CS 2200 Spring 2009 Sec A Final Exam

Name:______Kishore_______GT Number: _______________

Problem	Points	Lost	Gained	Running Total	TA
1	1				
2	10				
3	9				
4	5				
5	10				
6	5				
7	5				
8	5				
9	5				
10	15				
11	5				
12	10				
13	5				
14	10				
Total	100				

You may ask for clarification but you are ultimately responsible for the answer you write on the paper.

Please look through the entire test before starting. WE MEAN IT!!!

Illegible answers are wrong answers.

Show your work in the space provided to get any credit for problem-oriented questions.

Good luck!

1. (1 point, 1 min)
How many chapters does the required textbook for CS 2200 have?
(a) 10
(b) 12
(c) 14
(d) 16
(e) There is a textbook for the course?

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Memory hierarchy

2. (10 points, 10 mins)

(a) Explain spatial locality. How is it used in cache design?

Spatial locality: If memory location i accessed, then there is a good chance that locations around i (namely, i±Δ), where Δ is some small integer, will be accessed by the program.

Cache design: Upon access to memory location i, bring a block of memory around i (namely, i±Δ)into the cache.

-3 if spatial locality not explained
-2 if cache design not explained

(b) Explain temporal locality. How is it used in cache design?

Temporal locality: A memory location accessed at time t, is likely to be accessed again in the near future by the program.

Cache design: If a cache block has to be replaced, and if the cache organization allows a choice of cache block to be evicted, then pick the one that has not been recently accessed (i.e., use LRU for cache block replacement).

-3 if temporal locality not explained
-2 if cache design not explained

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3. (9 points, 10 min)
Memory address = 32 bits (little-endian) byte-addressed
Total cache size = 512 Kbytes
Organization:

- 4-way set associative
- 16 byte block size

(a) (6 points) Show the bit positions in the following figure for the way the memory address is interpreted by the cache subsystem

31 17 16 4 3 0

Show your work for partial credit.

Each parallel cache has 512/4 = 128K bytes
Number of lines = cachesize of parallel cache/blocksize = 8K
Number of index bits = $\log_2 8K$ = 13
Number of block offset bits = $\log_2 16$ = 4
Number of bits for tag = 32 – 17 = 15

-1 for each incorrect

If ALL are incorrect, give partial credit (2 points) if some supporting work as above.

(b) (3 points) Explain why write-back policy may be preferred over write-through for the cache

Program locality suggests that a variable may be accessed multiple times (temporal locality) or locations around a given location may be accessed (spatial locality). Since a cache block usually consists multiple contiguous memory locations, a write-back policy helps in taking better advantage of program locality, by reducing the bus traffic.

-2 if reduction in bus traffic due to write-back policy not mentioned

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I/O and Disk scheduling

4. (5 points, 5 minutes)
Explain the difference between programmed I/O and DMA.

Programmed I/O: The processor executes instructions to move data to/from the device controller from/to processor registers and memory.

DMA: The device controller has the ability to directly move data to/from the memory from/to the controller without involvement of the processor for the actual data transfer. However, the processor has to set up the registers in the controller to kick start the DMA activity.

-2 if programmed I/O not mentioned clearly

-3 if DMA not explained clearly

5. (10 points, 10 min)
Given the following specifications for a disk drive:

- 256 bytes per sector
- 12 sectors per track
- 20 tracks per surface
- 3 platters
- Average seek time of 8 ms
- Rotational speed 15000 RPM
- Normal recording

On an average, how much time would it take to read 6 contiguous sectors from the same track?

```
Time for one revolution = 60 * 1000/15000 ms = 4 ms     (+1 point)
Time to read one sector = time for one revolution/number of tracks
                        = 4 ms/12 = 0.333 ms            (+2 point)
Time to read 6 consecutive tracks = 6 * 4/12 = 2 ms     (+1 point)

Average rotational latency = rotational latency / 2 = 2 ms  (+1 point)
Access time to a track = average seek time + average rotational latency
                       = 8  ms + 2 ms
                       = 10 ms                          (+2 point)

Time taken to read 6 consecutive sectors on the same track
                       = access time to the track + time to read 6 sectors
                       = 10 ms + 2 ms
                       = 12 ms                          (+3 point)
```

(if the working is correct, and final answer is wrong use the above partial credit scheme. No double jeopardy.)

