CSE/MCA/T/211A

Master of Computer Application
Second Year First Semester Examination, 2021
Subject: Operating Systems

Time: 3 Hours | Full Marks: 70

Answer Any Five Questions

1. (a) Consider the following C Program.

```
int m=10;
int fact(int n){
    if(n==1)
        return(1);
    else
        return(n*fact(n-1));
}
int main(){
    int *p = (int *) malloc(sizeof(int));
    *p=fact(m);
    printf("%d", *p);
}
```

Describe the run-time memory layout of this program. Also, state the region of memory where the variables m, n, p are allocated space.

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

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

```
int i;
for(i=0; i<=3; i++)
    if(fork()!=0)
        i++;
    else
        i+=2;
}while(i<=2);
printf("Hello %d\n", i);
```

Provide necessary justifications.

(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

Find out the average waiting time.

4+3+4+3=14

2. (a) What are the advantages of multi-threading over multi-processing?

   (b) Consider the following multi-threaded code segment (in a mix of C and pseudo-code), invoked by two processes P_1 and P_2, and each of the processes spawns two threads T1 and T2:

```
int x=0;
Lock L1;
main(){
     create a thread to execute foo();
     create a thread to execute foo();
     wait for the two threads to finish execution;
     print(x);
}
foo(){
     int y=0;
     Acquire L1;
     x=x+1;
     y=y+1;
     Release L1;
     print(y);
}
```

   What would be the values of `x` and `y` that would be printed by all the processes and the threads belonging to all the processes respectively. Provide necessary justifications for your answer.

   (c) P_1, P_2, P_3 and P_4 are four processes executing their respective tasks. They should synchronize among themselves using semaphores such that the string "ABACAD" 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, P_3 and P_4. Provide necessary justifications.

P_1
```
while(true){
     print("A");
}
```

P_2
```
while(true){
     print("B");
}
```

P_3
```
while(true){
     print("C");
}
```

P_4
```
while(true){
     print("D");
}
```

6+3+5=14

3. (a) A system has four resource types and five running processes. Resource types A, B, C and D have 6, 7, 12 and 12 instances respectively. Consider the following snapshot of a system. Allocation column gives current allocation of each process and Maximum column gives maximum needs of each process.

	Allocation				Max			
	A	B	C	D	A	B	C	D
P_0	0	0	1	2	0	0	1	2
P_1	2	0	0	0	2	7	5	0
P_2	0	0	3	4	6	6	5	6
P_3	2	3	5	4	4	3	5	6
P_4	0	3	3	2	0	6	5	2

Determine if the system is currently deadlocked. If a request from P_2 arrives for (0, 1, 0, 0) can it be granted immediately? If not, which processes may become deadlocked if the whole request is granted?

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

(c) Consider a system with 3 processes that share 4 instances of the same resource type. Each process can request a maximum of K instances. Resource instances can be requested and released only one at a time. Find out the largest value of K that will always avoid deadlock. Provide necessary justifications.

8+3+3=14

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

(b) 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.

(c) In a virtual memory system, size of virtual address is 32-bit, size of physical address is 30-bit, page size is 4 Kbyte and size of each page table entry is 32 bit. The main memory is byte addressable. Determine the maximum number of bits that can be used for storing protection and other information in each page table entry.

(d) Consider a paging system that uses single level page table residing in main memory and a TLB for address translation. Each main memory access takes 100 ns and TLB lookup takes 20 ns. Each page transfer to/from the disk takes 5000 ns. Assume that the TLB hit ratio is 95%, page fault rate is 10%. TLB update time is negligible. Determine the average memory access time in ns.

2+3+3+6=14

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

(b) What is thrashing?

(c) 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?

(d) Consider a computer system with five physical page frames. The system is provided with an access sequence $(a_1, a_2, \ldots a_{10}, a_1, a_2, \ldots, a_{10})$, where each a_i is a distinct virtual page number. Determine the difference in the number of page faults between the last-in-first-out page replacement policy and the optimal page replacement policy.

2+2+4+6=14

6. (a) The index node (inode) of a Unix-like file system has 12 direct, one single-indirect and one double-indirect pointers. The disk block size is 4 KB, and the disk block address is 32-bits long. Determine the maximum possible file size supported in GB.

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

   (c) Consider a disk queue with requests for I/O to blocks on cylinders 47, 38, 121, 191, 87, 11, 92, 10. The C-LOOK scheduling algorithm is used. The head is initially at cylinder number 63, moving towards larger cylinder numbers on its servicing pass. The cylinders are numbered from 0 to 199. Determine the total head movement (in number of cylinders) incurred while servicing these requests.

   (d) Consider a hard disk with 16 recording surfaces (0-15) having 256 cylinders (0-255) and each track contains 64 sectors (0-63). Data storage capacity in each sector is 512 bytes. Data are organized cylinder-wise and the addressing format is <cylinder no., surface no., sector no.>. A file of size 427 KB is stored in the disk and the starting disk location of the file is <120, 9, 40>. What is the address of the last sector of the file, if it is stored in a contiguous manner?

4+3+3+4=14