, P_1, P_2
(d) Q_1, Q_2, Q_3, Q_4, Q_5

Numerical Answer Type Questions

Q.22 A binary semaphore variable mutex is initialized to '1' and the various binary semaphore operations like 9*p*(), 14*v*(), 6*p*(), 8*v*(), 3*p*(), 2*v*() are performed, then what is the present (final) value of the binary semaphore mutex?

Q.23 A counting semaphore was initialized to eight. Then four *p*(wait) operations and six *v*(signal) operations are performed on the semaphore. What is the resulting value of the semaphore?

Q.24 Two concurrent processes P_1 and P_2 use four shared resources R_1, R_2, R_3 and R_4 as shown below.

P_1 :	P_2 :
Compute ;	Compute ;
Use R_1 ;	Use R_1 ;
Use R_2;	Use R_2;
Use R_3;	Use R_3;
Use R_4;	Use R_4;

Both processes are started at the same time, and each resource can be accessed by only one process at a time. The following scheduling constraints exists between the access of resources by the processes.

- P_2 must complete use of R_1 before P_1 gets access to R_1
- P_1 must complete use of R_2 before P_2 gets access to R_2
- P_2 must complete use of R_3 before P_1 gets access to R_3
- P_1 must complete use of R_4 before P_2 gets access to R_4.

There are no other scheduling constraints between the processes. If the only binary semaphores are used to ensure the above scheduling constraints. What is the minimum number of binary semaphores needed?

Q.25 A shared variable x, initialized to zero, is operated on by four concurrent process W, X, Y, Z as follows. Each of the processes W and X reads x from memory, increments by one, stores it to memory, and then terminates. Each of the processes Y and Z reads x from memory, decrements by two, stores it to memory, and then terminates. Each process before reading x invokes the P operation (i.e. wait) on a counting semaphore S and invokes the V operation (i.e., signal) on the semaphore S after storing x to memory. Semaphore S is initialized to two. What is the maximum possible value of x after all processes complete execution?

Multiple Select Questions

Q.26 Which of the following options are correct?

(a) A critical section is a program segment which must be enclosed by a pair of semaphore operations i.e. P and V.

(b) A solution to the dining philosophers problems which avoids deadlock is to ensure that one particular philosophers picks up the left fork before the right fork, and that all other philosophers pick up the right fork before the left fork.

(c) Race condition occurs when the result of a competition depends on the order of the processes executed.

(d) None of these

Q.27 The following two functions $P_1( )$ and $P_2( )$ that share common variable B with an initial value is 2 executed concurrently.

```
P1 ( )
{
    C = B – 1
    B = 2 * B,
}
P2 ( )
{
    M = 2 * B;
    B = M – 1;
}
```

Which of the distinct values that B can possibly take after the execution?

(a) 2 (b) 3
(c) 4 (d) 5

Try Yourself

T1. Let A and B be two semaphore variables and they are initialized with 3 and 0 respectively. Consider the following three concurrent processes.

Process-1	Process-2	Process-3

while (1)
{
P(*A*);
Printf("0");
V(*B*);
}
	while (1)
	{
	P(*B*);
	Printf("1");
	Printf("2");
	V(*B*);
	}
		while (1)
		{
		P(*B*);
		Printf("3");
		}

At most how many times "3" is printed by process-3 when the above processes are executing concurrently?

(a) 1 (b) 3
(c) 5 (d) None of these

[Ans: (b)]

T2. Let A and B be two semaphore variables and they are initialized with 3 and 0 respectively. Consider following three concurrent processes.

Process-1	Process-2	Process-3

while (1)
{
P(*A*);
Printf("0");
V(*B*);
}
	while (1)
	{
	P(*B*);
	Printf("1");
	V(*B*);
	}
		while (1)
		{
		P(*B*);
		Printf("3");
		}

What is the minimum number of 1's printed by the execution of the above processes?

(a) 0 (b) 1
(c) 3 (d) None of these

[Ans: (a)]

T3. Consider the following codes:

P_1	P_2	P_3
P(*S*1); *P*(*S*2); *P*(*S*3); < critical section > *V*(*S*3); *V*(*S*2); *V*(*S*1);	*P*(*S*2); *P*(*S*3); *P*(*S*1); < critical section > *V*(*S*1); *V*(*S*3); *V*(*S*2);	*P*(*S*3); *P*(*S*1); *P*(*S*2); < critical section > *V*(*S*2); *V*(*S*1); *V*(*S*3);

Assume S1, S2 and S3 are shared binary semaphore variables. Initially S1 = 1, S2 = 1, and S3 = 1. If processes P_1, P_2 and P_3 executes concurrently then which of the following satisfied by them?

(a) Mutual exclusion and No deadlock
(b) No mutual exclusion but deadlock
(c) Mutual exclusion and deadlock
(d) Neither mutual exclusion nor deadlock

[Ans: (c)]

T4. Consider the following 3-processes with the semaphore variables S_1, S_2 and S_3.

P_1	P_2	P_3

while (1)
{
$P(S_3)$;
print "0";
$V(S_2)$;
}
	while (1)
	{
	$P(S_1)$;
	print "1";
	$V(S_3)$;
	}
		while (1)
		{
		$P(S_2)$;
		print "2";
		$V(S_1)$;
		}

To print the output 21021021021, which of the following could be initial values of semaphores when three processes executed concurrently?

(a) $S_1 = 0, S_2 = 0, S_3 = 0$
(b) $S_1 = 1, S_2 = 0, S_3 = 0$
(c) $S_1 = 0, S_2 = 0, S_3 = 1$
(d) $S_1 = 0, S_2 = 1, S_3 = 0$

[Ans: (d)]

T5. Let S be the binary semaphore variable and S = 1 initially. Assume there are no blocked processes in the system. If the following operations performed in the given order then how many blocked processes are present in the system at the end?

7 V, 5 P, 14 V, 10 P, 21 V, 15 P

(a) 0 (b) 14
(c) 20 (d) 12

[Ans: (b)]

T6. Suppose 2 processes P and Q are there

```
        P                          Q
while(1)                   while(1)
{                          {
    wait (mutex);              wait (mutex);
    print '1';                 print '0';
    signal (mutex)             signal (mutex)
}                          }
```

The string generated by the two processes is

(a) 1* 0* (b) (10)*
(c) (01)* (d) (1 + 0)*

[Ans: (d)]

T7. In the above question if process P executes then only Q will execute. If we assume this then the string generated by the two processes is

(a) (01)* (b) (10)*
(c) (1 + 0)* (d) None of these

[Ans: (d)]

T8. Let $m[0]$ to $m[4]$ be mutexes (binary semaphores) and $p[0]$ to $p[4]$ be processes. Suppose each process $p[i]$ executes the following:

```
wait(m[i]);
wait(m[(i + 1) mod 4]);
----------
release(m[i]);
release(m[(i + 1) mod 4]);
```

This could cause

(a) Thrashing
(b) Deadlock
(c) Starvation, but not deadlock
(d) None of the above

[Ans: (b)]

T9. Each process pi, i = 1, 2, ..., 9 is coded as follows:

```
repeat
    p(mutex)
    {critical section}
    V(mutex)
forever
```

The code for p_{10} is identical except that it uses V(mutex) in place of P(mutex). What is the largest number of processes that can be inside the critical section?

[Ans: (10)]

T10. Consider the procedure below for the producer consumer problem which uses semaphores:

```
semaphore n = 0, s = 1;
void producer( )
{
    while(true)
    {
        produce( );
        sem wait(s);
        add to buffer( );
        sem  signal(s);
        sem signal(n);
    }
}
void consumer( )
{
while(true)
    {
        sem wait(s);
        sem wait(n);
        remove from buffer( );
        sem signal(s);
        consume( );
    }
}
```

Which one of the following is true?

(a) The producer will be able to add an item to the buffer, but the consumer can never consume it
(b) The consumer will remove no more than one item from the buffer
(c) Deadlock occurs if the consumer succeeds in acquiring semaphore 's' when the buffer is empty
(d) The starting value for the semaphore 'n' must be 1 and not 0 for the deadlock free operation

[Ans: (c)]

T11. Consider the following proposed solution for the critical section problem. There are n processes: $P_0 \ldots P_{n-1}$. In the code, function *pmax* returns an integer not smaller than any of its arguments. For all i, $t[i]$ is initialized to zero.

