

# Exam 4

## Spring 2024: Released

Question	Topic	Points
1	Disk Size Calculation	8
2	Disk Scheduling	12
3	Networking	15
4	Networking Routing Algorithms	9
5	FAT Disk Allocation	10
6	Unix Commands	7
7	Network Transmission Time Calculation	9
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**Note:** Released questions will not change conceptually, but can change quantitatively. For example, numbers, instructions, order of events, etc. may be different in the exam. **In the actual exam, any such changes will be bolded.**

## Question 1 - Disk Size Calculation (8 points)

Suppose we have a hard disk drive with the following specifications:

- Number of platters: **15**
- Surfaces per platter: **2**
- Tracks per surface: **20000**
- Sectors per track: **400**
- Bytes per sector: **2048 bytes**
- Rotational Speed: **4000 RPM**
- Average seek time: **20 ms**

### Q1.1 (2 points)

How many bytes of data is stored on each platter of the hard disk drive?

Leave your answer as a math expression: eg.  $2 * 4 * (6 * 9 + 5)$

### Q1.2 (3 points)

How much time, in milliseconds, does it take to get to (access) a random sector on the disk?

Do NOT include units in your answer. Round to 1 decimal place if needed.

### Q1.3 (3 points)

Now suppose we have a different hard disk drive that utilizes zoned bit recording with the following specifications:

- Number of platters: **10**
- Surfaces per platter: **2**
- Bytes per sector: **2048 bytes**
- Rotational Speed: **9000 RPM**
- Average seek time: **10 ms**
- **4 Zones:**
  - Zone 0 (Outermost zone):
    - 24 tracks, 48 sectors per track
  - Zone 1:
    - 12 tracks, 30 sectors per track
  - Zone 2:
    - 6 tracks, 20 sectors per track
  - Zone 3:
    - 1 tracks, 6 sectors per track

What is the total capacity of this new hard drive in bytes?

Leave your answer as a math expression: eg.  $2 * 4 * (6 * 9 + 5)$

## Question 2 - Disk Scheduling (12 points)

We have a disk with the following specifications:

- **Total # of cylinders:** 350 (numbered 0 to 349). The outermost cylinder = 0 and the innermost cylinder = 349.
- **Current head position** = cylinder 190, and the head is currently moving inwards (moving towards cylinder 349)

There are 10 pending requests shown below in order of arrival from left to right. Assume that each request transfers an entire track, and, therefore, the disk head can immediately start transferring the track after locating it (i.e., there is no rotational latency incurred to locate a sector).

Request ID	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
Cylinder ID	34	50	2	100	49	36	200	250	1	10

The schedule for a scheduling algorithm is the list of cylinder IDs where the head stops to read a track and/or to change direction.

### Q2.1 (3 points)

Show the schedule for the SCAN scheduling algorithm.

Write your answer as a comma-separated list of cylinder IDs: eg. 109, 231, 4, 70

### Q2.2 (3 points)

Show the schedule for the C-SCAN scheduling algorithm.

Write your answer as a comma-separated list of cylinder IDs: eg. 109, 231, 4, 70

Suppose that the latency for moving the head position is **M** per cylinder, and the latency of transferring a track is **C**. Give your answers in terms of M and C.

### Q2.3 (3 points)

What is the expected response time for request R10 if the disk scheduling algorithm is SSTF?

Answer in terms of M + C: (eg.  $49M + 21C$ )

