OPERATING SYSTEMS
(MCA 1204)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) Assuming a 1 KB page size, what is the page number and offset for the logical address 4100 (provided as a decimal number)?
(a) Page = 4, offset = 100 (b) Page = 4, offset = 4
(c) Page = 5, offset = 100 (d) Page = 5, offset = 4

(ii) How many times the following C program prints MCA (Consider all the forks worked successfully)?

```
int main(void) {
        printf("MCA\n"); fork(); printf("MCA\n"); fork(); printf("MCA\n"); return 0;
}
```

(a) 3 times (b) 5 times (c) 7 times (d) 9 times

(iii) Which of the following disk scheduling algorithms never leads to starvation of a process?
(a) FCFS (b) SSTF (c) SCAN (d) LOOK.

(iv) Which module gives control of the CPU to the process selected by the short-term scheduler?
(a) Dispatcher (b) Mid-term scheduler (c) Interrupt (d) MMU.

(v) Let the time taken to switch between user and kernel modes of execution be t_1 while the time taken to switch between two processes be t_2. Which of the following is true?
(a) $t_1 < t_2$ (b) $t_1 = t_2$
(c) $t_1 > t_2$ (d) Nothing can be said about the relationship between t_1 and t_2

(vi) The essential content(s) in each entry of a page table is/are
(a) Virtual page number (b) Page frame number
(c) Both virtual page number and page frame number (d) Access right information

(vii) Thrashing
(a) Reduces page I/O (b) Implies excessive page I/O
(c) Improves the system performance (d) Decreases the degree of multiprogramming

(viii) Page fault occurs when
(a) The page is in main memory (b) The page is not in main memory
(c) Division by zero is encountered (d) The page is corrupted by application software

(ix) The data-in register of I/O port is
(a) Read by host to get input (b) Written by host to send output
(c) Read by controller to get input (d) Written by host to start a command

(x) When several processes access the same data concurrently and the outcome of the execution depends on the particular order in which access takes place, is called
(a) Starvation (b) Mutual exclusion
(c) Race condition (d) Critical section

Fill in the blanks with the correct word

(xi) If a process has 32 KB logical address space and the page size is 2048 bytes then the number of frames of that process is _____.

(xii) The time spent by a process in the ready queue is called_____.

(xiii) With relocation and limit registers, each logical address must be _____ the limit register.

(xiv) _____ is a scheduling problem when lower-priority process holds a lock needed by higher-priority process.

(xv) The devices those deliver or accept a stream of characters, without regard to any block structure, are called _____.

Group - B

2. (a) Consider the C code snippet given below, and answer the questions:

```
Line no.
 1  int main(void) {
 2      pid_t pid;
 3      pid = fork();
 4      if (pid > 0){
 5        /*code1*/
 6      }
 7      else if (pid == 0){
 8        /*code2*/
 9      }
10      else{
11        /*code3*/
12      }
13      return 0;
14  }
```

(i) Which among code1, code2 and code3 is executed if the fork() fails?
(ii) For a successful fork(), which among code1, code2 and code3 is executed in the parent process?
(iii) For a successful fork(), which among code1, code2 and code3 is executed in the child process?
(iv) Where should a wait(NULL) be inserted so that the code in the child gets executed before the code in the parent?
(v) Where should a sleep(10) be inserted so that the child may become an orphan?
(vi) Where should a sleep(10) be inserted so that the child may become a zombie? *[(CO2) (Analyse/IOCQ)]*

(b) Which of the following instructions should be privileged?
(i) Set value of timer (ii) Read the clock (iii) Turn off interrupts (iv) Issue a trap instruction. *[(CO1)(Apply/IOCQ)]*

(c) Consider the 4 processes, P1, P2, P3 and P4 shown in the table

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

The preemptive shortest job first scheduling algorithm is used. Scheduling is carried out only at arrival or completion of process. What is the order of completion and the average waiting time for the four processes? *[(CO2)(Apply/IOCQ)]*