Code for P_i:

```
do
{
    c[i] = 1; t[i] = pmax (t[0],..., t[n – 1]) +1;
    for every j ≠ i in {0,..., n – 1}
    {while (c[ j]);
    while (t[ j] != 0 && t[ j] <= t[i]);
    }
    Critical Section; t[i] = 0;
Remainder Section;
}    while (true);
```

Which one of the following is TRUE about the above solution?

(a) At most one process can be in the critical section at any time
(b) The bounded wait condition is satisfied
(c) The progress condition is satisfied
(d) It cannot cause a deadlock

[GATE-2016, Ans: (a)]

T12. Consider a non-negative counting semaphore S. The operation $P(S)$ decrements S, and $V(S)$ increments S. During an execution, 20 $P(S)$ operations and 12 V(S) operations are issued in some order. The largest initial value of S for which at lest one $P(S)$ operation will remain blocked is _____.

[GATE-2016, Ans: (7)]

■■■■

5 Deadlocks

Multiple Choice Questions

Q.1 When a process is rolled back as a result of deadlock the difficulty which arises is
(a) starvation
(b) system through put
(c) low device utilization
(d) cycle stealing

[ISRO-2009]

Q.2 A computer system uses the bankers algorithm to deal with deadlocks. It's current state is shown in the table below, where P_0, P_1, P_2 and P_3 are processes and A, B and C are resource types.

	Maximum			Allocated			Available		
	A	B	C	A	B	C	A	B	C
P_0	6	5	4	0	3	4	4	3	1
P_1	3	4	2	2	1	2			
P_2	1	0	4	0	0	2			
P_3	3	2	5	1	2	1			

Which of the following are safe sequences?
P : P_1, P_0, P_2, P_3
Q : P_1, P_2, P_3, P_0
R : P_1, P_3, P_0, P_2
(a) P and Q only (b) P and R only
(c) Q and R only (d) All P, Q and R

[DRDO-2008]

Q.3 Which of the following statements are TRUE?
A : If resource pre-emption is allowed, then deadlock can be avoided but cannot be prevented.
B : If the number of sharable resources is greater than the number of processes, then deadlock can be prevented.
C : Deadlock can be prevented by not allowing any process to request for resources when it enters a critical section.
D : Deadlock avoidance schemes require information concerning which resource a process will request and use during its life time.
(a) A and D only (b) A and B only
(c) A, B and C only (d) D only

[DRDO-2009]

Q.4 A system has P processes and R identical units of a re-usable resource. If each process can claim at most N units of the resource, then system will be deadlock free if and only if.
(a) $R \geq P(N-1)+1$ (b) $R \leq P(N-1)+1$
(c) $R \geq P(N-1)$ (d) $R = P(N-1)+1$

[JNUEE-2009]

Q.5 Which of the following is the solution of priority inversion problem?
(a) Kill the higher-priority process
(b) Kill the lower priority process
(c) Priority-Inheritance protocol.
(d) Semaphore.

Q.6 Consider P = {P_1, P_2, P_3}, R = {R_1, R_2, R_3, R_4} one instance of resource type R_1, two instances of resource type R_2, one instance of resource type R_3 and three instances of resource type R_4. The situation is P_1 is holding an instance of R_2 and waiting for an instance of R_1, P_2 is holding an instance of R_1, one instance of R_2 and waiting

for an instance of R_3 and P_3 is holding an instance of R_3.

(a) Deadlock will not occur
(b) Deadlock will occur
(c) All the instances of R_4 are held by the processes
(d) All the instances of R_2 are not allotted.

Q.7 Consider a system with 4 types of resources R_1 (3 units), R_2 (2 units), R_3 (3 units), R_4 (2 units). A non-pre-emptive resource allocation policy is used. At any given instance, a request is not entertained if it cannot be completely satisfied. Three processes P_1, P_2, P_3 request the resources as follows if executed independently.

Process P_1	Process P_2	Process P_3
$t = 0$: requests 2 units of R_2	$t = 0$: requests 2 units of R_3	$t = 0$: requests 1 units of R_4
$t = 1$: request 1 units of R_3	$t = 2$: request 1 units of R_4	$t = 2$: requests 2 units of R_1
$t = 3$: request 2 units of R_1	$t = 4$: request 1 units of R_1	$t = 5$: release 2 unit of R_1
$t = 5$: release 1 units of R_2 and 1 unit of R_1	$t = 6$: release 1 units of R_3	$t = 7$: requests 1 unit of R_2
$t = 7$: releases 1 unit of R_3	$t = 8$: finishes	$t = 8$: request 1 units of R_3
$t = 8$: request 2 units of R_4		$t = 9$: finishes
$t = 10$: finishes		

Which one of the following statements is TRUE if all three processes run concurrently starting at time $t = 0$?

(a) All processes will finish without any deadlock
(b) Only P_1 and P_2 will be in deadlock
(c) Only P_1 and P_3 will be in deadlock
(d) All three processes will be in deadlock.

[GATE-2009]

Common Data For Q.8 & Q.9

Assume a system with 4 resources, C = (6, 4, 4, 2). The maximum claim, table and the resource allocation tables are given below.

Process	R_0	R_1	R_2	R_3
P_0	3	2	1	1
P_1	1	2	0	2
P_2	1	1	2	0
P_3	3	2	1	0
P_4	2	1	0	1

Maximum Claim

Process	R_0	R_1	R_2	R_3
P_0	2	0	1	1
P_1	1	1	0	0
P_2	1	1	0	0
P_3	1	0	1	0
P_4	0	1	0	1

Current allocation

Q.8 Find whether the state is safe or not?

(a) unsafe state (b) safe state
(c) deadlock (d) none of the above

[GATE-IT-2007]

Q.9 What happens if the resource allocator allocates 1 instance of R_0 and 1 instance of R_1 to the process P_3?

(a) Results in deadlock state
(b) Results in an unsafe state
(c) Results in a safe state
(d) None of the above

[GATE-IT-2007]

Q.10 Consider the following snapshot of a system running "n" processes each process "i" is holding x_i instances of resource R, for $1 \le i \le n$. Currently, all instances of R are occupied. Further, for all i, process "i" has placed a request for an additional y_i instance while holding the x_i instances it already has. There are exactly two processes p and q such that $y_p = y_q = 0$. Which of the following can serve as necessary condition to guarantee that the system is not a deadlock?

(a) $\min(x_p, x_q) < \max y_k,\ k \neq p,\ q$
(b) $x_p + x_q \geq \max y_k,\ k \neq p,\ q$
(c) $\min(x_p, x_q) > 1$
(d) $\min(x_p, x_q) < 1$

[GATE-2006]

Q.11 Which of the following is NOT true of deadlock prevention and deadlock avoidance schemes?
(a) In deadlock prevention, the request for resources is always granted if the resulting state is safe.
(b) In deadlock avoidance, the request for resources is always granted if the resulting state is safe.
(c) Deadlock avoidance is less restrictive than deadlock prevention
(d) Deadlock avoidance requires knowledge of resource requirements a priori.

[GATE-2008]

Q.12 An operating system implements a policy that require a process to release all resources before making a request for another resource. Select the TRUE statement from the following.
(a) Both starvation and deadlock can occur
(b) Starvation can occur but deadlock cannot occur
(c) Starvation cannot occur but deadlock can occur
(d) Neither starvation nor deadlock can occur.

Q.13 Suppose "n" processes $P_1 \ldots\ldots P_n$ share "m" identical units, which can be reserved and released one at a time. The maximum resource requirement of process P_i is S_i where $S_i > 0$. Which of the following is a sufficient condition for ensuring that deadlock does not occur ?
(a) $\forall_i, S_i < m$
(b) $\forall_i, S_i < n$
(c) $\sum_{i=1}^{n} S_i < m + n$
(d) $\sum_{i=1}^{n} S_i < (m * n)$

[GATE-2005]

Q.14 A system has "n" resources $R_0 \ldots\ldots R_{n-1}$ and K processes $P_0 \ldots\ldots P_{k-1}$. The implementation of the resource request logic of each process P_i, is as follows.

```
if (i%2 = = 0)
{
    if (i < n) request R_i;
    if (i + 2 < n) request R_{i+2};
}
else
{
    if (i < n) request R_{n-i};
    if (i + 2 < n) request R_{n-i-2};
}
```

In which one of the following situations is a deadlock possible.
(a) $n = 40$, K = 26
(b) $n = 21$, K = 12
(c) $n = 20$, K = 10
(d) $n = 41$, K = 19

[GATE-2010]

Q.15 A single processor system has three resource types x, y, z, which are shared by three processes. There are 5 units of each resource type. Consider the following scenario, where the column alloc denotes the number of units of each resource type allocated to each process, and the column request denotes the number of units of each resource type requested by a process in order to complete execution. Which of these processes will finish LAST?

	alloc			request		
	x	y	z	x	y	z
P_0	1	2	1	1	0	3
P_1	2	0	1	0	1	2
P_2	2	2	1	1	2	0

(a) P_0
(b) P_1
(c) P_2
(d) None of these

[GATE-2007]

Q.16 Given the following system with four processes 1 to 4 and four resources A, B, C, D for what values of 'x' is the system in a safe state.