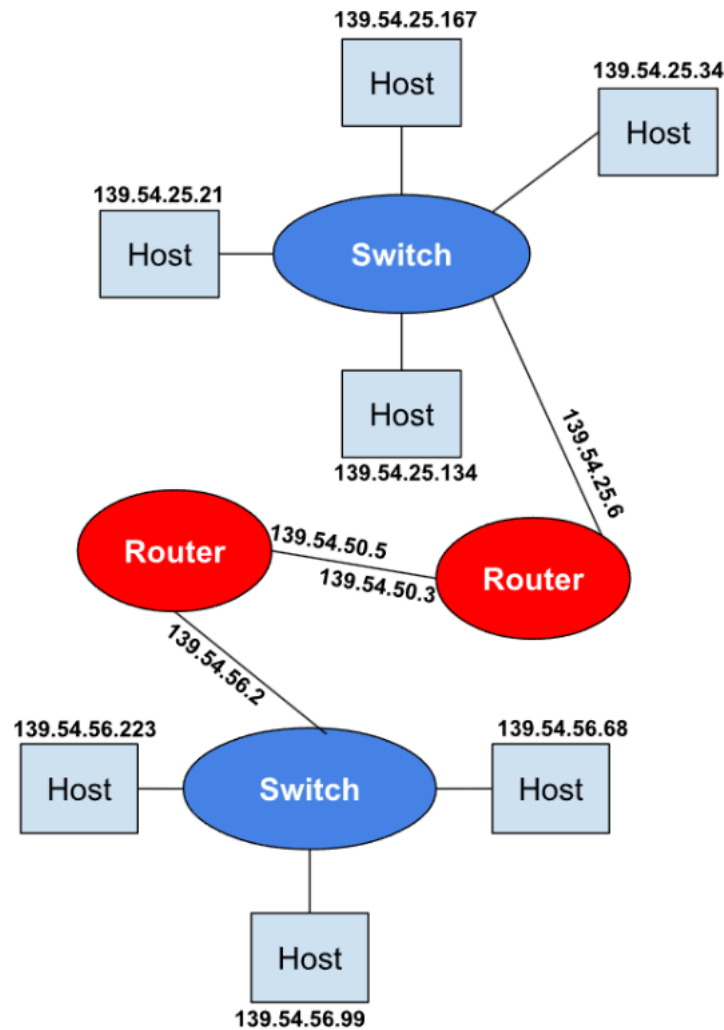
### Q2.4 (3 points)

What is the expected response time for request R3 if the disk scheduling algorithm is C-LOOK?

Answer in terms of M + C: (eg.  $49M + 21C$ )

## Question 3 - Networking (15 points)

Consider the following chunk of a network. All IPs in the figure are IPv4 addresses with a subnet mask of 255.255.255.0.



### Q3.1 (2 points)

How many network layer hops would it take to go from host 139.54.56.99 to host 139.54.25.34?

### Q3.1 (2 points)

How many link layer hops would it take to go from host 139.54.56.99 to host 139.54.25.34?

Nityam is responsible for managing a real-time video streaming service that delivers live broadcasts of sports events to viewers worldwide. The service needs to ensure minimal latency and can tolerate some packet loss without significant impact on user experience.

### Q3.3 (2 points)

Which transport layer protocol should Nityam use?

### Q3.4 (6 points)

Explain what characteristic of your chosen protocol makes it preferable for this exchange. Contrast it with the one not chosen in Q3.3.

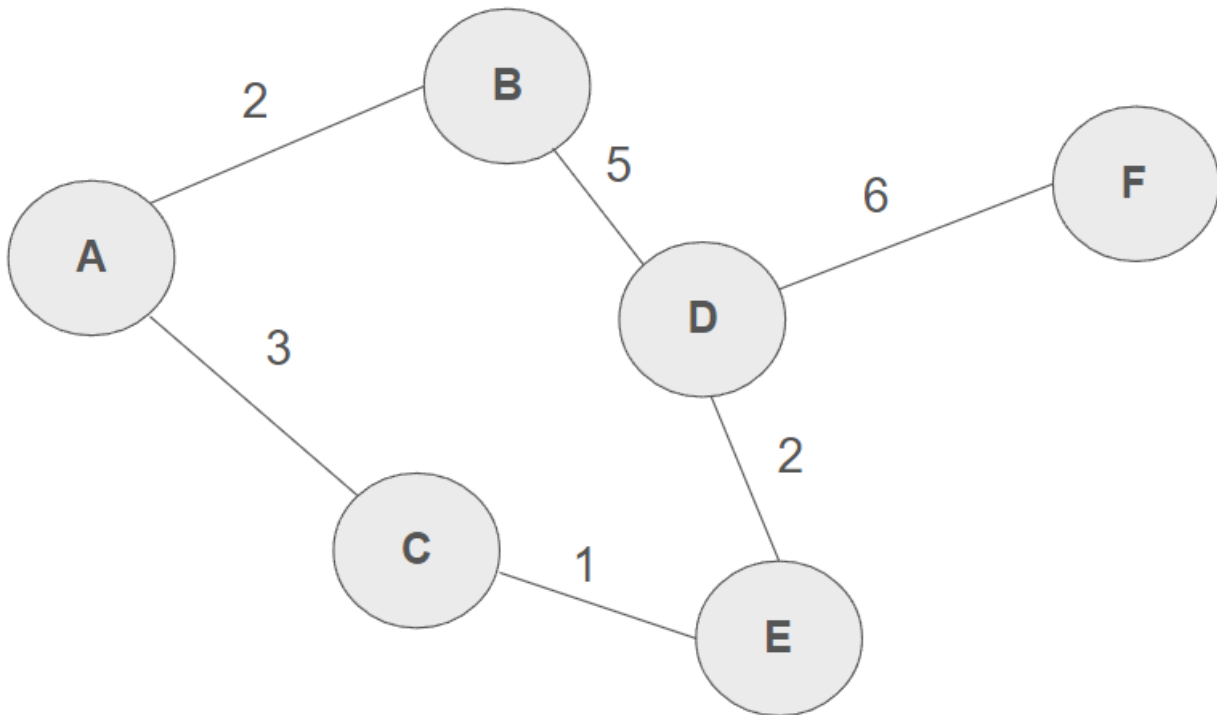
### Q3.5 (3 points)