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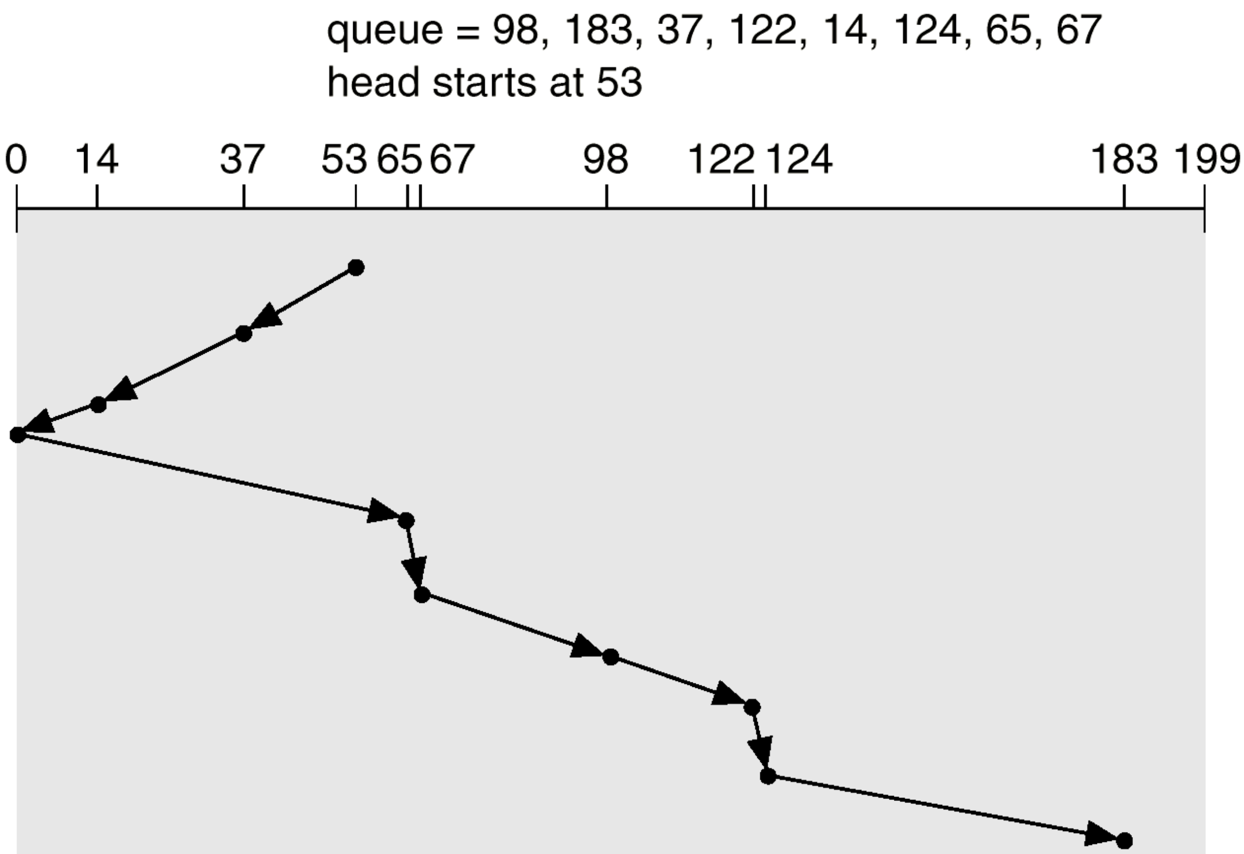
6. (5 points, 5 min)
Consider the head movement as shown in the figure below to satisfy a set of disk requests currently in the queue as shown below:



The disk schedule as pictured above corresponds to (choose one of the following)

1) FCFS
2) Shortest seek time first
3) SCAN
4) C-SCAN
5) LOOK
6) C-LOOK

All or nothing

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File System

7. (5 points, 5 min)

Linked allocation of disk space results in (choose one of the following)

1) Bad sequential access
2) Good random access
3) Ability to grow the file easily
4) Poor disk utilization
5) Good disk utilization
6) {1 and 2}
7) {3 and 5}

(+5 for choice 7; +2 for 3 or 5 alone; 0 if any other choice picked)

8. (5 points, 5 min)

Fixed contiguous allocation of disk space results in (choose one of the following)

1) Good sequential access
2) Good random access
3) Ability to grow the file easily
4) Poor disk utilization
5) Good disk utilization
6) {1 and 2}
7) {3 and 5}
8) {1, 2, and 4}

(+5 for choice 8; +1 for each of 1, 2, or 4; 0 if any other choice picked)

9. (5 points, 5 min)

Consider:

```
touch f1          /* create a file f1 */
ln –s f1 f2       /* sym link */
ln –s f2 f3
ln f1 f4          /* hard link */
ln f4 f5
```

(a) How many i-nodes will be created by the above set of commands?