	Allocation				Maximum				Available			
	A	B	C	D	A	B	C	D	A	B	C	D
$P_1 \rightarrow$	3	2	3	0	3	3	X	5	0	1	2	0
$P_2 \rightarrow$	1	1	2	2	1	2	4	2				
$P_3 \rightarrow$	1	0	0	3	2	1	0	3				
$P_4 \rightarrow$	0	1	0	0	2	2	2	1				

(a) $x < 3$ (b) $x > 7$
(c) $3 <= x <= 7$ (d) $x = 0$

Q.17 A system that uses Banker's algorithm deadlock avoidance has five processes (1, 2, 3, 4 and 5) and uses resources of 4 different types (A, B, C, D). There are multiple resources of each type.

Process	Current Allocation				Max Need				Total Available			
	A	B	C	D	A	B	C	D	A	B	C	D
P_1	1	0	2	0	3	2	4	2	13	13	9	13
P_2	0	3	1	2	3	5	1	2				
P_3	2	4	5	1	2	7	7	5				
P_4	3	0	0	6	5	5	0	8				
P_5	4	2	1	3	6	2	1	4				

Which are the valid schedules that do not lead system to unsafe state?

(a) 5, 4, 2, 1, 3 (b) 5, 2, 1, 3, 4
(c) 2, 5, 1, 3, 4 (d) All of these

Q.18 A multithreaded program P executes with x number of threads and uses y number of locks for ensuring mutual exclusion while operating on shared memory locations. All locks in the program are non-reentrant i.e. if a thread holds a lock l then it cannot re-acquire lock l without releasing it, If a thread is unable to acquire a lock, it blocks until the lock becomes available. The minimum value of x and the minimum value of y together for which execution of P can result in a deadlock are:

(a) $x = 1, y = 2$ (b) $x = 2, y = 1$
(c) $x = 2, y = 2$ (d) $x = 1, y = 1$

[GATE-2017]

Numerical Answer Type Questions

Q.19 Consider a system having 'n' resources of same type. These resources are shared by 3 processes A, B, C. These have peak demand of 5, 9 and 13 respectively. For what value of "n" deadlock won't occur.

Q.20 A computer system has 9 printers, with n processes competing for them. Each process needs 3 printers. What is the maximum value of 'n' for the system to be deadlock free?

Q.21 Consider a system with "3" processes. Each process requiring 2 units of resource "R" to complete their execution. What is the minimum number of units of resource "R" are require to ensure the system deadlock free?

Q.22 Consider a system which has 'n' processes 9 resources where each process requires '2' tape drives (resources) to complete their execution, then what is the maximum value of 'n', so that deadlock doesn't occur?

Q.23 Suppose four processes P_1, P_2, P_3 and P_4 share minimum 20 identical resources. The maximum resource requirement of processes P_1, P_2 and P_3 are respectively 4, 3 and 7 units. What may be the maximum demand of process P_4 for resource so that deadlock doesn't occur.

Multiple Select Questions

Q.24 Consider a system having m resources of the same type. These resources are shared by 3 process X, Y and Z which can have peak demands of 8, 6, 10 respectively. For what value of m deadlock will not occur?

(a) 20 (b) 21
(c) 22 (d) 23

Q.25 Which of the following options are correct for preventing deadlock in a system with mutually exclusive resources?

(a) The resources are numbered uniquely. A process is allowed to request for resources only for a resource with resource number larger than its currently held resources.

(b) Process should acquire all their resources at the beginning of execution. If any resources is not available all resources acquired so far are released.

(c) The resources are numbered uniquely and processes are allowed to request for resources only in decreasing resource number.

(d) The resources are numbered uniquely and processes are allowed to request for resources only in increasing resources numbers.

Q.26 A system shares a tape drives the current allocation and maximum requirement of tape drives for that processes are shown below: (Consider 12 tape drives are available)

Process	Current Allocation	Maximum Requirement
P_1	3	7
P_2	1	6
P_3	3	5

Which of the following best describes about the state of the system?

(a) The sequence for safe state is $P_1 \rightarrow P_2 \rightarrow P_3$

(b) The sequence for safe state is $P_3 \rightarrow P_2 \rightarrow P_1$

(c) The sequence for safe state is $P_3 \rightarrow P_1 \rightarrow P_2$

(d) The above system has circular wait and subsequently deadlock.

Try Yourself

T1. Consider the following table with 4 processes,

Process	Maximum Demand	Currently holds
P_1	70	45
P_2	60	40
P_3	60	X
P_4	40	Y

If a system has total of 150 units of resource. Identify which of the following values of X and Y the above system will be in safe state?

(a) X = 40, Y = 20

(b) X = 50, Y = 10

(c) X = 30, Y = 20

(d) X = 20, Y = 30

[Ans: (d)]

T2. Consider the following snapshot of a system with 5 processes and 3 resources:

Process	Current Allocated			Maximum Demand		
	R_1	R_2	R_3	R_1	R_2	R_3
P_1	0	0	1	1	1	1
P_2	0	1	0	1	1	0
P_3	1	2	3	2	2	4
P_4	0	1	1	1	2	1
P_5	1	0	1	3	0	1

If the system has 1 unit of R_1 and 1 unit of R_3 available then how many minimum resource units available for R_2 to guarantee deadlock free?

(a) 0 (b) 1

(c) 2 (d) 3

[Ans: (a)]

■■■■

6 Memory Management

Multiple Choice Questions

Q.1 How many 256 × 4 RAM chips are required to organize a memory of capacity 32 KB? What is the size of decoder required in this implementation to select a row of chip?

(a) 128, 7 × 128 (b) 256, 7 × 128
(c) 512, 7 × 128 (d) 256, 8 × 256

Q.2 The number of entries in an inverted page table

(a) depends on the size of the process
(b) is equal to the number of page frames in main memory.
(c) is equal to the number of page frames in virtual memory
(d) is equal to the size of the page frame.

[DRDO-2009]

Q.3 On a system with 1 MB of memory using the buddy system, what is the first request that will fail in the following string of request due to lack of available memory?

Request: 50 K, 150 K, 90 K, 130 K, 70 K, 80 K, 120 K, 180 K, 60 K

(a) 120 K (b) 80 K
(c) 180 K (d) 60 K

Q.4 In a buddy system of memory management successive request of 50 K, 25 K and 35 K are satisfied with 256 K of available memory. How many blocks (with sizes) are left?

(a) Two block (32 K, 64 K)
(b) One block (94 K)
(c) One block (145 K)
(d) Many blocks with varying sizes.

Q.5 Suppose that a certain computer with paged virtual memory has 4 kB pages. A 32-bit byte addressable virtual address and 30 bit Byte addressable physical address. The system manages an inverted page table. Where each entry includes the page number plus 12 overhead bits. How big is the basic inverted page table including page number and overhead bits?

(a) 2^{10} B (b) 2^{20} B
(c) 2^{30} B (d) 2^{32} B

Common Data For Q.6 & Q.7

Consider a system using paging and segmentation. The virtual address space consist of up to 8 segments and each segment is 2^{29} bytes long.
The hardware pages each segment into 2^8 Byte pages.

Q.6 How many bits in the virtual address specify the segment number?

(a) 1 bits (b) 2 bits
(c) 3 bits (d) 4 bits

Q.7 How many bits in the virtual address specify the page number?

(a) 4 bits (b) 5 bits
(c) 16 bits (d) 21 bits

Q.8 Consider a system, which has virtual address as 29 bits, and physical address as 21 bits, and the pages size is 4 KW then calculate the number of pages and number of frames in the system?

(a) 128 K, 512
(b) 512, 128 K
(c) 128 KW, 512 W
(d) 256 K, 256

Q.9 Consider a system, which has number of pages 8K, and the page size 16 KW. And the system has the physical address of 22 bits, Then calculate the logical address and the number of frames, in the above system?
(a) 21 bits, 512
(b) 26 bits, 128
(c) 27 bits, 256
(d) 25 bits, 1 K

Common Data For Q.10 Q.11

A system uses a two level page table has 2^{12} bytes pages and 32-bit virtual addresses. The first 8-bit of the address serve as a index into the first level page table.