If all the following IP addresses have a subnet mask of **20 bits**, which ones are in the same subnet as the device with IP **118.211.30.56**? Select all that apply.

- ☐ 118.211.31.23
- ☐ 118.211.34.56
- ☐ 118.211.255.18
- ☐ 118.211.16.240
- ☐ 118.212.30.56
- ☐ 120.211.12.56
- ☐ 118.211.1.138

## Question 4 - Network Routing Algos (9 points)

Suppose we have the following network. At each time step starting from  $t=1$ , every node sends its distance vector (i.e., a given node's latency to all the other nodes) to its neighbor. At  $t=0$ , all the nodes know the latencies to their respective immediate neighbors.



At time  $t=0$ , the distance vector for **A** is as follows:

**A: 0, B: 2, C: 3, D: x, E: x, F: x**

Use x to represent an unknown/infinite distance

### Q4.1 (4 points)

Compute the distance vector for **A** at time  **$t=2$** .

Write your answer as a comma-separated list of distances of all nodes in alphabetical order from A, including A.

Example answer for distance vector for A at  $t=0$ : **0, 2, 3, x, x, x**



#### Q4.2 (5 points)

Compute a link-state routing table at node A for the network after a long period of time has passed. Assume that A already knows the whole topology of the network.

Write your answer as a comma-separated list of distances of all nodes in alphabetical order from A, including A.

Answer format: <dist to A>, <dist to B>, ..., <dist to F>

Example answer for link-state routing table at A: 0, 2, 3, 4, 5, 6

## Question 5 - FAT Disk Allocation (10 points)

Assume that we are using a File Allocation Table (FAT) disk allocation scheme that manages 12 data blocks numbered from 1 to 12. The table consists of 4 columns containing metadata for the FAT scheme:

1. Block number (Labeled from 1 to 12)
2. A busy bit
3. The name of the file, or NA if the block is unallocated
4. A block number for the next disk block of that file, or -1 if that block is the corresponding file's last block.

Block Number	Busy	File Name	Next
1	1	Karan	-1
2	1	Nami	7
3	1	Fizz	4
4	1	Fizz	-1
5	0	NA	-1
6	1	Fizz	12
7	1	Nami	8
8	1	Nami	-1
9	1	Diana	-1
10	0	NA	-1
11	1	Diana	9
12	1	Fizz	3

### Q5.1 (6 points)

List the data blocks that comprise each file in the correct order.

Write your answer as comma-separated list of block numbers for each file: eg. 8, 1, 4, 6

Fizz:

Nami:

Karan:

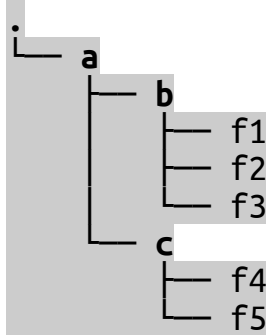
Diana:

### Q5.2 (4 points)

Explain one advantage and one disadvantage of the File Allocation Table (FAT) scheme.

## Question 6 - Unix Commands (7 points)

Given the following **initial** directory structure and file contents, write the command you would use to achieve each of the following outcomes.



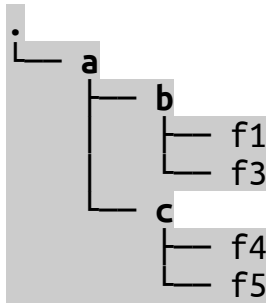
File Name	Contents
f1	foo
f2	bar
f3	baz
f4	fred
f5	waldo

Each question below is **independent** of each other and should each assume restarting from the initial state.