3 i-nodes:
- f1_inode
- f2_inode
- f3_inode

(+1 for each i-node)

(b) What is the reference count on each node thus created?

Ref count:

f1_inode	3	(f4 and f5 are hard links to f1)
f2_inode	1	
f3_inode	1	

(+1 for f1_inode; 0.5 for each of f2_inode and f3_inode)

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Symmetric Multiprocessor
10. (15 points, 10 min)
Given the following details about an SMP (symmetric multiprocessor):
Cache coherence protocol: **write-invalidate**
Cache to memory policy: **write-back**

Initially:
The caches are empty
Memory locations:
C contains 31
D contains 42

Consider the following timeline of memory accesses from processors P1, P2, and P3.

Time (in increasing order)	Processor P1	Processor P2	Processor P3
T1		Load C	Store #50, D
T2	Load D	Load D	Load C
T3			
T4		Store #40, C	
T5	Store #55, D		

Fill the table below, showing the contents of the cached after each timestep. We have started it off for you by showing the contents after time T1.
(**I indicates the cache location is invalid. NP indicates not present**)

Time	Variables	Cache of P1	Cache of P2	Cache of P3	Memory
T1	C	NP	31	NP	31
	D	NP	NP	50	42
T2	C	NP	31	31	31
	D	50	50	50	42
T3	C	NP	31	31	31
	D	50	50	50	42
T4	C	NP	40	I	31
	D	50	50	50	42
T5	C	NP	40	I	31
	D	55	I	I	42

(-0.5 for each mistake for each gray cells)

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11. (5 points, 10 min)
Given the following threads and their execution history, what is the final value in memory location x? Assume that the execution of each instruction is atomic. Assume that Mem[x] = 0 initially.

Thread 1 (T1)	**Thread 2 (T2)**
Time 0: R1 <- Mem[x]	
	Time 1: R2 <- Mem[x]
Time 2: R1 <- R1+2	
	Time 3: R2 <- R2+1
Time 4: Mem[x] <- R1	
	Time 5: Mem[x] <- R2

At time 4: T1 stores value 2 into Mem[x]
At time 5: T2 stores value 1 into Mem[x]

So final value in Mem[x] is 1

(all or nothing)

Network
12. (10 points, 10 min)
Given the following:
Message size = 100,000 bytes
Header size per packet = 100 bytes
Packet size = 1100 bytes
How many packets are needed to transmit the message assuming a 10% packet loss? Ignore fractional packet loss. Ignore ACKs. Show your work for partial credit.

Maximum payload in each packet = packet size – header size
= 1100 – 100 bytes
= 1000 bytes

Number of packets needed for the message = message size/payload
= 100,000/1000
= 100 packets

The following is the packet schedule accounting for the losses

Packets sent	Packets received	Packets lost	
100	90	10	**(+3)**
10	9	1	**(+3)**
1	1	0	**(+3)**

Total number of packets needed for successful completion of message delivery
= 111 **(+1 for doing the math, no double jeopardy)**

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13. (5 points, 10 min)
The following are the sizes of the fields of a packet header:

Destination address	8 bytes
Source address	8 bytes
Number of packets in message	4 bytes
Sequence number	4 bytes
Actual packet size	4 bytes
Checksum	4 bytes

Assuming that the maximum packet size is 1100 bytes, what is the maximum payload in each packet?

Total size of packet header = 32 bytes **(+2)**

Maximum payload in each packet = packet size – header size
= 1100 – 32 bytes
= 1068 bytes **(+3)**

(-1 for math errors)

14. (10 points, 10 mins)
Given the following:

Sender overhead	= 1 ms
Message size	= 200,000 bits
Wire bandwidth	= 100,000,000 bits/sec
Time of flight	= 2 ms
Receiver overhead	= 1 ms

Compute the observed bandwidth. Recall that the message transmission time consists of sender overhead, time on the wire, time of flight, and receiver overhead. Ignore ACKs.

Time on wire = message size/wire bandwidth
= $2 * 10^5 / 10^8$ seconds
= 2 ms **(+3)**

Message transmission time
= sender ovhd + time on wire + time of flight + receiver ovhd
= 1 ms + 2ms + 2ms + 1 ms
= 6 ms **(+4)**

Observed bandwidth = message size/transmission time
= 200,000/6 bits/ms
= 33.333 Mbits/sec (where M = 10^6) **(+3)**

(-1 for math errors)