Master of Computer Application

Second Year First Semester Examination

27^{th} January, 2021

Subject: Operating Systems

Time: 3 Hours | Full Marks: 100

PART-I

Answer Any Two Questions

1. (a) What is a Process Control Block? What are the different information stored in it?

   (b) Explain the working principle of the `fork()` system call.

   (c) For the following code segment determine the output.

```
int i=0;
do{
    if(fork()!=0);
        i++;
    else
        i+=2;
}while(i<=2);
printf("Hello %d\n", i);
```

   Provide necessary justifications.

   (d) State the different conditions under which a process is brought to the ready state.

   (e) What are the usages of stack and heap section within a process?

4+2+5+2+2=15

2. (a) Differentiate between preemptive and non-preemptive scheduling.

   (b) Differentiate between a long term scheduler and a short term scheduler. Under which conditions a mid-term scheduler is invoked?

   (c) What are the advantages of having different time-quantum sizes on different levels of multi-level queue scheduling?

   (d) An operating system uses Shortest Remaining Time First (SRTF) process scheduling algorithm. Consider the arrival times and execution times for the following processes:

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

   What is the total waiting time for process P2?

   (e) Consider an arbitrary set of CPU-bound processes with unequal CPU burst lengths submitted at the same time to a computer system. Which one of the following process scheduling algorithms would minimize the average waiting time in the ready queue?

(i) Shortest remaining time first

(ii) Round-robin with time quantum less than the shortest CPU burst

Provide necessary justifications.

2+3+2+4+4=15

3. (a) What is a relocatable code?

   (b) What is external fragmentation? Describe how it can be reduced by using compaction.

   (c) Describe how segmentation can be implemented using segment table, segment table base register and segment table length register.

   (d) What are the pros and cons of an inverted page table?

   (e) A computer system implements 8 kilobyte pages and a 32-bit physical address space. Each page table entry contains a valid bit, a dirty bit, three permission bits, and the frame number. If the maximum size of the page table of a process is 24 megabytes, determine the length of the virtual address supported by the system.

1+3+4+2+5=15

PART-II

Answer Any Five Questions

1. (a) What is a `TestAndSet` instruction? Describe how this instruction can be used to solve critical section problem. Explain if your solution satisfies the bounded waiting requirement. Provide justification for your answer.

   (b) P_1, P_2 and P_3 are three processes executing their respective tasks. They should synchronize among themselves using semaphores such that the string "ABCACB" gets printed infinite times. Determine, minimum number of semaphores required and their initial values. Also identify places where operations on those semaphore should be inserted in the code of P_1, P_2 and P_3. Provide necessary justifications.

```
P1
while(true){
    print("A");
}
```

```
P2
while(true){
    print("B");
}
```

```
P3
while(true){
    print("C");
}
```

   (c) Explain how starvation may occur in priority scheduling. Propose a solution to overcome this. Provide necessary justifications.

(1+2+2)+6+3=14

2. (a) Consider the following set of processes, assumed to have arrived at time 0. Consider CPU scheduling algorithms Shortest Job First (SJF) and Round Robin (RR). For RR, assume that the processes are scheduled in the order P_1, P_2, P_3, P_4.

Processes	P_1	P_2	P_3	P_4
Burst Time (in ms)	8	7	2	4

If time quantum for RR is 4 ms, then find the absolute value of the difference between the average turnaround times (in ms) of SJF and RR.

(b) What is a Resource Allocation Graph? Describe with a suitable example how it can be used to detect deadlock.

(c) What is critical section problem? What are the requirements those are to be met by a solution to the critical section problem?

(d) "In a computer system with n CPU's, the maximum number processes that can be present in ready state depend on n." State with necessary justifications whether this statement is true or false.

6+3+3+2=14

3. (a) What is a dispatcher?

(b) What are the synchronization requirements of the producer and consumer processes in both bounded-buffer and unbounded-buffer producer consumer problem?

(c) Differentiate between user level and kernel level threads.

(d) An operating system uses the Banker's algorithm for deadlock avoidance when managing the allocation of three resource types X, Y, and Z to three processes P_0, P_1, and P_2. The table given below presents the current system state. Here, the Allocation matrix shows the current number of resources of each type allocated to each process and the Max matrix shows the maximum number of resources of each type required by each process during its execution.

	Allocation			Max		
	X	Y	Z	X	Y	Z
P_0	0	0	1	8	4	3
P_1	3	2	0	6	2	0
P_2	2	1	1	3	3	3

There are 3 units of type X, 2 units of type Y and 2 units of type Z still available. Determine whether the system is currently in a safe state.

Now if P_0 requests 0 units of X, 0 units of Y and 2 units of Z, determine whether the request can be granted or not?

1+3+2+8=14

4. (a) Relate logical address to physical address (whether same or different) in each case of compile time, load time and execution time address binding. Provide necessary explanations.

(b) Given five memory partitions of 100 KB, 500 KB, 200 KB, 300 KB, and 600 KB (in order), how would each of the first-fit, best-fit, and worst-fit algorithms place processes of 212 KB, 417 KB, 112 KB, and 426 KB (in order)? Which algorithm makes the most efficient use of memory?

(c) Consider a paging system with 36 bit logical address and 32 bit physical address. Page size is 4 KB and size of each page table entry is 4 bytes. Determine the size of page table if single level page table is used. How many bits in each page table entry can be used for storing protection and other information?

Now, assume that you want to implement a multi level page table. Determine how many levels of page table is required if you need to store each page of the page table possibly in non contiguous frames in physical memory. Determine the division of bits of the logical address that is required to address each levels of the multi level page table. Also determine the size of the multilevel page table.

3+3+8=14

5. (a) What are the pros and cons of a dynamically linked library?

(b) In a system inverted page table is used. Each entry of the inverted page table stores pid and page number. Logical address is 36 bit, physical memory size is 16 GB and page size is 4 KB. Process pid is represented by 8 bit. Determine size of the inverted page table.

(c) Under what circumstances do page faults occur? Describe the actions taken by the operating system when a page fault occurs.

(d) Which factors determine minimum number of page frames that must be allocated to a running process in a virtual memory environment?

2+6+3+3=14

6. (a) Describe the working principles of a hashed page table.

(b) In a system, the page size is 16 and it uses LRU page replacement policy. Number of frames allocated to a process is 4. A process generates the following sequence of virtual addresses:

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 numbers of the pages present in the main memory at the end of the sequence?

(c) In a particular Unix OS, each data block is of size 1024 bytes, each i-node has 8 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? What is the approximate maximum size of a file in the file system?

4+5+5=14

7. (a) Describe how file information is stored in File Allocation Table (FAT). How does FAT-16 differ from FAT-32?

(b) A disk pack has 16 surfaces, 1024 tracks per surface and 128 sectors per track. Size of each sector is 512 bytes. Determine the size of the disk pack and the number of bits required to address each cylinder and each sector.

(c) Suppose that a disk drive has 2,000 cylinders, numbered 0 to 1999. The drive is currently serving a request at cylinder 143, and the previous request was at cylinder 125. The queue of pending requests, in FIFO order, is:

86, 913, 1774, 948, 1509, 1022, 1750, 130

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

(3+1)+4+6=14