- You are executing your commands from the parent directory “a”
- “b” and “c” are subdirectories of “a”

For example, in order to print the contents of f4, you would type `cat C/f4`

### Q6.1 (2 points)

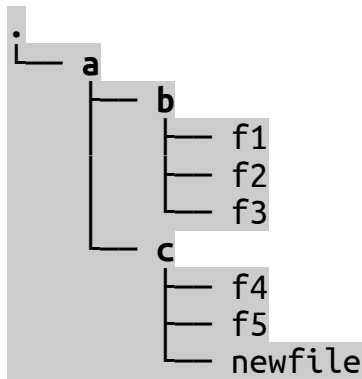


File Name	Contents
f1	foo
f3	baz
f4	fred
f5	waldo

What Unix command would you execute to achieve the above changes?

Write your answer as a properly formatted Unix command

### Q6.2 (2 points)

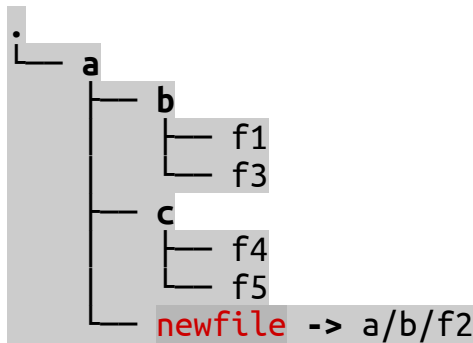


File Name	Contents
f1	foo
f2	bar
f3	baz
f4	fred
f5	waldo
newfile	

What Unix command would you execute to achieve the above changes?

Write your answer as a properly formatted Unix command

### Q6.3 (3 points)



File Name	Contents
f1	foo
f3	baz
f4	fred
f5	waldo

After executing a command to achieve the above, you run 3 more in succession. The following is the terminal output for doing so:

```
$ <unknown command>
$ cat newfile
bar
$ rm a/b/f2
$ cat newfile
error: no such file or directory
```

What was the <unknown command> you executed to achieve the above results?

Write your answer as a properly formatted Unix command

## Question 7 - Network Transmission (9 points)

Suppose now that you are trying to send a 30,000 byte file to your friend, and you'd like to take advantage of TCP for the transmission. Suppose also that

- The size of each TCP packet is 2000 bytes
- The size of a TCP packet header is 500 bytes
- We have a fixed window size of 5 packets
- Time of flight is 11 ms
- Assume negligible overhead at sender and receiver.
- Wire bandwidth is 18 Mbps
- Assume for simplicity that an ACK has negligible transmission delay

### Q7.1 (2 point)

What is the total number of packets you will need to send to your friend?

### Q7.2 (1 point)

How many pipelined transmission windows will you need to send over all the packets?

### Q7.3 (4 points)

Compute the end-to-end transmission time, in milliseconds, to send **1 window** of packets. Assume the window contains packets with full payloads.

Do NOT include units in your answer. Round to 1 decimal place if needed.

### Q7.4 (2 points)

Still using sliding window transmission, compute the end-to-end transmission time, in milliseconds, to send **all packets**. Assume the window contains packets with full payloads.

Do NOT include units in your answer. Round to 1 decimal place if needed.



# Appendix

Unix Command	Semantics
touch <name>	Create an empty file with name <name>
mkdir <sub-dir>	Create a sub-directory <sub-dir>
rm <name>	Remove or delete the file named <name>
rmdir <sub-dir>	Remove or delete the sub-directory named <sub-dir>
ln -s <orig> <new>	Create a name <new> and make it symbolically equivalent to the file <orig>
ln <orig> <new>	Create a name <new> and make it physically equivalent to the file <orig>
chmod <rights> <name>	Change the access rights for the file <name> as specified in the mask <rights>
chown <user> <name>	Change the owner of the file <name> to be <user>
chgrp <group> <name>	Change the group associated with the file <name> to be <group>
cp <orig> <new>	Create a new file <new> that is a copy of the file <orig>
mv <orig> <new>	Renames the file <orig> with the name <new>
cat/more/less <name>	View the file contents

## **p\_thread library function**

```
int pthread_mutex_lock(pthread_mutex_t *mutex);
```

Arguments

mutex	address of mutex variable to be locked
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```
int pthread_mutex_unlock(pthread_mutex_t *mutex);
```

Arguments

mutex	address of mutex variable to be unlocked
-------	--

```
int pthread_cond_wait(pthread_cond_t *cond,  
pthread_mutex_t *mutex);
```

Arguments

cond	address of condition variable to wait upon.
mutex	address of mutex variable associated with cond

```
int pthread_cond_signal(pthread_cond_t *cond);
```

Arguments

cond	address of condition variable
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