Q.10 How many bits specify the second-level index?
(a) 8 bits (b) 10 bits
(c) 12 bits (d) 16 bits

Q.11 How many entries in a level-one page table?
(a) 2^4 (b) 2^8
(c) 2^{16} (d) 2^{32}

Q.12 For 64 bit virtual addresses, a 4 KB page size and 256 MB of RAM an inverted page table requires.
(a) 2^{40} entries (b) 2^{52} entries
(c) 2^{16} entries (d) 2^{78} entries

Q.13 Consider an address of 16 bit, with 4 bit as segment number then maximum possible segment size is
(a) 16 (b) 65536
(c) 4096 (d) 12

Q.14 Assume a machine with 64 MB physical memory and 32 bit virtual address. If the page size is 4 KB, what is the approximate size of the page table (memory is bytes addressable)?
(a) 16 MB (b) 1 MB
(c) 24 MB (d) 2 MB

Q.15 Consider a system with 80% hit ratio, 50 ns time search the associative registers, 750 ns to access memory. Find the effective access time
(a) 640 ns (b) 950 ns
(c) 310 ns (d) 800 ns

Q.16 Consider a system with 1 K pages and 512 frames and each page is of size 2 KB. How many bits are required to represent the virtual address space?
(a) 20 bits (b) 21 bits
(c) 11 bits (d) None of these

Common Data for Q.17 & Q.18

Consider a logical address space of 64 pages of 2048 words each, mapped onto a physical memory of 16 frames.

Q.17 How many bits are there in the logical address?
(a) 13 (b) 17
(c) 15 (d) 27

Q.18 How many bits are there in the physical address?
(a) 17 (b) 14
(c) 15 (d) 19

Q.19 Consider a system which has the logical address space of 128 mw and physical address of 24 bits. And the physical address space is divided into 8 k frames. Then what is the page size and how many pages are there in the system?
(a) 1 kw, 32 k (b) 4 kw, 16 k
(c) 8 kw, 8 k (d) 2 kw, 64 k

Common Data for Q.20 to Q.22

Consider a virtual memory of 256 Tera bytes. The page size is 4 KB. This logical address space is mapped into a physical memory of 256 Mega bytes.

Q.20 How many bits specify the page Number in the virtual memory?
(a) 28 (b) 48
(c) 36 (d) 58

Q.21 How many pages are there in the virtual memory?
(a) 64 Giga pages (b) 32 Tera pages
(c) 64 Mega pages (d) 256 Kilo pages

Q.22 Given the address : 0_X 304F 48A C5345 what is the page offset in decimal?
(a) 837 (b) 709
(c) 345 (d) 563

Q.23 Consider virtual address of 32 bits and page size of 4 KB. Consider RAM of 128 KB. Then what will be ratio of page table and inverted page table size if each entry in both is of 4 B?

(a) 2^{15} : 1 (b) 2^{20} : 1
(c) 2^{10} : 1 (d) None of these

Q.24 On system using simple segmentation, following is the segment table.

Segment	Base	Length
0	330	124
1	876	211
2	111	99
3	498	302

Complete the physical address for the logical address 3 : 222

(a) 720 (b) 498
(c) 302 (d) 800

Q.25 A computer has a 32-bit virtual address and 1024 Bytes pages. A page table entry 4 bytes. A multi level page table is used because each page table must fit with in a page. How many levels are required?

(a) 5 (b) 4
(c) 3 (d) 2

Q.26 Match the following:

(A) Next Fit	1. The memory is divided into a number of small size memory and required no. of memories are allocated to the needed segment.
(B) Buddy system	2. When process and holes are kept on a list sorted by address then, this algorithm is faster.
(C) Best Fit	3. It chooses the hole from the list from the place where it left off last time while searching hole.
(D) First Fit	4. When process and holes are kept on a list sorted on size then this algorithm is faster.

(a) A2, B5, C1, D4 (b) A3, B2, C4, D1
(c) A2, B1, C4, D5 (d) A3, B1, C4, D2

Q.27 A processor uses 36 bit physical addresses and 32 bit virtual addresses, with a page frame size of 4 KB. Each page table entry is of size 4 bytes. A three level page table is used for virtual to physical address translation, where the virtual address is used as follows.

- Bits 30-31 are used to index into first level page table.
- Bits 21-29 are used to index into second level page table.
- Bits 12-20 are used to index into the third level page table.
- Bits 0-11 are used as offset within the page.

The number of bits required for addressing the next level page table (or page frame) in the page table entry of first, second and third-level page tables respectively.

(a) 20, 20 and 20 (b) 24, 24 and 24
(c) 24, 24 and 20 (d) 25, 25 and 24

Q.28 Consider a computer system where the size of logical address space and physical address space is respectively 2^{16} Bytes, with segmented paging architecture applicable. The virtual address space is divided into 8 equal size segments. The segment is divided into equal size pages which are of powers of 2. Memory is byte addressable and page table entry size is 2 B, and page tables are stored in the main memory. What must be the size of page of segment in bytes so that the page table of segment exactly fits in one page frame?

(a) 256 B (b) 128 B
(c) 512 B (d) 1024 B

Q.29 Consider a computer system with a logical address of size 32 bits with 8 KB page size. Page table entry size is 2 Bytes. If the page table contains 1 valid/invalid bit, 1 reference and 1 modified bit apart from frame number. What is the size of physical address space in Bytes?

(a) 64 KB (b) 64 MB
(c) 64 GB (d) 8 MB

Q.30 Given that the logical address is "d" bits. Page table entry size is 4 Bytes, what must be the optimal page size P by minimizing the page table size overhead and internal fragmentation in paging?

(a) $\sqrt{4d}$ (b) $(4 \cdot d)^2$
(c) $\sqrt{8 \cdot 2^{2d}}$ (d) $\sqrt{2^{d+3}}$

Q.31 Pick the incorrect statements?

1. Dynamic loading optimizes the memory space utilization
2. Dynamic linking increases program execution time.
3. Multi level paging optimizes the program execution time.
4. As the page size increases, the page fault rate may decreases.

(a) 1 only (b) 1, 2, 3 and 4
(c) 2, 3 and 4 (d) Only 3

Common Data for Q.32 & Q.33

Consider a computer system using 2-level paging with TLB. The logical address supported is 32 bits. The page table is divided into 512 pages each of size 1 K. The memory access time is 100 ns and TLB access time is 15 ns. Page table entry size at 1st level is 2 bytes and that at second level is 4 bytes each.

Q.32 What is the memory overhead of storing the top level page table along with page of the second level page table for a process?

(a) 6 KB (b) 4 KB
(c) 5 KB (d) 12 KB

Q.33 If the TLB hit ratio is 95%, what is the effective memory access time with the above 2-level page architecture.

(a) 130 ns (b) 128 ns
(c) 125 ns (d) 127 ns

Q.34 Consider a system in a demand paged environment supporting a virtual address of 32 bits with a page size of 4 KB, the physical address is 29 bits. Page fault rate is 2% page fault service time is 20 milli sec and memory access time is 2 micro sec. Page table entry contains 1 valid/invalid bit, 1 reference bit, 1 modified bit and 3 bits for page protection apart from other information.

If the page table entry size is multiple of 3 bytes, what is the approximate page table size of the process in bytes and what is the effective access time?

(a) 6 MB, 420 µs (b) 3 MB, 402 µs
(c) 12 MB, 419 µs (d) 3 MB, 42 µs

Q.35 Consider a system which is having a page table with 4 k entries. And the logical address is 29 bits, then what is the physical address if the system has 512 frames?

(a) 26 bits (b) 25 bits
(c) 24 bits (d) 23 bits

Q.36 In which of the following external fragmentation exists?

(a) paging (b) multi level paging
(c) inverted paging (d) segmentation

Q.37 Recall that Belady's anomaly is that the page-fault rate may increase as the number of allocated frames increases. Now, consider the following statements:

S_1: Random page replacement algorithm (where a page chosen at random is replaced) suffers from Belady's anomaly

S_2: LRU page replacement algorithm suffers from Belady's anomaly

Which of the following is CORRECT?

