United International University
Department of Computer Science and Engineering
CSI 309/CSE 4509: Operating System Concepts/Operating Systems

Final Examination: Fall 2023

Total Marks: 40   Time: 2 hours

Answer all the questions. Numbers to the right of the questions denote their marks.

1. (a) Consider a system with three frames and the following page reference string:

$$3, 1, 0, 2, 0, 1, 3, 2, 0, 1, 3, 2$$

"First In First Output (FIFO) hit ratio is same as optimal page replacement algorithm in this scenario"- **Justify** the given statement.   [5]

   (b) Suppose, a system has a physical memory of 16 bytes, a page size of 8 bytes. A process creates and uses an array **A** of size **64**. Each element of that array occupies 2 bytes, and initially array isn't in the main memory and i, and j are in the register. Also, the code segment to initialize array elements is the following:

```
1      for(i=0;i<32;i++){
2          for(j=0;j<=i;j++){
3              A[i] = A[j]+A[i];
4          }
5      }
```

For the given code segment **calculate** the miss rate using FIFO page replacement algorithm.   [5]

2. (a) Suppose there is a logical address space of 1KB with a maximum offset size of 128 bytes. Given a segment table-1 **Convert** the following logical addresses into their corresponding physical addresses.   [2]

   i. 511
   ii. 110
   iii. 1040
   iv. 704

segment number	limit	base
0	105	1216
1	125	2300
2	70	90
3	128	1327
4	120	1952
5	83	200
6	100	2752
7	75	950

Table 1: Segment Table for Question 2a

   (b) In a system with a 35-bit physical address and a frame size of 2 KB, there are 64 processes with memory requirements of 8 KB each and 192 processes with memory requirements of 4 KB each.

   i. **Calculate** the total page table size for all processes.   [2]
   ii. If each entry in the inverted page table includes a 1-byte process ID, a 1-bit valid/invalid indicator, and the page number of the corresponding process, **Calculate** the size of the inverted page table for only these 256 processes.   [3]

   (c) Suppose, a system uses TLB while calculating physical address from logical address. The size of virtual memory is 64KB and physical memory is 32 KB. Page size is 4KB. CPU requests for five pages: 0xAF50, 0x20BA, 0xB8C2, 0x8CDA, 0xEBCD.**Calculate** the Effective Memory Access Time if TLB access time 20ns and memory access time 100ns. TLB and page table is shown in figure-1.   [3]
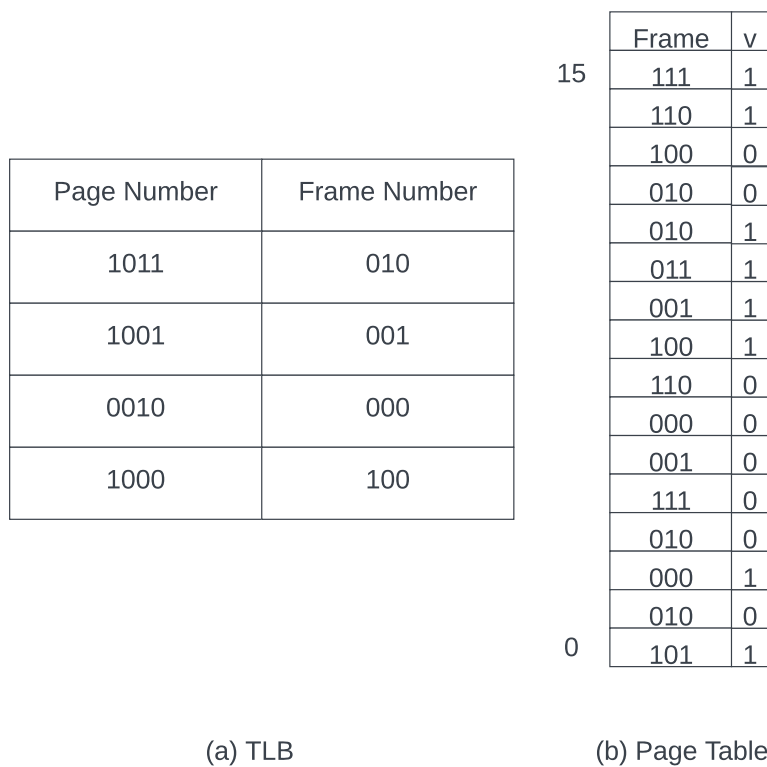
Page Number	Frame Number
1011	010
1001	001
0010	000
1000	100

