

## MTL458: Operating Systems

Major (2023)

Time: 120 Min, Total marks: 35.

**Honour Code:** "As a student of IIT Delhi, I will not give or receive aid in examinations. I will do my share and take an active part in seeing to it that others as well as myself uphold the spirit and letter of the Honour Code."

### Instructions:

- Write your answers neatly and to the point.
- Remember that you will be graded on what you write and not what you intend to write.

### Questions:

Q1 You are given a new atomic primitive, called `FetchAndSubtract()`. It executes as a single atomic instruction, and is defined as follows:

```
int FetchAndSubtract(int *location){  
    int value=*location; // read the value pointed to by location  
    *location=value-1; // decrement it, and store result back  
    return value; // return old value  
}
```

You are given the task: write the `lock_init()`, `lock()` and `unlock()` routines that use `FetchAndSubtract()` to implement a working ticket lock. (2+6+2)

Q2 Let's examine a program with two threads.

Thread 1

```
-----  
pending = 1;  
while (pending) {  
    printf("hello\n");  
}
```

Thread 2

```
-----  
pending = 0;
```

- a) What are the possible outputs of this system, given an arbitrary interleaving of Threads 1 and 2?
- b) How could we re-write the code such that Thread 2 would only run after "hello" has been printed at least one time? (1+3)

Q3 Consider a hard-disk with the following specifications:

Capacity: 1 TB; RPM: 18,000; Avg Seek: 10 ms; Max Transfer: 100 MB/s; Platters: 6; Cache: 16 MB.

Calculate the throughput of the disk in a random workload where the size of each random read is 16 KB. (6)

Q4 Consider a very simple filesystem with the following parameters.

- disk block size = 1024 bytes
- space required to store an inode on disk = 128 bytes
- amount of space used to store inode list = 100 blocks
- amount of space used to store data blocks = 800 blocks

Suppose the filesystem is full. Assume that none of the files contain any "holes".

- Compute how much space would be wasted if the average file size is (a) 16KBytes, (b) 16MBytes. Clearly justify your answer.
- For what value of the average file size will no space be wasted when the file system is full? Clearly justify your answer.

(10)

Q5 Someone has written new memory allocator to replace the standard malloc()/free() implementation. It works as follows: one half of available memory is divided into fixed-sized units of 4KB, and the other half is managed by a best-fit free list. If an allocation request is less than or equal to 4KB and there is space in the fixed-sized half, a 4KB unit is allocated from the fixed-sized half; otherwise, the best-fit algorithm is used over the other half of memory, and the requested size is returned (if space is available).

- Assuming 32KB of total memory is available, what series of allocation requests will most quickly lead to all of memory getting allocated, all while requesting the least total amount of memory?
- What type(s) of fragmentation occurs with this new allocator? Explain your answer.

(2.5+2.5=5)