(a) S_1 is true, S_2 is true
(b) S_1 is true, S_2 is false
(c) S_1 is false, S_2 is true
(d) S_1 is false, S_2 is true

[GATE-2017]

Numerical Answer Type Questions

Q.38 On a system using fixed partitions with sizes 2^8, 2^{16}, 2^{24}, 2^{32} and 2^{64}. How many bits must the limit register have?

Q.39 In a simple paging system with 2^{24} bytes of physical memory, 256 pages of logical address space, and a page size of 2^{10} bytes, how many bits are in logical address?

Q.40 Consider a computer system with logical address space and physical address space of 2^{16} Bytes. Page size is 512 Bytes. Page table entry size is 2 bytes. If page table entry contain besides frame some other information like one bit for valid/Invalid, 1 bit for reference and 1 dirty

bit, 3 bits for protection. How many bits are still available in the page table entry to store aging information of the page? Memory is byte addressable.

Q.41 Consider the 23 bit logical address specified as

Segment	Page	Words
5 bits	9 bits	9 bits

The size of the largest segment is____(in K words)

Multiple Select Questions

Q.42 A memory have free block of sizes 2 MB, 20 MB, 4 MB and 8 MB. For allocating there blocks best-fit strategy is used. Below are the allocation request in *a* queue where *A* enters first in the queue as shown in the table.

Arrival time in queue	Request Process Name	Request size	Usage Time (T)
0	A	2 MB	4
1	B	14 MB	10
2	C	3 MB	2
3	D	6 MB	8
4	E	6 MB	4
5	F	10 MB	1
6	G	7 MB	8
7	H	20 MB	6

Which of the following processes have been completed after $T = 10$?

(a) B (b) F
(c) E (d) D

Q.43 1000 GB memory is managed using variable partitions and assume no compaction of memory is done. Currently it has 2 partitions of sizes 340 GB and 381 GB respectively which are occupied. Which of the following is correct?

(a) A memory allocation request of 300 GB is granted.
(b) A memory allocation request for 181 GB will be granted.
(c) A memory allocation request for 240 GB will be granted.
(d) A memory allocation request for 58 GB will be granted.

Try Yourself

T1. On a system with 1 MB of memory using the buddy system, what is the first requests due to lack of available memory? 50 K, 150 K, 90 K, 130 K, 70 K, 80 K, 120 K, 180 K, 60 K.

(a) 120 K (b) 80 K
(c) 180 K (d) 60 K

[Ans: (a)]

T2. Suppose you have a 47-bit virtual address space with a page size of 16 KB and that page table entry takes 8 bytes. How many levels of page tables would be required to map the virtual address space if every page table is required to fit into a single page?

(a) 1 (b) 2
(c) 3 (d) 4

[Ans: (c)]

T3. Consider a system that uses 3 bits to denote the page number and 5 bits to denote the offset. In this system, memory is accessed in bytes. Suppose a process is executing that has six pages and two following page table.

Valid bit	Page frame number
1	4
1	7
1	1
0	0
1	2
1	1

What are the physical addresses for the corresponding logical addresses.

	L.A		P.A
1.	158	(a)	245
2.	53	(b)	Page fault
3.	125	(c)	94
4.	167	(d)	39

Match the table (**Hint:** Convert all decimal logical addresses to binary logical addresses and separate them into p, d)

(a) 1-c, 2-d, 3-a, 4-b (b) 1-d, 2-a, 3-b, 4-c
(c) 1-c, 2-a, 3-d, 4-b (d) 1-c, 2-a, 3-b, 4-d

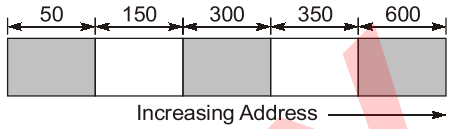
[Ans: (d)]

T4. A link editor is a program that:

(a) Matches the parameters of the macro definition with locations of the parameters of the macro call
(b) Matches external names of one program with their location in other programs
(c) Matches the parameters of routine definition with the location of parameters of sub routine call
(d) Acts as a link between compiler and user program

[Ans: (d)]

T5. Consider the heap in which blank regions are not in use and shaded regions are in use. The sequence of requests for blocks of size 300, 25, 125, 50 can be satisfied if we use



(a) Either first fit or best fit policy
(b) First fit but not best fit policy
(c) Best fit but not first fit policy
(d) None of the above

[Ans: (b)]

■■■■

7 Virtual Memory

Multiple Choice Questions

Q.1 A page fault ?
(a) occurs when a program accesses an available page of memory.
(b) is an error in a specific page.
(c) is a reference to a page belonging to another program.
(d) occurs when a program accesses a page not currently in memory.
[ISRO-2009]

Q.2 Which one of the following page replacement method guarantee the minimum number of page faults?
(a) Replace the page whose next reference will be the farthest in future.
(b) Replace the page whose next reference will be the nearest in future.
(c) Replace the page whose recent reference was the nearest in the past.
(d) Replace the page whose most recent reference was the farthest in the past.
[DRDO-2008]

Q.3 Which of the following statements are TRUE about paging?
P : It divides memory into units of equal size
Q : It permits implementation of virtual memory
R : It suffers from internal fragmentation.
(a) P only (b) Q only
(c) R only (d) P and Q and R
[DRDO-2008]

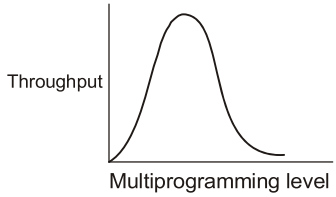
Q.4 The sequence of page addresses generated by a program is 1, 2, 1, 3, 4, 2, 1, 3, 4. The program is run on a system with main memory size equal to 3 pages. Which pages are in the memory just before 5th page fault, if least recently used page replacement is followed ?
(a) 1, 2, 3 (b) 1, 2, 4
(c) 1, 3, 4 (d) 2, 3, 4
[DRDO-2008]

Q.5 In inverted page table organization, the size of the page table depends on
(a) The number of processes
(b) the size of processes
(c) The size of the main memory
(d) The number of frames in the main memory
[JNUEE-2009]

Q.6 "Belady's Anomaly" is related through which of the following statements.
(a) FIFO CPU scheduling algorithm
(b) Inter process communication
(c) FIFO page replacement algorithm
(d) Semaphore.

Q.7 Working set is directly related through which of the following.
(a) Circular wait
(b) Monitor
(c) Principle of locality
(d) Mutual exclusion

Common Data for Q.8 & Q.9
Consider the graph below:



The above graph shows measured values of throughput versus multiprogramming level for a particular computer system. Throughput is the rate at which requests are satisfied and multiprogramming level is the number of requests competing for system resources.

Q.8 At lower multiprogramming levels, throughput increases as multiprogramming level increases. The phenomenon is best explained by the fact that as multiprogramming level increases.
(a) System overhead increases
(b) System resources to be utilized perfectly
(c) I/O activity per request remains constant
(d) The potential for concurrent activity among system resources increases.

Q.9 At intermediate multiprogramming levels, the rate of increase of throughput with multiprogramming levels decreases. This phenomenon is best explained by the fact that as multiprogramming level increase.
(a) I/O activity per request remain constant
(b) Some system resource to be utilized 100%
(c) The utilization of memory improves
(d) The average time spent in the system by each process increases.

Q.10 In a system, an instruction takes "t" time if there is no page fault, and time "t_1", if there is a page fault. What is the effective instruction time if page fault occur every "k" instructions?

(a) $t_1 - \frac{t}{k}$ (b) $1 + \frac{t_1 - t}{k}$

(c) $t + \frac{t_1 - t}{k}$ (d) $t - \frac{t_1}{k}$

Q.11 Consider the following page addresses stream formed by executing the program with 3 frames 1, 2, 3, 1, 2, 5, 8, 7.
By using optimal page replacement number of page faults and number of page hits will be?
(a) 3, 6 (b) 5, 3
(c) 2, 6 (d) 6, 2

Q.12 Consider a system having one process which is referring 'n' pages in the logical address and out of which 'm' unique pages occur in it. And 's' is the number of frames allocated to the process, then what is the minimum and maximum number of page faults possible?
(a) n, s (b) s, n
(c) m, n (d) s, m

Q.13 Consider the demand page environment where if it takes 8 ms to service a page fault , if either an empty frame is available or the replaced page is NOT to be modified. And if it takes 20 ms if the replaced page is modified. Assuming the main memory access time is 1 ms, and further assume the page to be replaced is modified 70% of the time. Then what is the maximum acceptable page fault rate to get an effective memory access time not more than 2 ms.
(a) 0.032 (b) 0.064
(c) 0.128 (d) 0.008

Q.14 Consider the virtual page reference string, 1, 2, 3, 2, 4, 1, 3, 2, 4, 1. On a demand paged virtual memory system running on a computer system that has a main memory size of 3 page frames which are initially empty. Let LRU, FIFO and OPTIMAL denote the number of page faults under the corresponding page replacement policy. Then
(a) OPTIMAL < LRU < FIFO
(b) OPTIMAL < FIFO < LRU
(c) OPTIMAL = LRU
(d) OPTIMAL = FIFO **[GATE-2012]**

Q.15 Consider a string 1, 2, 3, 1, 5, 2, 8, 5, 7 and there are 3 frames in main memory. Using this table below shows which algorithm is being used.