	Frame	v
15	111	1
	110	1
	100	0
	010	0
	010	1
	011	1
	001	1
	100	1
	110	0
	000	0
	001	0
	111	0
	010	0
	000	1
	010	0
0	101	1

(a) TLB   (b) Page Table

Figure 1: Diagrams for Question 2c

3. Look at the code snippet below and answer the questions.

```cpp
#include <iostream>
#include <thread>
#include <semaphore.h>

using namespace std;
sem_t semaphoreA, semaphoreB, semaphoreC;

void threadFunction1() {
    sem_wait(&semaphoreA);
    sem_wait(&semaphoreC);
}

void threadFunction2() {
    sem_wait(&semaphoreB);
    sem_wait(&semaphoreC);
}

int main() {
    sem_init(&semaphoreA, 0, 3);
    sem_init(&semaphoreB, 0, 2);
    sem_init(&semaphoreC, 0, 1);

    thread t1(threadFunction1);
    thread t2(threadFunction2);
    t1.join();
    t2.join();
    return 0;
}
```

[Note: the function sem_init(&sem, 0, x) initializes the value of sem with an initial value x]

   (a) **Draw** the resource allocation graph for the above code. [2]

   (b) Is there any deadlock? **Write** an explanation in three sentences supporting your answer. [1]

   (c) What will happen if we replace **semaphoreC** by **semaphoreB** in both line 10 and 15? [2]

4. Consider the Table-2 snapshot of a system:

Table 2: Processes, its allocated resources, and maximum resources required if each process wants to execute.

Process	Allocation			Max		
	A	B	C	A	B	C
P0	2	1	2	4	2	2
P1	1	2	3	1	4	3
P2	2	1	1	3	6	5
P3	1	1	4	5	1	4

Assume that available resources are {4,0,2}

   (a) **Calculate** the Need matrix [1]

   (b) **Determine** the system is in safe state or not? [2]

   (c) "**If a request from process P2 arrives for (1,0,2), request will be granted immediately.**"-**Justify** the statement. [2]

5. (a) Imagine you have a digital camera that allows users to categorize their photos into different folders based on events, locations, or themes. However, there's a distinctive functionality: when users navigate to view the photos within a specific folder, the images are presented in the exact order they were taken. Which type of directory structure would be suitable for this scenario? [2]

   (b) Answer the following regarding file block allocation strategies: [1+1]

      i. Which type of fragmentation occurs for contiguous allocation of file blocks?

      ii. Mention one disadvantage of linked allocation.

   (c) Consider a file system that uses inodes to represent files. Disk blocks are 4 KB in size, and a pointer to a disk block requires 4 bytes. A file requires 12 direct disk blocks and single indirect disk block. What is the maximum size of this file ? The UNIX inode is shown in figure-2. [2]
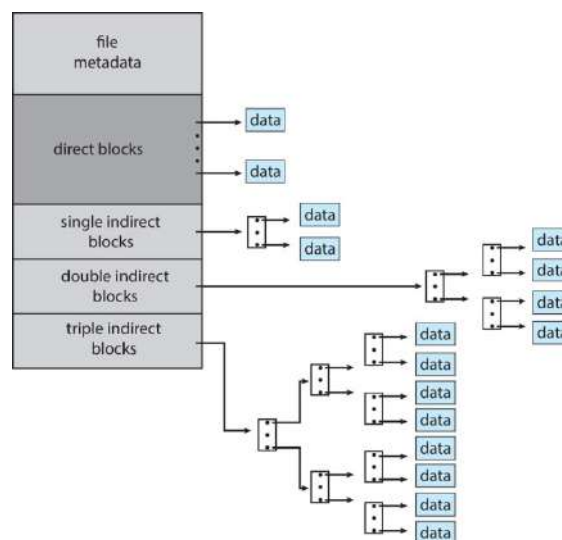
Figure 2: The UNIX inode

   (d) The address space of file system is 32 bits. Each disk block size 1 KB.

i. How many disk blocks will be required for a file of size 32 KB in linked allocation method?. [2]

ii. In case of contiguous allocation method, if the starting block of this file is 19 in disk, then find the physical disk address of this logical address 20520. [2]