6 + 2 + (2 + 2) = 12

3. (a) Consider a system running ten I/O-bound tasks and one CPU-bound task. Assume that the I/O-bound tasks issue an I/O operation once forevery millisecond of CPU computing and that each I/O operation takes10 milliseconds to complete. Also assume that the context switchingoverhead is 0.1millisecond and that all processes are long-running tasks. What is the CPU utilization for a round-robin scheduler when the time quantum is 10 milliseconds? *[(CO2)(Apply/IOCQ)]*

(b) The following processes are being scheduled using a pre-emptive, priority based, round robin scheduling algorithm.

Process	Priority	Burst	Arrival
P1	40	20	0
P2	30	25	0
P3	35	25	30
P4	35	15	45
P5	5	10	90
P6	10	10	105

Each process is assigned a numerical priority, with a higher number indicating a higher relative priority. The scheduler will execute the highest priority process. For processes with the same priority, a round robin scheduler will be used with a time quantum of 10 units. If a process is pre-empted by a higher-priorityprocess, the pre-empted process is placed at the end of the queue.

(i) Show the scheduling order of the processes using a Gantt chart.
(ii) What is the turnaround time for each process?
(iii) What is the waiting time for each process? *[(CO2)(Apply/IOCQ)]*

3 + (3 + 3 + 3) = 12

Group - C

4. (a) Differentiate inter process communication through message passing and shared memory. *[(CO3)(Understand/LOCQ)]*

(b) State the classical definition of wait() and signal() operations on a semaphore. How can the classical definition be modified to have an implementation without busy waiting? *[(CO3)(Apply/IOCQ)]*

(c) Explain why spinlocks are not appropriate for single-processor systems. *[(CO3)(Understand/LOCQ)]*

4 + (2 + 4) + 2 = 12

5. (a) Two processes, P1 and P2, need to access a critical section of code. Consider the following synchronization construct used by the processes:

```
/* P1 */
while (true) {
        wants1 = true;
        while (wants2 == true);
        /* critical section */
        wants1 = false;
}
/* remainder section */
```

```
/* P2 */
while (true) {
        wants2 = true;
        while (wants1 == true);
        /* critical section */
        wants2 = false;
}
/* remainder section */
```

wants1 and wants2 are shared variables, which are initialized to false.
Analyse the synchronization construct used by the processes to check if

(i) Mutual exclusion is preserved?
(ii) The progress requirement is satisfied?
(iii) The bounded-waiting requirement is met? *[(CO3)(Analyse/IOCQ)]*

(b) Explain why spinlocks are not appropriate for single-processor systemsyet are often used in multiprocessor systems. *[(CO3)(Understand/LOCQ)]*

(c) Differentiate inter process communication through message passing and shared memory. *[(CO3)(Understand/LOCQ)]*

(2 + 2 + 2) + 3 + 3 = 12

Group - D

6. (a) Doesthe resource-allocation graph given in Fig. 1 indicate a deadlock? If it is a deadlock situation, explain why. If it is not a deadlock situation, illustrate an order in which the processes may complete execution. *[(CO4)(Analyse/IOCQ)]*

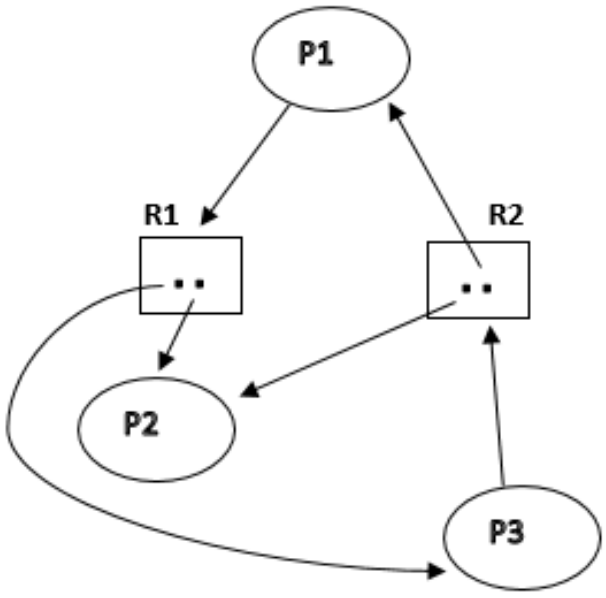

Fig. 1

(b) Compare the main memory organization schemes of contiguous-memory allocation, pure segmentation, and pure paging with respect to the following issues:

(i) External fragmentation
(ii) Internal fragmentation
(iii) Ability to share code across processes. *[(CO5)(Analyse/IOCQ)]*

3 + (3 + 3 + 3) = 12

7. (a) Consider a logical address space of 256 pages with a 4-KB page size, mapped onto a physical memory of 64 frames.

(i) How many bits are required in the logical address?
(ii) How many bits are required in the physical address? *[(CO5, CO6)(Appy/IOCQ)]*

(b) Explain why mobile operating systems such as iOS and Android do not support swapping. *[(CO1, CO5)(Understand/IOCQ)]*

(c) Consider the following page reference string:

1, 2, 3, 4, 2, 1, 5, 6, 2, 1, 2, 3, 7, 6, 3, 2

Assuming demand paging with four frames, how many page faults would occur for the following replacement algorithms?

(i) FIFO replacement
(ii) Optimal replacement
(iii) LRU replacement. *[(CO2)(Apply/IOCQ)]*

(1 + 1) + 4 + (2 + 2 + 2) = 12

Group - E

8. (a) Suppose that a disk drive has 3,000 cylinders, numbered 0 to 2999. The drive is currently serving a request at cylinder 103, and the previous request was at cylinder 125. The queue of pending requests, in FIFO order, is:

86, 1470, 913, 1774, 948, 1509, 1022, 1750

Starting from the current head position, what is the total distance (in cylinders) that the disk arm moves to satisfy all the pending requests for each of the following disk-scheduling algorithms?

(i) FCFS
(ii) SSTF
(iii) SCAN.

[(CO5)(Apply/IOCQ)]

(b) "None of the disk-scheduling disciplines, except FCFS, is truly fair". Argue in favour of or against the given statement.

[(CO5, CO6)(Evaluate/HOCQ)]

(c) Consider a free space list implemented with bit vector. What is the storage (in MB) required by the bitmap for a 2-TB disk with 4KB block size?

[(CO5)(Apply/IOCQ)]

(2 + 2 + 2) + 4 + 2 = 12

9. (a) Describe the steps in a DMA (Direct Memory Access) transfer. How does DMA increase system concurrency?

[(CO5, CO1)(Understand/LOCQ)]

(b) Consider a UNIX based file system where a logical block on the file system holds 4 KB, and that a block number is addressable by a 32-bit integer. The inode has 13 pointers for blocks of which 10 points to direct blocks and one each for a single, double and triple indirect blocks. What is the maximum file size supported by this system? *[(CO5) (Apply/IOCQ)]*

(c) In a UNIX based system, what happens when you invoke the command lnprog1mca if
(i) mca doesn'texist,
(ii) mca exists as an ordinary file,
(iii) mca exists as a directory?

[(CO1, CO5)(Apply/IOCQ)]

(4 + 2) + 3 + 3 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	18.75	77.08	4.17

Course Outcome (CO):

After the completion of the course students will be able to
CO1: Discuss how operating systems are used in various computing environments.
CO2: Identify the components of a process and thread and illustrate how they are represented and scheduled in an operating system.
CO3: Demonstrate different hardware and software techniques to solve critical section problem.
CO4: Evaluate approaches for deadlock detection and recovery from deadlock.
CO5: Analyse the various device and resource management techniques for timesharing systems.
CO6: Conceptualize the components involved in designing a contemporary OS.

**LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.*