1			PF
1	2		PF
1	2	3	PF
1	2	3	
5	2	3	PF
5	2	3	
5	8	3	PF
5	8	3	
7	8	3	PF

(a) Optimal (b) FIFO
(c) LRU (d) MRU

[GATE-2008]

Q.16 A computer system supports 32-bit virtual address as well as 32-bit physical addresses. Since the virtual address space is of the same size as the physical address space, the operating system designers decide to get rid of the virtual memory entirely.
Which one of the following is true?
(a) Efficient implementation of multi-user is no longer possible.
(b) The processor cache organization can be made more efficient now.
(c) Hardware support for memory management is no longer needed.
(d) CPU scheduling can be made more efficient.

[GATE-2006]

Q.17 The address sequence generated by tracing a particular program executing in a pure demand paging system with 100 records per page with 1 free memory frame is recorded as follow.
What is the number of page faults?
0100, 0200, 0400, 0499, 0510, 0530, 0560, 0120, 0220, 0240, 0260, 0320, 0370.
(a) 7 (b) 8
(c) 10 (d) 13

Q.18 The main memory size is assumed to be 4 KB and the page size is 1 KB. If LRU (least Recently used) algorithm is used for page replacement then what pages should reside in main memory at the end for the following sequence of page references?
4, 8, 2, 3, 2, 8, 3, 1, 2, 6, 7
(a) 1, 6, 2, 7 (b) 2, 4, 7, 8
(c) 1, 2, 6, 8 (d) 1, 2, 3, 8

Q.19 Determine T(true) / F(False) of the following statements.
1. The translation look a side buffer is a software data structure that supports the virtual memory address translation operation.
2. Demand paging requires the programmer to take specific action to force the operating system to lead a particular virtual memory page.
3. A page frame is portion of the memory.
(a) (1) — F, (2) — F, (3) — T
(b) (1) — F, (2) — T, (3) — F
(c) (1) — T, (2) — F, (3) — T
(d) (1) — T, (2) — T, (3) — T.

Q.20 Consider a system where an instruction takes 'i' μ sec and an additional 'j' μ sec if the page fault occurs, then what is the effective instruction access time if the page fault occurs on an average for every 'k' instructions?
(a) $k+\frac{j}{i}$ (b) $i+\frac{j}{k}$
(c) $j+\frac{i}{k}$ (d) $k+\frac{j}{k}$

Q.21 Consider a system where the page fault service time is 200 ms, and the main memory access time is 10 ms. The translation look aside buffer is added to improve the performance. The 80% references are found in the T.L.B. and that of the remaining 10% cause page faults. (The T.L.B. access time and the page table access times are negligible). Then what is the effective memory access time ?
(a) 15.8 ms (b) 14.8 ms
(c) 13.8 ms (d) 12.8 ms

Q.22 The number of page faults with a given string "S" using LRU algorithm is "N" and considering the reverse of string S^R the number of page faults will be:
(a) N (b) $\frac{N}{2}$
(c) 2 N (d) 3.75 N

Q.23 A virtual memory system uses First In First Out (FIFO) page replacement policy and allocates a fixed number of frames to a process. Consider the following statements.
P: Increasing the number of page frames allocated to a process sometimes increases the page fault rate.
Q: Some program do not exhibit locality of reference.

Which one of the following is true?

(a) Both P and Q are true, and Q is the reason for P
(b) Both P and Q are true, but Q is not the reason for P
(c) P is false, but Q is true
(d) Both P and Q are false.

Common Data for Q.24 & Q.25

A process has been allocated 3 page frames. Assume that none of the pages of the process are available in the memory initially. The process makes the following sequence of page references (reference string).
1, 2, 1, 3, 7, 4, 5, 6, 3, 1.

Q.24 If optimal page replacement policy is used, how many page faults occur for the above reference string.

(a) 7 (b) 8
(c) 9 (d) 10

[GATE-2007]

Q.25 Least recently used (LRU) page replacement policy is a practical approximation to optimal page replacement. For the above reference string, how many more page faults occur with LRU than with the optimal page replacement policy?

(a) 0 (b) 1
(c) 2 (d) 3

[GATE-2007]

Q.26 If an instruction takes 5 microseconds to complete and it takes 105 microseconds to complete with a page fault. If the page hit ratio is 95%, what is the effective instruction time?

(a) 10 μ sec (b) 15 μ sec
(c) 25 μ sec (d) None

Q.27 Consider the reference string for different page replacement algorithm.

7, 0, 1, 2, 0, 3, 0, 4, 2, 3, 0, 3, 2, 1, 2, 0, 1, 7, 0, 1.

If FIFO, OPTIMAL, LRU page replacement algorithm is used then percentage of page faults respectively is? [Assume number of frames assigned = 3]

(a) 75%, 45%, 60% (b) 85%, 55%, 65%
(c) 65%, 60%, 70% (d) None of these

Q.28 Assume that a memory with only 4 pages, each of 16 bytes, is initially empty. The CPU generates the following sequence of virtual addresses and uses the least recently used (LRU) page replacement policy.
0, 4, 8, 20, 24, 36, 44, 12, 68, 72, 80, 84, 28, 32, 88, 92

How many page faults does this sequence cause? What are the page number of the pages present in the main memory at the end of the sequence?

(a) 6 and 1, 2, 3, 4 (b) 7 and 1, 2, 4, 5
(c) 8 and 1, 2, 4, 5 (d) 9 and 1, 2, 3, 5

[GATE-IT-2008]

Q.29 A demand paging system takes 100 time units to service a page fault if it is not a dirty page and 300 time units as page fault service time if it is a dirty page. Memory access time is 1 time unit. The probability of a page fault is P. In case of page fault, the probability of page being dirty is also P. It is observed that the average access time is 3 time units. Then the value of "P" is.

(a) 0.233 (b) 0.514
(c) 0.019 (d) None of the above

Q.30 Let a memory have four free blocks of sizes 4 K, 8 K, 20 K, 2 K. These blocks are allocated following the best-fit strategy. The allocation request are stored in a queue and coming in the same order, as shown below J_1 at t_0, J_2 at t_1, J_3 at t_2 and so on.

Request Number	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8
Request Sizes	2K	14K	3K	6K	6K	10K	12K	20K
Usage Time	1	10	2	8	4	1	8	6

The time at which the request for J_7 will be complete will be. (Assume fixed partition scheme).

(a) 16 (b) 14
(c) 20 (d) 37

Q.31 Thrashing
(a) reduces page I/O
(b) decreases the degree of multi-programming
(c) improve the system performance
(d) implies excessive page I/O.

Q.32 Which of the following statements is false about virtual memory?
(a) Translates programs logical address space into physical address space.
(b) Reduce the context switching overheads.
(c) Allows each program to exceed the size of the primary memory.
(d) Increases degree of multiprogramming.

Q.33 Which of the following statements are TRUE about thrashing?
P : Implies excessive page faults
Q : CPU utilization decreases
R : Implies less page faults
(a) P only (b) Q only
(c) P and Q only (d) Q and R only

Q.34 IF page fault service time is 50 milli seconds and memory access time is 100 ns, then what will be the effective access time, if the probability of page fault is P.
(a) (500000 + 100 P) ns
(b) (100 + 500000 × P) ns
(c) $10^{-7} - 10^{-7}$ P (500000) seconds
(d) 10^{-7} + 49.9 * 10^{-3} P seconds.

Q.35 The minimum number of page frames that must be allocated to a running process in a virtual memory environment is determined by
(a) The instruction set architecture
(b) Page size
(c) Physical memory size
(d) Number of process in memory

Numerical Answer Type Questions

Q.36 There are four page frames in the memory. The following sequence of virtual page numbers is encountered in the course of execution of a program, 3, 4, 2, 6, 4, 7, 6, 1, 3, 7, 3, 5. Assume that main memory is initially empty and LRU replacement policy is adopted. The number of pages transferred during this sequence of reference is _____.

Q.37 Let the page fault service time be 10 ms in a computer with average memory access time being 20 ns. If one page fault is generated for every 10^6 memory access, what is the effective access time approximately (in ns) for the memory?

Q.38 Given references to the following pages by a program, 0, 9, 0, 1, 8, 1, 8, 7, 8, 7, 1, 2, 8, 2, 7, 8, 2, 3, 8, 3.
How many page faults will occur if the program has been three page frames available to it and uses an optimal replacement?

Q.39 The address sequence generated by tracing a particular program executing in a pure demand paging system with 100 Bytes per page is 0100, 0200, 0430, 0499, 0510, 0530, 0560, 0120, 0220, 0240, 0260, 0320, 0410.
Suppose that the memory can store only one page and if "X" is the address which causes a page fault then the byte from addresses "X" to $x + 99$ are loaded on to the memory. How many page faults occur?

Q.40 A system uses FIFO policy for page replacement. It has 4 page frames with no pages loaded to begin with .The system first accesses 100 distinct pages in some order and then accesses the same 100 pages but now in the reverse order. How many page faults will occur?

Multiple Select Questions

Q.41 In a main memory with only 4 pages each of 16 B. Assume initially it is empty. The CPU generates the following virtual addresses.
0, 4, 8, 20, 24, 36, 44, 12, 68, 72, 80, 84, 28, 32, 88, 92
Which of the below options are correct?
(a) Total 7 page faults when FIFO replacement policy is used.

(b) Total 7 page faults when LRU replacement policy is used.
(c) Page number 1, 2, 4 and 5 will be in the memory after execution of generated address when LRU is used.
(d) Page number 1, 2, 3 and 4 is there after execution when FIFO is used.

Try Yourself

T1. Consider a system with a demand paging environment, where main memory access time is 120 ns and page fault, service time is 5 ms. Then what should be page fault rate to achieve an effective memory access time of 1 µsec.

[Ans: 1.7600×10^{-4}]

T2. Given references to the following page by a program

0, 9, 0, 1, 8, 1, 8, 7, 8, 7, 1, 2, 8, 2, 7, 8, 2, 3, 8, 3

How many page faults will occur if the program has three page frames available to it and uses the below algorithms

List-I	List-II
1. FIFO	A. 7
2. LRU	B. 8
3. Optimal	C. 9
	D. 10
	E. 6

Codes:

	1	2	3
(a)	C	B	E
(b)	A	B	E
(c)	B	C	A
(d)	B	D	A

[Ans: (c)]

T3. Consider a system using a demand paging where the main memory access time is 150 ns and the page fault rate is 10%. To achieve the EMAT of 500 µsec. What would be the page fault service time?

(a) 2.99 ms (b) 1.32 ms
(c) 4.99 ms (d) 5.37 ms

[Ans: (c)]

T4. Virtual memory fetch strategies determine when a page or segment should be moved from _____ to _____.

(a) main memory, the TLB
(b) secondary storage, main memory
(c) main memory, secondary storage
(d) the TLB, registers

[Ans: (b)]

T5. A process in demand paging environment has reference string mark 1 to n process refers the pages in same order then it refers the pages again in reverse order. K-frame are allocated to process. Assume pure demand paging with FIFO replacement. What is the number of page fault for process.

(a) $2n - k$ (b) $2n - 1$
(c) $2(n - k)$ (d) $2(n - 1)$

[Ans: (a)]

T6. Consider a system having a LA = 28 bits. The address space is divided into page with page size be power of 2. PTE size is 4 bytes. What must be the page size in a system (in bytes) such that the page table of process exactly fits in 4 page frame of memory.

[Ans: (16384)]

T7. Consider a paging hardware with a TLB. Assume that the entire page table and all the pages are in the physical memory. It takes 10 ms to search the TLB and 80 ms to access the physical memory. If the TLB hit ratio is 0.6, the effective memory access time (in ms) is _____.

[Ans: (122)]

T8. A system uses 3 page frames for storing process pages in main memory. It uses that LRU page replacement policy. Assume that all the page frames are initially empty. What is the total number of page faults that will occur while processing the page reference string given below ?

4, 7, 6, 1, 7, 6, 1, 2, 7, 2

[Ans: (6)]

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8 Disk Scheduling

Multiple Choice Questions

Q.1 Consider a disk system with 100 cylinders. The requests to access the cylinders occur in the following sequence:

4, 34, 10, 7, 19, 73, 2, 15, 6, 20

Assuming that the head is currently at cylinder 50, what is the time taken to satisfy all requests if it takes 1 ms to move from one cylinder to adjacent one and shortest seek time first policy is used.

(a) 95 ms (b) 119 ms
(c) 233 ms (d) 276 ms

[GATE-2009]

Q.2 Consider the following disk queue with request for I/O blocks on cylinder 98, 180, 37, 170, 14, 75, 67, 165.

Initially the disk head is at cylinder 55. Assume that the seek time for one cylinder is 1 MS. Find the total time required to complete this request if shortest seek time first algorithm is used.

(a) 180 MS (b) 235 MS
(c) 293 MS (d) 391 MS

[DRDO- 2009]

Q.3 If the read/write head of a disk starts at track 100 and the disk has requests pending to tracks 43, 158, 44, 203 and 175. What is the total number of tracks that the read/write head will cross to satisfy these requests under the following disk scheduling technique?

A. FCFS 1. 263 tracks
B. SSTF 2. 473 tracks
C. LOOK 3. 217 tracks

(a) A2, B3, C1
(a) A1, B2, C3
(c) A2, B1, C3
(d) None of these

Common Data for Q.4 & Q.5

A particular disk unit uses a bit string to record the occupancy or vacancy of its tracks, with '0' denoting vacant and '1' denoting occupied. A 32-bit segment of this string has the hexadecimal value D4FE2003.

Q.4 What is the percentage of occupied tracks for the corresponding part of the disk.

(a) 38% (b) 44%
(c) 62% (d) 56%

Q.5 What is the percentage of vacant tracks for the corresponding part of disk.

(a) 38% (b) 44%
(c) 62% (d) 56%

Q.6 Disk requests come to disk driver for cylinder 10, 22, 20, 2, 40, 6 and x, in that order at a time when the disk drive is reading from cylinder 20. The seek time is 6 ms per cylinder. If the total seek time 876 ms under FCFS scheduling algorithm then what is the value of 'x'?

(a) 32 (b) 34
(c) 38 (d) None of these

Q.7 The head of a moving disk with 100 tracks numbered 0 to 99 is serving a request at track 'x'. If the requests of track 25, 76, 43, 10, 67 are served using FCFS algorithm, then head

movements are 194. The track 'x' initially served was.

(a) 45 (b) 55
(c) 70 (d) 35

Q.8 On a disk with 1000 cylinders, numbers '0' to '999', compute the number of tracks the disk arm must move to satisfy all the requests in the disk queue. Assume the last request serviced was at track 345 and the head is moving toward track 0. The queue in FCFS order contains requests for the following tracks. 123, 874, 692, 475, 105, 376, perform the computation using C-SCAN scheduling algorithm. What is the total distance?

(a) 1219 (b) 1009
(c) 1967 (d) 1507

Q.9 A disk has 200 tracks (numbered '0' through 199). At a given time, it was servicing the request of reading data from track (120, and at the previous request, service was for track 90. The pending requests (in order of their arrival) are for track numbers. 30, 70, 115, 130, 110, 80, 20, 25. How many times will the head change its direction for the disk scheduling policies SSTF (shortest seek time first) and FCFS (First come first serve)?

(a) 2 and 3 (b) 3 and 3
(c) 3 and 4 (d) 4 and 4

[GATE-IT : 2004]

Q.10 Comparison of disk scheduling algorithms with total 200 tracks, 0 - 199. The requested tracks in the order received are 55, 58, 39, 18, 90, 160, 150, 38, 184. The current position of the head is at 53. The average seek time of (read/write header moving towards positive direction consider this, in case of scan and C-SCAN)

(a) C-SCAN (b) SCAN
(c) SSTF (d) FCFS

(a) a > b > d > c
(b) b > c > d > a
(c) d > a > b > c
(d) d > c > b > a

Numerical Answer Type Questions

Q.11 On a disk with 1000 cylinders, numbers 0 to 999, compute the number of tracks the disk arm must move to satisfy all the requests in the disk queue. Assume the last request served was at track 345 and the head is moving to wards track '0'. The queue in FCFS order contains the requests for the following tracks:

123, 874, 692, 475, 105, 376

The computation for FCFS algorithm will be _____.

Multiple Select Questions

Q.12 Consider the options below and select the correct answer.

(a) Time sharing system uses shortest job first scheduling algorithm.
(b) First come first serve algorithm may give the best throughout for disk scheduling.
(c) Nearest cylinder next will always give the best throughput for disk scheduling.
(d) None of these

Try Yourself

T1. Data cannot be written to secondary storage unless written within a _____.

(a) file (b) swap space
(c) directory (d) text format

[Ans: (a)]

T2. File attributes consist of

(a) name (b) type
(c) identifier (d) All of these

[Ans: (d)]

T3. Suppose a disk has 201 cylinders, numbered from 0 to 200. At some time the disk arm is at cylinder 100, and there is a queue of disk access requests for cylinders 30, 85, 90, 100, 105, 110, 135 and 145. If SSTF is being used for scheduling the disk access, the request for cylinder 90 is serviced after servicing _____ number of requests.

[Ans: (3)]

T4. A FAT based file system is being used and the total overhead of each entry in the FAT is 4 bytes in size. Give a 100×10^6 bytes disk on which the file system is stored and data block size is 10^3 bytes, the maximum size of a file that can be stored on the disk in units of 10^6 bytes is _____.

[Ans: (99.60)]

T5. Suppose the following disk request sequences for a disk with 100 tracks is given:

45, 20, 90, 10, 50, 60, 80, 25, 70

Assume that the initial position of R/W head is on track 50. The additional distance that will be traversed by R/W head when SSTF is used as compared to SCAN (assuming SCAN moves towards 100 when started) is _____ tracks.

[Ans: (10)]

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9 File System

Multiple Choice Questions

Q.1 Which of the following is not file attributes?
(a) read only flag (b) password
(c) record length (d) relocation bit

Q.2 The time to access the first word of a specific sector of a hard disk depends on the rotational speed of the disk, the average seek time and the number of sectors per track. If we want not just the first word but an entire sector (assume a sector holds about 100 words). How much longer will it take?
(a) about 100 times longer
(b) about 10 time longer
(c) about the same amount of time
(d) about 50 times longer

Q.3 Which of the following file allocation method require less seek time to access file?
(a) contiguous allocation
(b) linked allocation
(c) indexed allocation
(d) none of these

Q.4 Consider a file system where linked allocation strategy and contiguous allocation strategy is used. The number of disk blocks to be accessed if the K^{th} block of file to be accessed respectively is ?
(a) 1, K (b) K, 1
(c) K log K, K (d) K, K log K

Q.5 A sequential access file has fixed sized "M" byte records. The first byte of record "N" will start at which logical location?
(Logical address start from location "0")
[And record number starts from 1]
(a) $(n-1)\,m+1$ (b) $(n-1)\,m-1$
(c) $(n-1)\,m$ (d) $(n+1)\,m-1$

Q.6 Each I-node in file system has 5-direct pointers to disk blocks, 3 single indirect pointers to disk blocks, 2 double indirect pointers to disk blocks and nothing else. A disk block is 400 bytes. A pointer to a disk block is 10 byte. What is the total size of the entire file system?
(a) 1325250 bytes (b) 1325000 bytes
(c) 1330000 bytes (d) None of these

Q.7 Unix-style I-node has 10 direct pointers, 1 double indirect, 1 triple indirect and 1 quadruple indirect pointer. Disk block size is 1 K Byte. If the maximum number of bytes of a file that can be accessed by quadruple pointer is 4 tera bytes using the I-Node, then how many bits are required to address disk block?
(a) 4 (b) 8
(c) 16 (d) 32

Q.8 Consider the organization of a UNIX file as represented by the inode. Assume that there are 12 direct block pointers and a singly, doubly and triply indirect pointer in each inode. Further, assume that the system block size 8 KB. The disk pointer is 32 bits and maximum file size is 16 MB.
Assuming no information other than the file inode is already in main memory, how many disk accesses are required to access the byte in position 13423826 of the file?
(a) 1 (b) 2
(c) 4 (d) 8

Q.9 What is the reference count filed in the I-Node?
(a) counts the number of processes currently executing in the inode
(b) counts the number of hard links presently pointing at a particular inode.
(c) count the size of memory required by inode
(d) None of the above.

Q.10 The data block of a very large file in the unix file system are allocated using
(a) Contiguous allocation
(b) Linked allocation
(c) Indexed allocation
(d) An extension of indexed allocation
[GATE-2008]

Q.11 In a particular Unix OS, each data block is of size 1024 Bytes, each node has 10 direct data block addresses and three additional addresses, one for single indirect block, one for double indirect block and one for triple indirect block. Also each block can contain addresses for 128 blocks. Which one of the following is approximately the maximum size of a file in the file system?
(a) 512 MB (b) 2 GB
(c) 8 GB (d) 16 GB
[GATE-IT-2004]

Q.12 The UNIX I-node holds 8-direct disk block addresses a single indirect and double indirect disk block addresses. If the disk blocks are accessible with 16 bits and disk block offset is 12 bits. The approximate maximum file size supported is
(a) 2 GB (b) 4 GB
(c) 16 GB (d) 8 GB

Q.13 Belady's anamoly is about
(a) Thrashing in paging
(b) Abnormal segmentation
(c) Abnormal page fault in FIFO
(d) Abnormal page fault in LRU

Q.14 A file system with 300 GByte disk uses a file descriptor with 8 direct block addresses, 1 indirect block address and 1 doubly indirect block address. The size of each disk block is 128 Bytes and the size of each disk block address is 8 Bytes. The total size of the file system is
(a) 3 KBytes
(b) 35 KBytes
(c) 280 KBytes
(d) Dependent on the size of the disk
[GATE-2012]

Numerical Answer Type Questions

Q.15 A computer system uses a single level directory structure. The directory occupies '2' disk blocks. The disk block size is 2 KB. Directory entry size is 4 bytes. What is the maximum number of files in the file system?

Q.16 A hard disk has a capacity of 40 MB. Disk block size is 2 KB. Disk block address is 3 bytes. If the system uses bit map approach to maintain free space utilization, what is the number of blocks required to store the bit map?

Q.17 What is approximate maximum file size (in GB) supported by a file system with 16 direct block, single, double and triple indirection? Block size is 512 bytes. Disk block numbers can be stored in 4 bytes.

Multiple Select Questions

Q.18 Which of the following options are correct?
(a) Using a larger block size in a fixed block size file system leads to better disk thoughput.
(b) Using a larger block size in a fixed block size file system leads to poorer disk thoughput.
(c) Using a larger block size in a fixed block size file system leads to poorer disk space utilization.

(d) Using a larger block size in a fixed block size file system leads to better disk space utilization.

Q.19 Consider the following statements and select the correct options.

(a) An extension of indexed allocation is used for the data blocks of a very large file in the unix file system.

(b) In a file allocation system both linked and index allocation scheme is free from external fragmentation.

(c) Contiguous file allocation scheme is free from external fragmentation.

(d) Linked allocation scheme is used for the data blocks of a very large file in unix file system.

Try Yourself

T1. Consider a file system in which files are stored in blocks of 8 kB. For each of the following file sizes, calculate the percentage of wasted file space due to incomplete filling of the last block. Match the following groups.

File size	% of wastage in the last block
1. 3209 bytes	A. 57.7%
2. 24,576 bytes	B. 0%
3. 2,328,432,002 bytes	C. 60.82%
4. 2,328,927,678 bytes	D. 76.56%
	E. 7.05%

Codes:

	1	2	3	4
(a)	C	A	B	D
(b)	C	B	A	E
(c)	C	B	A	D
(d)	B	C	A	D

[Ans: (b)]

T2. A file system with 300 GB disk uses a file decreptor with 8 direct block addresses, 1 indirect block address and 1 doubly indirect block address. The size of each disk block is 128 bytes and the size of each disk block address is 8 bytes. The maximum possible file size in this file system is

(a) 3 KB

(b) 32 KB

(c) 230 KB

(d) Dependent on the size of the disk

[Ans: (b)]

T3. In the index allocation scheme of blocks to a file, the maximum possible size of the file depends on

(a) the size of the blocks, and the size of the address of the blocks

(b) the number of blocks used for the index, and the size of the blocks

(c) the size of the blocks, the number of blocks used for the index, and the size of the address of the blocks

(d) None of the above

[Ans: (c)]

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